Waste Management Association of Australia - Energy from Waste Division

IEA Bioenergy Task 36: Topic 1 - PS/EPR Scheme Impact on MSW

Extended Producer Responsibility and Product Stewardship Scheme Impacts on Energy Recovery from Municipal Solid Waste

Stage 2 Report: Review and Assessment of the Performance of PS/EPR Schemes

March 2006

Executive Summary

The Energy from Waste (EfW) Division is a national division of the Waste Management Association of Australia and a member of Bioenergy Australia, the vehicle for national participation in the International Energy Agency's (IEA) Bioenergy program. Task 36 of this program is Energy from Integrated Solid Waste Management Systems and the EfW Division is taking responsibility for delivering Topic 1 of Task 36: Extended Producer Responsibility and Product Stewardship Scheme Impacts on Energy Recovery from Municipal Solid Waste.

The purpose of this Topic is to provide a planning platform for resource recovery infrastructure requirements in general and energy recovery in particular. The central thesis of Topic 1 is that product design and infrastructure planning need to be integrated in order to achieve desired sustainability outcomes.

The first stage in Topic 1 was a review of theoretical concepts surrounding Extended Producer Responsibility/ Product Stewardship (EPR / PS) that highlighted the potential for product design to influence sustainable resource recovery outcomes. Value Chain Optimisation (VCO - applying the design intent of maximising value added or retained throughout all stages of the value chain) was identified as a model for engagement and integration between product designers and resource recovery service providers, and as a planning platform for resource recovery infrastructure and technology requirements in general, and energy recovery in particular.

This current report represents the outcomes from Stage 2 of the EPR / PS Topic: a review and assessment of the performance of EPR / PS schemes, with reference to actual programs, experience and case studies from a range of OECD countries.

EPR / PS schemes can be grouped as: take-back requirements for specific products or waste streams to facilitate material recovery and recycling; economic instruments such as advance recovery/disposal fees, deposit/refund schemes, levies or taxes on particular materials, compliance measures and incentives and rewards; performance standards such as the setting of targets to improve environmental performance/reduce waste; and other complementary measures including eco-labelling, education and awareness-raising, extended product ownership, green procurement, product design, cleaner production processes, and bans and restrictions on disposal and materials.

EPR / PS schemes and approaches address a wide variety of product types including general packaging, plastic bags, end-of-life vehicles, mobile phones, paint, electrical and electronic equipment, tyres, paper, rechargeable batteries, hazardous materials, oil and pesticides. There are a variety of legislative frameworks that are used to facilitate the implementation of EPR / PS schemes, ranging from voluntary industry led 'opt in' schemes to heavily regulated and mandatory schemes. Many of the European schemes are being driven by EU Directives.

Ultimately all costs are passed on to consumers by industry, however there are a number of different approaches to funding EPR / PS schemes (for example the creation of a secondary market in tradeable certificates for recovery services, and direct payments by industry or consumers), in addition to how these funds are used.

Operational issues for EPR / PS schemes are usually coordinated by an administrative organisation. These agencies undertake promotion and marketing; organise mechanisms for take back, collection and recycling; and support the development of in-house planning and continuous improvement. Other issues relate to the effectiveness of associated regulation as an impetus for industry change.

Social issues related to the implementation of EPR / PS schemes relate primarily to changes in market place. For example, the need to re-examine attitudes towards 'used' goods, price increases associated with internalising environmental costs into product prices, spheres of responsibility that extend to a product's end-of-life and the more general issue of societal impact caused by the actions of free riders.

The technical challenges created by the implementation of EPR / PS schemes relate to the: capacity of existing recovery infrastructure to handle increased volumes; development of new resource recovery technologies to meet recovery requirements; quality of recycled content and component reuse for incorporation into new product manufacture; and suitability of substitute materials to replace those being phased out.

Participation in EPR / PS schemes, although undermined by the presence of free riders, has been shown to increase the resource recovery rates of targeted products and materials. Other beneficial outcomes include a reduction in associated litter and improved design and process engineering in product manufacture.

Examples identified of a direct link between EPR / PS schemes and design intent include: design to reduce hazardous materials; design for disassembly; design to dematerialise (lightweighting); design for durability and design for recycling.

EPR / PS schemes have the potential to reduce the amount of recyclable material going to disposal via kerbside collected Municipal Solid Waste (MSW). Those schemes targeted toward domestic packaging have the end result of reducing the amount of dry recyclables that end up in the residual MSW stream, while other schemes that address domestic products, such as electrical and electronic equipment, mobile phones, rechargeable batteries and paint can also reduce the occurrence of these items in the kerbside waste stream.

New and emerging EPR / PS schemes are addressing used tyres, paper and printing products, electrical and electronic equipment (EEE), disposable nappies and hazardous substances. Australia in particular is acting to establish a model of co-regulation when developing EPR / PS schemes. Under this style of approach there are regulatory consequences for non participation. This is done to remove 'free riders' and allow industry greatest flexibility in responding to the challenges that EPR / PS present.

For those EPR / PS schemes with flexibility in meeting recovery targets, the question of whether to recover materials for recycling or for energy generation is important. One factor in addressing this issue is the difference between a material's calorific value (inherent energy released during combustion) and embodied energy (amount of energy required to transform raw materials into final products).

In general most materials have a higher embodied energy than calorific value, meaning that a wholesale approach of calorific energy recovery will lose the embodied energy 'invested' within materials and products. At the same time it is of limited value to take no action to recover calorific energy while waiting for the perfect 'mousetrap', especially when disposal provides a zero value return. Also given that some material types cannot be infinitely recycled, and increasing volumes of lightweight composite convenience packaging, it is suggested that the recovery of calorific energy from waste will feature as part of an integrated and sustainable resource recovery system.

Achieving an optimal balance between recovery options may be assisted by calculating the embodied energy recovery associated with material recycling and developing a mechanism to financially reward this form of 'recovered energy'. One starting point could be valuing the avoided carbon emissions brought about by recovering embodied energy. Under this approach the purpose of calorific energy recovery is to act as a broad 'filter' ensuring that value is not lost to disposal technologies.

The composition and volumes of materials available for energy recovery will depend on given market conditions, materials used in product manufacture and the prevalence of non-recyclable convenience packaging within the economy, in addition to giving due consideration to recovering the net highest resource value of materials under management. (This is a similar conclusion to that of the Energy from Waste Sustainability Guide discussed in the Stage 1 Report).

The principles of Value Chain Optimisation indicate that product designers and initiators need to cooperate with resource recovery service providers to ensure that a network of Energy from Waste facilities is available to manage those packaging materials and disposable/short life products unable to be readily recycled. The integration of design intent with end-of-life resource recovery is all the more important as a means of removing hazardous materials that could disrupt the clean and efficient operation of an energy recovery technology.

Household hazardous wastes (HHW) are products used and disposed of by residential as opposed to industrial consumers. HHW include paints, stains, varnishes, solvents, pesticides, and other materials or products containing volatile chemicals that can catch fire, react or explode, or that are corrosive or toxic. A variety of schemes exist to remove HHW from the urban waste stream, including temporary collection days, permanent collection facilities, mobile call-up programs and kerbside collections.

The challenges to the ongoing effectiveness of EPR / PS schemes include: reverse logistic infrastructure; innovative technologies for product and material dissimilation and assimilation; elimination of 'free-riders'; development of markets for recovered resources; and development of principles for Value Chain Optimisation.

If these challenges can be met the end result of EPR / PS actions will be a decrease in the amount of readily recyclable material in the urban waste stream, a decrease in the amount of household hazardous materials disposed of in urban waste and an increase in the proportion of materials available to be recycled through the economy (with the associated economic value and reduced environmental impact of these commodities).

The future urban waste stream is likely to be dominated by plastic and paper/cardboard items, predominately related to disposable products and to lightweight convenience packaging. This composition suggests a greater role for energy recovery in the overall provision of resource recovery services.

The potential to integrate design and resource recovery infrastructure, means that a theoretical 'total resource recovery' could be achieved within major metropolitan centres: through the provision of anaerobic recovery for food and other putrescible items; energy recovery for the residual 'dry high calorifics' with a pre-sort for recyclable metals, plastics and inert materials; and then processing of inert fully mineralised residuals for use in civil works like roads and construction.

In order to deliver this system of resource recovery a new range of capabilities is required in planning, design and resource recovery services. For example: an understanding of materials currently in service within the economy, their stock life and recovery options at end-of-life; the ability to design products to be readily assimilated into existing reverse logistic resource recovery pathways; and the provision of infrastructure to keep pace with the changing composition of the urban waste stream.

These capabilities are required to scope the generic systems and infrastructure needs that should be available if energy recovery (embodied and calorific) from residual urban wastes is to be put on a sustainable footing.

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1. Background and Introduction

The Energy from Waste (EfW) Division, a national division of the Waste Management Association of Australia, is a member of Bioenergy Australia. Bioenergy Australia, in turn, is the vehicle for national participation in the International Energy Agency's (IEA) Bioenergy program.

IEA Bioenergy provides opportunities for interested countries to work collaboratively on topics of mutual interest and importance, one of which is Task 36 - Energy from Integrated Solid Waste Management Systems. As part of this task, the EfW Division is taking responsibility for delivering Topic 1: Product Stewardship / Producer Responsibility.

1.1 Project Stages

The purpose of Topic 1 is to provide a platform to plan for infrastructure requirements for resource recovery technologies in general, and energy recovery in particular. The central thesis of Topic 1 is that product design and infrastructure planning need to be integrated in order to achieve desired sustainability outcomes. In order to fully investigate this thesis, the Topic 1 Project is being undertaken in three stages:

Stage 1: Review theoretical concepts surrounding Extended Producer Responsibility/ Product Stewardship and discuss the potential for product design to influence/deliver sustainable resource utilisation outcomes.

Stage 2: Review actual experience and outcomes of Extended Producer Responsibility/ Product Stewardship schemes with case studies in order to identify the existing level of integration between design intent and resource recovery, and provide a comparison of tangible results against the potential for integration of design and resource recovery infrastructure outlined in Stage 1.

Stage 3: Synthesise outcomes from earlier Stages 1 and 2 to scope the generic systems and infrastructure needs that should be available if energy recovery (embodied and inherent) from residual urban wastes is to be put on a sustainable footing.

This discussion paper represents the outcomes from Stage 2 of the process. Further details on the structure of this paper are provided following a brief review of conclusions from Stage 1.

1.2 Review of Stage 1

The foundation of the drive for increased resource recovery is a need for change from a "take-make-waste" mentality relying on disposal in "mass-dump" landfill or "mass-burn" incineration to a resource circulation philosophy. Using the "nature as model" approach, the goal of the resource recovery industry is to establish a platform of cyclical material and energy flows from which sustainable outcomes can be delivered.

Decision support tools used to assist in meeting these goals and overcoming potentially suboptimal recovery options include (amongst others): the Sustainability Guide for Energy from Waste, to identify when energy recovery is the preferred resource recovery outcome; assessment of net present highest resource value, to qualitatively differentiate between resource recovery options; and Life Cycle Assessment, which can be used to quantitatively assess resource recovery options for a given region or city.

Another useful approach revolves around the concept of value chain. Here the value chain includes the physical supply chain (resource flows from extraction through manufacturing, assembly service life and final disposal), and also flows of information, ideas, decisions and finance – everything that can add, retain or subtract value from a product or service, from its point of initiation to end-of-life management.

Mapping the value chain identifies the product designer as the key element in determining value balances of each stage during a product's life cycle (value added, retained or subtracted). As value here refers to a combination of environmental, techno-economic and socio-political values, the role of product design becomes central to determining sustainability outcomes. Recognition of this fact is part of the rationale behind Extended Producer Responsibility (EPR) and Product Stewardship (PS) principles. Both EPR and PS focus responsibility on the original brand owner or manufacturer so that consideration is given to down stream impacts at the point of product design/initiation.

However, the potential for positive end-of-life management outcomes is also influenced by the availability of post consumer services and capabilities, demonstrating the need to integrate design intent with resource recovery. (It is recognised that the unavailability of these services is not an excuse for a producer to disregard their design responsibilities).

If EPR / PS initiatives are to have a positive impact on sustainability outcomes, part of the equation must be sufficient post consumer services and capabilities a closer relationship between product designers and providers of post consumer resource recovery services is needed to better plan for resource recovery technologies and infrastructure provision.

Changing market economics to better reflect the true costs of production and consumption (internalisation of externalities) will create a commercial imperative to link product design with infrastructure planning. Strategies can also be developed by applying the principles of Value Chain Optimisation (VCO), which is applying the design intent of maximising value added or retained throughout all stages of the value chain.

VCO has the potential to integrate designers into dialogue regarding: highest resource value pathways to deliver sustainable energy and material flows; overcoming market failures; development and sharing of reverse distribution infrastructure; development of resource recovery processing technologies; and education of consumers. The result is that design choices are improved in step with improvements made to post consumer resource recovery services.

Value Chain Optimisation thus provides not only a model for engagement and integration between product designers and resource recovery service providers, but also a planning platform for resource recovery infrastructure and technology requirements in general, and energy recovery in particular.

1.3 Introduction to Stage 2

This second stage of IEA Bioenergy Task 36 Topic 1: Product Stewardship / Producer Responsibility reviews actual experience and outcomes of Extended Producer Responsibility / Product Stewardship (EPR / PS) schemes, with reference to actual programs, experience and case studies from a range of OECD countries.

The main aim of this report is to identify the existing level of integration between design intent and resource recovery and to identify the potential future impact on residual waste streams as a result of applying the principles of Value Chain Optimisation. It is intended that this will provide useful and informative advice for future post consumer resource planning and capability building.

The structure of this report is presented in Figure 1-1 below.

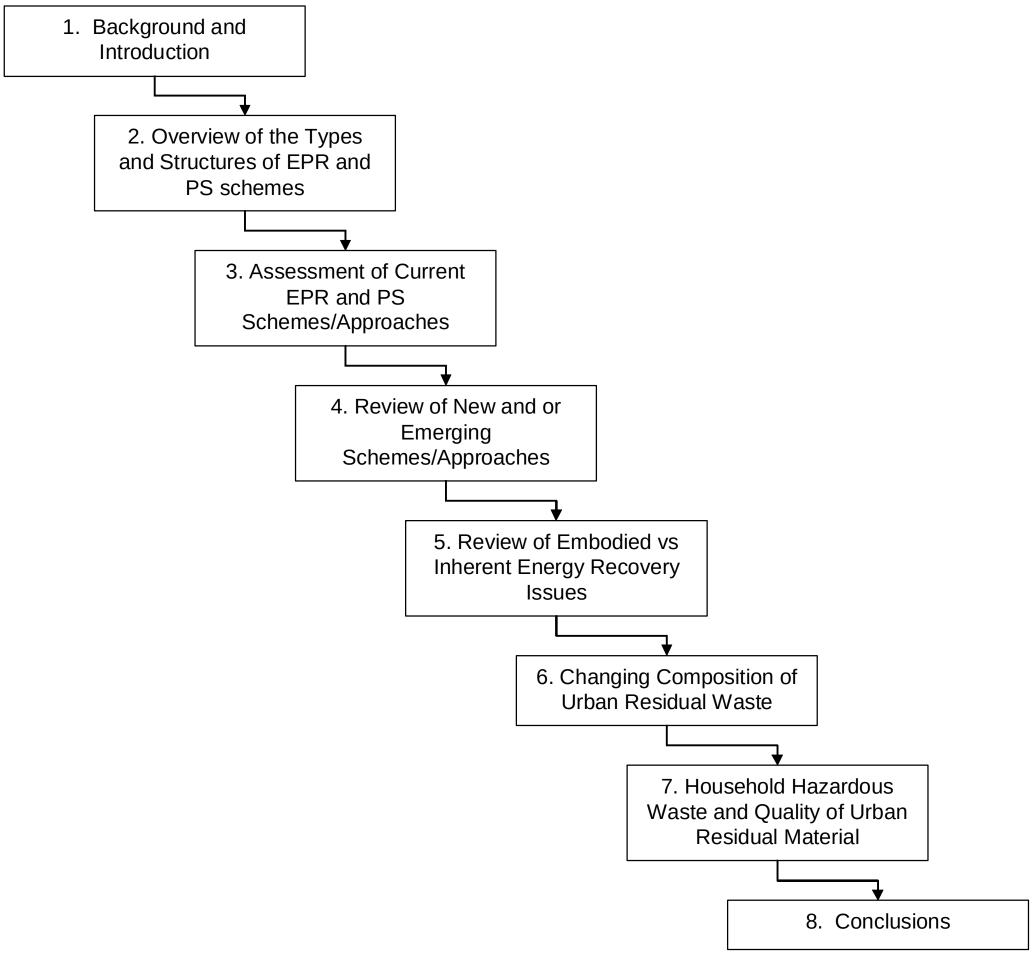

Figure 1-1 Structure of report

Following this introduction, Section 2 of this report reviews the definitions of EPR and PS and presents the basic structures of EPR / PS schemes, namely take back requirements, economic instruments, performance standards and other complementary measures.

Section 3 provides an assessment of EPR / PS schemes in operation in Australia, France, the United Kingdom, Sweden and Canada. The review covers the various legislative frameworks, financial frameworks, operational structures and details, social issues, technical issues, participation and outcomes, relationship of schemes to design intent and impacts on kerbside arising from different EPR / PS schemes.

Section 4 reviews new and/or emerging schemes and approaches, while Section 5 presents a review of embodied versus inherent energy recovery issues and addresses whether the recovery of energy invested in the manufacture of materials and products (embodied) is preferable to inherent energy recovery (calorific value).

Section 6 examines the changing composition of Urban Residual Waste, according to historical events such as the introduction of new products and services, and identifies prevailing trends affection waste composition. On the basis of this analysis an estimate of the composition of future residual waste is made.

Section 7 looks at Household Hazardous Waste and discusses the link between programs to remove these materials and the quality of Urban Residual Waste. Finally the conclusions of this Stage 2 report are presented in Section 8.

2. Overview of the Types and Structures of EPR and PS schemes

The report from Stage 1 "Discussion Paper on the Theoretical Concepts and Potential Surrounding Extended Producer Responsibility and Product Stewardship" identified the following definitions for Extended Producer Responsibility (EPR) and Product Stewardship (PS – sometimes know as shared responsibility):

» Extended Producer Responsibility (EPR): Transferring the cost of the environmentally significant post-consumer characteristics of products, such as waste volume, toxicity and recyclability, from local authorities to the producers. This transfer of costs is designed to provide economic incentives for producers to prevent/reduce the amount of waste generated, reduce the usage of toxic materials, increase recycling and enhance markets for secondary materials (OECD 1996).

» Product Stewardship (PS): All participants (such as designers, suppliers, manufacturers, distributors, retailer, consumers, recycler and disposers) that are involved in the product supply chain take responsibility for the full environmental and economic impacts of that product (ILSR 2000).

For the purpose of this report, the terms EPR and PS refer to the above definitions and are used in concert to identify the broad coverage, similarity and often overlap between schemes.

EPR / PS are concepts that have the potential to be broadly influential. They encompass a wide range of initiatives that can prospectively target all stages in the supply chain of products and packaging materials.

According to the OECD (2000), the three main types of EPR (and PS) instruments include take-back requirements, economic instruments and performance standards. EPR / PS mechanisms can also range from fully mandatory to fully voluntary – with negotiated mechanisms in between. The actual structure of EPR / PS schemes varies widely. Factors such as regional and local circumstances, the precise materials and products being addressed, and the overall objectives for the program (product redesign, waste diversion, etc.) can be reflected in the design of the scheme.

There are also a range of other complementary measures that seek to deliver EPR / PS outcomes. Further information on these and take-back requirements, economic instruments and performance standards are provided in the following sections Examples of actual EPR / PS are provided in Appendix A. 3. An assessment of current EPR / PS schemes and approaches is provided in Section 3.

2.1 Take Back Requirements

Take-back requirements refer to obligation of retailers and/or producers to take back specific products, product categories or waste streams (or they are returned to them) for material recovery and recycling. Take-back schemes provide the most immediate assignment of responsibility compared to the other broad categories of EPR programs, with the producer responsible for the resource recovery of returned or collected products. These types of schemes often have charges incorporated into the price of the product in order to fund the recovery program (Warnken ISE 2003).

Take-back policy approaches are implemented through legal requirements, negotiated industry / government agreements and completely voluntary industry-based programs. The funding of take back requirements can often be through an economic instrument.

2.2 Economic Instruments

Economic instruments “allow industry much more flexibility in establishing the means of compliance” (Warnken ISE 2003). They have the benefit of both raising funds for the management or enforcement of the EPR scheme as well as modifying the market in favour of more environmentally sound outcomes. Economic instruments are a direct financial incentive for all parties involved in the product supply chain to implement and maintain EPR. Examples of economic instruments include deposits/refund schemes, advance disposal fees, material taxes and other tax or subsidy arrangements, and levies.

The administration of economic instruments (and in many cases product take back) is often undertaken by producer responsibility organisations (PROs). PROs are private or public bodies taking partial or total financial and/or organisational responsibility for managing end-of-life products on behalf of producers or market operators.
(ADEME 2003)

PROs undertake a number of activities including administrative arrangements with enterprises that guarantee the recycling targets, setting prices for individual members, reporting the performance of the scheme as required by the regulator, and undertaking public awareness programs (DEH website).

2.3 Performance Standards

Performance standards include minimum recycled content requirements to encourage the take-back of materials for recycling or reuse, recycling targets and restrictions on the use of hazardous materials. Performance standards have the benefit of focusing attention on the design stage of a product and can be used to provide a market pull for recovered resources. Progressive standards can also open up opportunities for innovation.

Standards and targets are often established voluntarily by industry bodies as a means of avoiding regulation. However, widespread participation is required and often complementary regulation is desirable to counter the problem of “free riders”.

2.4 Other Complementary Measures

Other complementary measures can be implemented to support the goals and objectives of the other EPR schemes, or can be used stand-alone as well. These include initiatives such as eco-labelling, education and awareness-raising, extended product ownership, green procurement, product design, cleaner production processes, and disposal bans on materials and products.

Information on these complementary measures, in addition to take back requirements, economic instruments and performance standards are presented in Table 2-1 below.

Table 2-1 EPR and PS approaches

Category	EPR / PS approach	Details/examples
Take-back requirements	Take-back schemes	Specific products or waste streams are taken back by the producer or returned to them for material recovery and recycling.
Economic instruments	Advance recovery/disposal fees	A fee is levied on certain products to fund their collection, recycling, if possible, or appropriate disposal. It is often used for long life products such as tyres or whitegoods.
	Deposit/refund schemes	A payment is made when the product is purchased, which is fully or partially refunded when the product is returned to an appropriate dealer or specialised treatment facility.
	Levies or taxes on particular materials	Taxes on virgin materials to discourage their use where recycled or recovered products would not be competitive on cost, or to provide funds to cover the cost of managing externalities, such as education, enforcement or clean-up of litter or illegal dumping or for the management of waste with problematic components.
	Compliance measures	Penalties for non-compliance with EPR schemes, material bans and/or restriction or prohibitions on the disposal of certain products to landfill or to waste treatment facilities.
	Incentives and rewards	Store discounts or other benefits, to encourage consumers to return goods to stores; subsidies to recyclers for effective reuse; grants to develop resource-efficient alternatives; or incentives to replaces toxic materials.
Standards	Performance standards	Setting of targets to improve environmental performance/reduce waste such as minimum amounts of recycled content per product.
Other complementary measures	Eco-labelling	Labels are placed on products or packaging to provide consumers with information about a product's environmental performance.
	Education and awareness-raising	Promotion of community awareness regarding how to safely dispose of certain products/wastes or access EPR / PS schemes.

Category	EPR / PS approach	Details/examples
	Extended product ownership	The producer retains ownership of the product and leases it to the consumer for use under certain conditions.
	Green procurement	Purchasing authorities aim to promote sustainable resource use, resource recovery and recycling through purchasing policies.
	Product design	Adoption of 'design for the environment' and 'design for disassembly' principles.
	Cleaner production processes	Implementation of cleaner production to reduce the use of hazardous materials and adopt more sustainable production processes.
	Disposal bans and restrictions	Legislated bans on the disposal of certain materials or products. For example banning the disposal of tyres to landfill.
	Materials bans and restrictions	Legislated or regulated complete or maximum content bans on certain materials – often used for hazardous substances to reduce the risks associated with reuse and recycling of products containing such substances, and also to make reuse and recycling easier.

Adapted from NSW EPA, accessed online 27/05/05 [URL: www.epa.nsw.gov.au/waste/epr/faq.htm]

3. Assessment of Current EPR and PS Schemes/Approaches

The main function of Extended Producer Responsibility and Product Stewardship (EPR / PS) schemes is arguably twofold: firstly to remove from residual urban waste those products and materials with resource value that would be wasted if lost to landfill or an alternative waste technology; and secondly, to remove from the residual urban waste those products and materials that are hazardous and have the potential to toxify the environment (either directly through landfill or indirectly though an output from an alternative technology). The actual implementation and operation of EPR / PS schemes is more intricate, especially given that EPR / PS schemes are not a panacea for all resource recovery problems and suffer from their own inherent limitations.

A total of 38 schemes were identified and reviewed as the basis for an assessment of current EPR / PS schemes. These are presented in Appendix B. A selection of twelve schemes was made for a more in-depth review of their operation and implementation. These case studies are presented in Appendix A. The main issues as they relate to the legislative framework, financial framework, operational structures and details, social issues, technical issues, participation and outcomes, relationship of schemes to design intent and impacts on kerbside are discussed in the sections below.

3.1 Product Types

EPR / PS schemes and approaches address a wide variety of product types including general packaging, plastic bags, end-of-life vehicles, mobile phones, paint, electrical and electronic equipment, tyres, paper, rechargeable batteries, hazardous materials, oil and pesticides. For an EPR / PS scheme to be effective, the focus of the scheme needs to be identifiable as a distinct product or material type, in addition to having a well defined and identifiable industry.

If it is difficult to identify producers within an industry, it will be hard to avoid the issues of free riders caused by non-participation in the scheme. For example EPR / PS schemes do not work well with products or industries with low cost barriers to entry that exist as ‘backyard’ operations. It is too easy for producers to avoid participation with these types of products.

As an increasing variety of EPR / PS schemes are established it will become important to examine potential synergies between initiatives. There are many product types that have similarities in composition, but exist in different markets, especially amongst electrical and electronic equipment. Opportunities exist to improve the overall efficiency of EPR / PS schemes by overcoming duplicated effort, for example by sharing collection and processing infrastructure.

3.2 Legislative Framework

There are a variety of legislative frameworks that are used to facilitate the implementation of EPR / PS schemes, many of which are designed around avoiding free riders. The spectrum of options ranges from voluntary industry led 'opt in' schemes to heavily regulated and mandatory schemes. Many of the European schemes are being driven by EU Directives.

For example the Swedish scheme of producer responsibility for Waste Electrical and Electronic Equipment (Ordinance SFS 2005:209) is based on Directive 2002/96/EC (the WEEE Directive). Other approaches to legislative underpinnings include:

- Compulsory across the board – for example paint stewardship in British Columbia – which is mandatory for all paint sold.
- Compulsory on reaching a threshold – for example EPR for Packaging Waste – United Kingdom – more than 50 tonnes of packaging a year and an annual turnover of more than £2 million.
- Voluntary with a regulatory underpinning – for example the National Packaging Covenant in Australia is a voluntary industry initiative with a National Environmental Protection Measure to regulate non-participants so that there is no 'free-rider' advantage gained.
- Voluntary industry initiative – for example mobile phones industry recycling program in Australia, which was initiated by the Australian Mobile Telecommunication Association (AMTA).

3.3 Financial Framework

Ultimately all costs are passed on to consumers by industry, however there are a number of different approaches to funding EPR / PS schemes, depending on whether a secondary market for recovery services is provided (for example tradeable certificates) or if direct payment is made by industry or consumers, in addition to how these funds are used. Examples of financial frameworks in use include:

- Self funded through a tradeable certificate system – obligations are placed on liable parties to meet certain recovery targets, with a penalty set for non-compliance. Each tonne of recovery is registered with a certificate. Certificates are then used to discharge liability. Those companies able to provide the recovery service, or able to recover more than required under their liability, are able to trade certificates. Usually the penalty for non-compliance sets the maximum market value for certificates. An example of this type of scheme is Packaging Recovery Obligations in the UK, which have tradeable Packaging Recovery Notes (PRNs).
- Costs borne directly by industry – a recovery target is set and it is up to each liable organisation to meet the costs of achieving the target. For example, end-of-life vehicles in Germany.
- Industry funded producer responsibility organisations (PROs) – industry participants pay a fee to a company established for the purpose of co-ordinating the collection, take back and recycling of liable products. Fees are usually levied on a per product or weight based scale. Examples include El-kresten in Sweden (EPR Scheme for Waste Electrical and Electronic Equipment) and Duales System Deutschland (Green Dot Program for Packaging in Germany).

- Point-of-sale advanced recovery/disposal fee – the costs of collection, take back and recovery are incorporated into a fee charged to consumers at the retail point-of-sale. Often a separate company or not-for-profit organisation is established to oversee the collection and distribution of revenue. Funds are paid out to processors or recyclers, usually on a volume basis. Examples include the paint stewardship scheme in British Columbia and the plastic bag environmental levy in Ireland (although this mechanism also funds other environmental activities).
- Deposit return on packaging – a deposit is passed on to consumers at the retail point-of-sale on packaging items such as beverage containers. Consumers then return the packaging to redeem the deposit, either directly to the point-of-sale or indirectly to a separate collection facility. Unredeemed deposits can be used to fund the administration of the scheme (in part or in some cases in full), or a separate charge is raised against producers. Examples include container deposit legislation for used beverage containers in many countries and states around the world, in addition to a myriad of individual product/brand initiatives, such as pallets, bulker bags and other refillable containers.
- Levy benefit scheme – a levy is extracted from manufacturers on a per unit of production basis and used to fund the administration of the scheme and to fund resource recovery activities. Payments can be made on a graduated scale to priorities higher value recovery results, for example, direct recycling over energy generation as is the case for the proposed used tyre scheme in Australia. These schemes differ from the establishment of PROs in that they generally require close collaboration between government and industry.
- Development of support funds – industry makes voluntary contributions to a fund that can be used to develop better systems of resource recovery. Usually these funds are matched by government contributions, but may have very short sunset clauses and are sometimes seen as a stalling tactic to avoid higher costs of a mandatory EPR / PS scheme.

3.4 Operational Structures and Details

Operational issues for EPR / PS schemes are usually coordinated by an administrative organisation. These agencies undertake promotion and marketing; organise mechanisms for take back, collection and recycling; and support the development of in-house planning and continuous improvement. Other issues relate to the effectiveness of associated regulation as an impetus for industry change. Examples of different operational structures, activities undertaken and issues include:

- Establishment of an administrative organisation – this may be an 'official' Producer Responsibility Organisation (PRO), an adjunct to an industry association or a government department. For example the Rechargeable Battery Recycling Corporation (RBRC) was established by the Portable Rechargeable Battery Association (PRBA), and the Environment Fund in Ireland that is supported by the plastic bag levy and administered by the Department of the Environment, Heritage and Local Government. These organisations are responsible for issues including the controlling of financial expenditure, certification of recovered amounts and industry education

- Promotion and marketing – participation in some schemes is organised on the basis of product identification via a trademark, label or other certification scheme. For example the green dot in Germany. Not only does the use of this trademark need to be administered, but the 'meaning' and required consumer action needs to be promoted. Furthermore, some schemes like WEEE (Waste Electrical and Electronic Equipment) in Sweden, require the transfer of information from manufacturers to recyclers so as to assist the process of recycling.
- Take back and/or collection – some countries, for example Norway, have mandated that consumers can take back all WEEE products to distributors who sell similar products or to other municipal collection points for no charge.
- Recycling – the actual recycling of products or materials collected under EPR / PS schemers are not recycled by the managing organisations themselves, rather they are subcontracted out to recycling service providers. However, there are some initiatives like the German end-of-life vehicle take back system that require manufacturers to reuse parts and materials, in addition to using recycled content, wherever technically feasible and economic.
- Planning and in-house continuous improvement – some schemes rely on the individual actions of companies for success. For example the National Packaging Covenant in Australia requires signatories to the Covenant to prepare 'Action Plans' detailing their response to packaging issues such as light weighting, use of recycled content and recyclability.
- Regulatory pressure – some of the voluntary schemes with a regulatory underpinning are only effective when the associated regulator uses the powers provided to regulate free riders, for example the National Packaging Covenant in Australia. Without this action there is no imperative for action by those businesses that are driven solely by bottom line concerns.

3.5 Social Issues

Social issues related to the implementation of EPR / PS schemes relate primarily to changes in market place. For example, the need to re-examine attitudes towards 'used' goods, price increases associated with internalising environmental costs into product prices, spheres of responsibility that extend to a product's end-of-life and the more general issue of societal impact caused by the actions of free riders. Examples of these social issues include:

- Change in mindset toward 'used' products – much consumerism is predicated on the drive to own the latest and greatest technology. Used goods are regarded as substandard. This can reduce market uptake for reconditioned products making it difficult to establish EPR / PS schemes around product re-use.
- Increased cost of products – an EPR / PS scheme increases costs for manufacturers. As businesses expect to create a return on investment and have no other form of income than sale of product, any increase in costs are passed on to

the consumer who ultimately pays for the EPR / PS scheme. Some concerns have been raised with regard to increased costs in living for consumers, which could have the flow on impact of slowing economic growth. However the counter point to this argument is that any increase in cost is the removal of an artificial subsidy, previously provided through externalised environmental costs.

- Increased responsibilities for consumers – the implementation of various EPR / PS schemes has meant that consumers now have ongoing responsibilities related to product take-back than was previously the case. The consumer needs to understand the significance of 'eco' trademarks and behave accordingly.
- Free riders – those companies that do not participate in an EPR / PS scheme externalise the costs of end-of-life management onto competitors and broader society. Because they do not internalise any of the EPR / PS costs, they can arguably gain a commercial advantage by being 'artificially' cheaper. As a result demand for the 'wrong' types of products from irresponsible manufacturers can increase, willingness to participate in schemes from bona fide manufacturers decreases as a result of perceived commercial threats and the general effectiveness of EPR / PS schemes is undermined

3.6 Technical Issues

The technical challenges created by the implementation of EPR / PS schemes relate to the capacity of existing recovery infrastructure to handle increased volumes, the development of new resource recovery technologies to meet recovery requirements, the quality of recycled content and component reuse for incorporation into new product manufacture, and the ability for substitute materials to adequately replace those being phased out. Technical issues identified in operational EPR / PS schemes relate to:

- Capacity of existing recovery infrastructure – the implementation of EPR / PS schemes results in an increase in the volume of resources recovered from the waste stream. This can strain the capacity of existing collection and processing infrastructure and may require the development of new innovative infrastructure (with accompanying planning and zoning issues). For example under the green dot programme for packaging in Germany, many packaging materials were stockpiled or exported to other countries until infrastructure could be upgraded.
- Development of new resource recovery technologies – in order to achieve required resource recovery obligations, the development of new technologies is often required. For example, the increased volume of tyres collected through the Swedish EPR scheme has resulted in new processing and recycling technologies. Also the green dot programme for packaging in Germany, resulted in improved resource recovery technologies for plastics, including the BASF Pyrolysis Process, Hydrogenation in the Kohle-Öl-Anlage, Synthesis Gas Production Technology, and Plastics as a Reducing Agent in Steel Production.
- Quality of recycled content and component reuse – some EPR / PS schemes require the incorporation of recycled content and reusable components into new product manufacture. This can create technical challenges for production line

tooling, especially if the quality of recycled materials has not sufficiently progressed. One example is the quality of recycled plastics and suitability of application under the end-of-life vehicle scheme in Germany. Another issue for this scheme is ensuring the quality of used parts is appropriate to the model and the condition of the vehicle.

» Substitute materials – materials phase out, such as that required by the European Union's Restriction of Hazardous Substances Directive, forces producers to look for substitute materials. In the case of lead solder, this presents a number of technical challenges related to product reliability, component compatibility, energy use, and cost.

3.7 Participation and Outcomes

Participation in EPR / PS schemes, although undermined by the presence of free riders, has been shown to increase the resource recovery rates of targeted products and materials. Other beneficial outcomes include a reduction in associated litter and improved design and process engineering in product manufacture. Specific issues related to participation in EPR / PS schemes and how this affects outcomes include:

» Non-participation of free riders – as has already been highlighted, EPR / PS schemes are not well suited for industries where it is easy for a large number of players to avoid participation (free ride on the efforts of others). Without regulation, or the threat of regulation, as a mechanism to ensure participation, EPR / PS schemes are easily undermined and lose their effectiveness.

» Increased resource recovery rates – the implementation of EPR / PS schemes has been shown to dramatically increase recycling rates. For example, in the UK recycling increased, from 30 per cent in 1997 to 42 per cent in 2000, following the introduction of EPR for Packaging Waste. Other increases relate to paint recycling and reuse in British Columbia, mobile phone handsets in Australia, rechargeable batteries in the United States and Canada, and waste electronic and electrical equipment in Norway, where the EU requirement was exceeded. However, as noted in the preceding technical challenges, greater than anticipated participation presents its own set of challenges that must be proactively managed.

» Reduction in litter rates – the introduction of a deposit or levy on the purchase of products or packaging that was previously perceived to be free has an associated impact on the litter associated with that product or packaging. For example Ireland has reported a reduction in plastic bag litter from 5 per cent down to 0.22 per cent since the introduction of a 15 euro-cent environmental levy on plastic bags.

» Improved design and production – schemes that incorporate elements of design for environment and cleaner production, in addition to end-of-life management issues, can reduce the amount of materials, energy, water and waste in the production process. For example, through individual company Action Plans, the Australian National Packaging Covenant has improved light weighting of packaging and in some cases reduced the volume of packaging for products.

3.8 Relationship of Schemes to Design Intent

The importance of product design to optimising the value recovered at a product's end-of-life was highlighted in the Stage 1 report - "Discussion Paper on the Theoretical Concepts and Potential Surrounding Extended Producer Responsibility and Product Stewardship". The need for greater integration of design intent with resource recovery was identified. Examples of this direct link with design intent include:

» Design to reduce hazardous materials – some EPR / PS schemes, for example the EU Directive on the Restriction of Hazardous Substances (RoHS), call for phasing out or limiting the use of certain materials. The RoHS Directive is already influencing the design of electrical and electronic products as alternatives to lead and brominated flame retardants must be found.

» Design for disassembly - other key roles for product redesign in electrical and electronic equipment (other than the removal of toxic constituents like brominated flame retardants) includes labelling plastic use and manufacture that facilitates end-of-life disassembly (Fishbein 2002).

» Design to dematerialise (lightweighting) – EPR / PS can encourage designers to use less materials ('dematerialise') in the manufacture of products and/or packaging, while achieving the same performance. Examples in packaging include the German green dot program and the National Packaging Covenant in Australia.

» Design for durability – EPR / PS schemes that incorporate the reuse of components into new products, such as the end-of-life vehicle scheme in Germany, encourages designers to consider durability aspects of products and components.

» Design for recycling – targets for increased resource recovery, especially in packaging related EPR / PS schemes provides an incentive to ensure that packaging (and in some cases products) are recyclable. Part of design for recycling also includes reducing the different types and grades of materials used in manufacture. For example, as part of the end-of-life vehicle scheme in Germany, Ford has reduced its use of types of nylon from 150 different grades to 20 and aims to reduce this number further.

3.9 Impacts on Kerbside

EPR / PS schemes have the potential to reduce the amount of recyclable material going to disposal via kerbside collected Municipal Solid Waste (MSW). As has been noted previously, EPR / PS schemes have the impact of increasing the amount of resources recovered from the waste stream. Those schemes targeted toward domestic packaging are designed to reduce the amount of dry recyclables that end up in the residual MSW stream.

Other schemes that address domestic products, such as electrical and electronic equipment, mobile phones, rechargeable batteries and paint can also reduce the occurrence of these items in the kerbside waste stream. Those EPR / PS schemes that target products such as end-of-life vehicles and used tyres have no influence on the composition of residual kerbside waste as these items do not normally report to this waste stream.

4. Review of New and or Emerging Schemes/Approaches

There are a number of new or emerging EPR / PS schemes which act to deal with additional product types and expand jurisdictional coverage as regulators continuously improve to meet world's best practice. A summary of these is shown in Table 4-1.

Table 4-1 Summary of new and or emerging EPR / PS schemes / approaches

Product	Details
Used tyres	Product stewardship scheme (Australia) for used tyres. In August 2002 a tyre producer group called the 'Joint Working Group on Tyres (JWGT) approached the Australian Commonwealth Department of Environment and Heritage (DEH) with a proposal to develop an industry-run Product Stewardship scheme for end-of-life used tyres. The Environment Ministers agreed that national action was required on end-of-life tyres. In 2005 a consultant was contracted by the Australian Tyre Manufacturers Association (ATMA) and the Australian Tyre Importers Group (ATIG) to carry out a financial and economic analysis of a national used tyre product stewardship scheme, looking at the option to implement a national industry-led scheme involving an Advanced Recycling Fee. A Draft Product Stewardship Plan is expected to be presented at the June 2006 Environmental Protection and Heritage Council meeting. Source: EPHC (26 October 2005) Communique: Council Tackles Environmental Costs of Modern Living [online] available: http://www.ephc.gov.au/pdf/EPHC/FINAL_Comm_26_Oct_05.pdf (The full report is available at http://www.atma.org.au/Position%20Papers.htm). In response to the EU Landfill Directive (which will ban the landfilling of virtually all tyres from July 2006), the UK implemented voluntary EPR scheme for used tyres.
Paper and printing products	In New South Wales, Australia, Printing Industries is working with industry stakeholders to create a self-managed EPR system for the printing industry. Progress has already been made with proposals to establish a producer responsibility organisation. A draft operational budget has been prepared and circulated to the stakeholders. Recruitment is also underway for a Chief Executive Officer to head the proposed producer responsibility organisation.[1] A draft product stewardship concept to be prepared and submitted to the NSW Government by March 2006; and a detailed product stewardship plan to be prepared and presented to the NSW Government by October 2006
Electrical and Electronic Equipment (EEE)	In the United States, California recently enacted a fee on cathode ray tubes to pay for e-waste recycling. Also, more recently, manufacturers of TVs and computer monitors whose products are sold in Maine must now pay for the recycling of these items at the end of their life cycle. The portion of Maine's e-waste law requiring this took effect on January 18, 2006.

[1] Printing Industries works toward EPR, Printer Magazines December, 23 2005 [online] accessed 9/2/06, [URL: http://www.i-grafix.com/australian_printer/news.php/Printing+Industries+works+toward+EPR/3206]

Product	Details
	Other countries have also recently or are currently introducing EPR type legislation to deal with waste electrical and electronic equipment, particularly throughout Europe. Refer to the case studies in Appendix A for more details.
Disposable nappies	One possible area for future EPR or PS is for disposable nappies. Although no formal scheme is in place that makes producers responsible for the collection and or disposal / recycling of nappies, there are new technologies that are making recycling and collection of disposable nappies (and hence EPR or PS) feasible on a large scale. For example, MyPlanet Recycling in Melbourne, Australia separates nappies into their raw material components and allows the wood pulp and plastic to be recycled (plastics into products including park benches and bollards and wood pulp to make paper and cardboard products). The technology is also used in a plant in the Netherlands that has recycled nappy waste from around Europe since 1999.[2]
Hazardous substances	The EU Directive for 'Restriction of Hazardous Substances' and the closely related Directive on 'Waste Electrical and Electronic Equipment' are some of the more recent EPR / PS initiatives. These Directives are currently being transposed into law in the EU's member states in various forms. Refer to the case studies in Appendix A for more details.

4.1 Co-regulatory Approach to Product Stewardship in Australia

Australia is currently developing a nationally consistent approach to product stewardship. The proposed approach is co-regulatory, which involves some form of government regulatory action in support of specific industry product stewardship schemes. In other words, co-regulation is a combination of industry self-regulation and government regulation. This approach is well supported by industry in Australia.

In December 2004, a discussion paper titled *"Co-regulatory Frameworks for Product Stewardship"* was released for consultation to seek feedback on the proposed approach, and in particular using a National Environment Protection Measure (NEPM) for consistency nationally.

The NEPM was initiated in July 2005 which upon finalisation is expected to include "a generic framework that establishes guidelines and principles to be applied by governments in determining the merits of a co-regulatory approach for a particular sector, and guides the development of product stewardship agreements for particular sectors. The NEPM will also include schedules relating to sector-specific product stewardship agreements setting out the requirements for non-participants captured under the regulatory safety net for a particular sector. Sector-specific schedules under consideration for initial incorporation in the NEPM include, but may not be limited to, televisions and tyres."[3]

[2] MyPlanet website [online] accessed 9/2/06, [URL: http://www.myplanet.com.au/AboutMyPlanet/]

[3] Product Stewardship NEPM [online] available: http://www.ephc.gov.au/nepms/product_stewardship/product_stewardship.htm#CoRegFrameWk_Industry

The co-regulatory approach would provide a significant amount of flexibility in determining how a particular industry scheme would operate, however 'Guiding Principles' would be used to steer development. It is recognised that co-regulation would not be suitable for every industry type / sector. Threshold criteria have also been proposed to detail when a co-regulatory approach is appropriate.

The framework proposed includes:

- A voluntary 'Product Stewardship Agreement' negotiated and signed by industry association and / or individual producers in an identified sector and governments; and
- A 'Regulatory Safety Net' comprising laws that would be implemented either through State, Territory and / or Commonwealth legislation.

Figure 4-1 shows how this might work in practice for televisions. This is illustrative only, but gives an indication of what elements can be considered and how safety net components interrelate.

This co-regulatory approach to EPR / PS will drive future EPR / PS schemes in Australia.

Television (TV) Case Study

Implications for companies:

Voluntary	Product Lifecycle	Regulated Non-Participants
Company pays fee to Producer Responsibility Organisation (PRO), including cost per unit fee for collection and reprocessing based on number of TVs produced/imported. The PRO also uses the levy for management, public awareness and reporting.	**Costs**	Company pays administrative fee to regulator for costs of oversight of scheme plus all costs of meeting mandated obligations under safety net.
Based on PRO feedback and working on agreed outcomes in the Product Stewardship Agreement, individual companies (domestic and imported) improve TV design eg for easier disassembly and recycling, using less materials, less toxic substance (lead, cadmium, mercury).	**Design**	Individual company (manufacturer or importers) required to produce a plan for approval indicating how it will improve TV design to meet the same agreed outcomes as Voluntary Agreement, eg more recyclable, fewer toxic substances.
For each TV produced or imported, the company pays a levy to the PRO. Each company must also collect and supply data to the PRO for reporting purposes.	**Manufacture**	Company must organise contracts for transport, collection, processing and disposal of the equivalent percentage of their annual TV production. It must also pay its share of recovering historic and orphaned TVs (calculated on market share). Company must also collect annual data and submit this to the regulator.
At point of sale, PRO responsible for ensuring consumer is provided with information about what to do with TV at end-of-life and that collection is free. Levy cost passed on to consumer; docket may itemise levy amount.	**Retail**	At point of sale, company is responsible for ensuring consumer is provided with information about what to do with TV at end-of-life. Additional costs incurred by company would be passed on to purchaser.
PRO is responsible for raising awareness about members product stewardship including where to take TVs at end-of-life.	**Use**	Company is responsible for raising awareness of their specific scheme including where to take TVs at end-of-life.
PRO is responsible for ensuring a collection network is established and achieving the negotiated targets. In practice, the end-user will take the TV to a transfer station or other nearby collection site, where it is accepted free of charge.	**Collection**	Company is responsible for ensuring a collection service/network is established and maintained to collect TVs from wherever they are sold and for achieving equivalent recovery targets as the Voluntary Agreement, including a share of historic and orphaned products.
PRO is responsible for ensuring all collected TVs are processed and that best practice recycling and targets are achieved. In practice, the PRO will negotiate national or regional contracts with qualified recyclers. The PRO will be responsible for auditing, verifying and reporting the results.	**Processing**	Company is responsible for ensuring all collected TVs are processed and that recycling targets are achieved. In practice, this will mean contracting a recycler to undertake the processing according to best practice. The company would also be responsible for auditing, verifying and reporting the results.
PRO is responsible for safe disposal of residual materials. In practice, the contracted recycler would be obliged to follow best practice, with the PRO responsible for auditing and reporting.	**Disposal**	Company is responsible for safe disposal of residual materials. In practice, the contracted recycler would be obliged to follow best practice, with the company responsible for the cost of auditing and reporting.

Figure 4-1 Example case study of co-regulatory approach to EPR / PS[4]

[4] EPHC (December 2004) *Industry Discussion Paper on Co-regulatory Frameworks for Product Stewardship* [online] available: http://www.ephc.gov.au/pdf/product_stewardship/ProductStewardship_IndustryDP.pdf

5. Review of Embodied vs Inherent Energy Recovery Issues

Embodied energy refers to the amount of energy required to transform raw materials into final products during the pre-consumer stages of a product's life cycle, whereas inherent energy (or calorific value) refers to energy released during combustion. In general most materials have a higher embodied energy than calorific value, meaning that a wholesale approach of energy recovery will not recover the maximum value possible as the embodied energy 'invested' within materials and products is lost.

However, it is equally true that any disposal technology gives a zero value return (embodied or calorific). The following sections provide further detail on issues related to the recovery of embodied and inherent energy and presents the goal of maximising material use within given market conditions as a means of recovering highest resource value. This approach highlights the need for designers to avoid materials that could disrupt the clean and efficient operation of an energy recovery technology.

5.1 Defining Inherent and Embodied Energy

Inherent energy refers to the amount of energy released during the combustion of a fuel. Known also as the heating value or calorific value of a material, inherent energy is measured in units of energy per amount of material (for example, giga-joules per tonne (GJ/t)).

Many working references to heating energy are presented on an as received basis. This measurement accounts for the moisture content of a fuel material and discounts the energy used to 'drive' this moisture from the fuel (latent heat of water vaporisation). For example the bone-dry calorific value of timber is in the order of 21 GJ/t, while the as received calorific value of newly harvested sawlogs is in the order of 13 GJ/t because of the much higher water content in recently harvested logs.

Embodied energy is contrasted against inherent energy as an alternative approach to measuring energy content. Embodied energy is a measure of the amount of energy used to transform raw materials into a final product or material. At a minimum this includes life cycle stages of extraction, processing and refining for commodity materials, and additional elements of transport, manufacturing and assembly for products. Care must be taken to ensure that gross energy inputs are calculated, as compared to net usage, for example measuring electricity usage needs to account for the source energy input and the inefficiency of electricity generation, in addition to distribution losses.

Embodied energy is also measured in terms of units of energy per amount of material or product, for example mega-joules per kilogram (MJ/kg). In a similar contrast between gross and net calorific value, there are two approaches to measuring embodied energy based on different system boundaries. Gross energy requirement (GER) aspires to measure all of the lifecycle energy load for a given material or product, including extraction, processing, assembly, transportation and contributing infrastructure, including roads, energy and water supply and factories. This is what would be calculated during a detailed life cycle assessment. However, there are many practical restrictions to calculating the GER of a given material owing to the multitude of minute energy calculations that must be performed (Reardon 2005).

A simpler form of measuring embodied energy is Process Energy Requirement (PER), which is the amount of energy directly used to manufacture a material or product. This would include transportation of raw materials and component parts to the factory for final manufacture/assembly, but excludes transport to the wholesaler or retailer.

It has been suggested that PER can account for anywhere between 50 and 80 per cent of GER and can vary between manufacturers, making a single PER estimate for materials or products difficult. This variability is caused by differences in manufacturing efficiency, energy sources in manufacturing process, transportation distances for material and product inputs and the amount of recycled content (which has a lower embodied energy that virgin resources). Data on embodied energy tends to refer to PER owing to the problematic nature of calculating GER.

5.2 Comparing Inherent and Embodied Energy of Common Waste Materials

The table below presents estimates of embodied energy for common material types that are found in residual waste streams and contrasts these against estimates of net calorific value. These data show that embodied energy is always higher than calorific value, from anywhere from double to nine times the difference. The one exception being timber products, which have a calorific value higher than the embodied energy content, much of which has been received as a ‘free’ eco-system service from the use of photosynthesis to create cellulose, hemi-cellulose and lignin.

Table 5-1 Comparison of Inherent Energy and Embodied Energy (see Appendix C for references)

Material Type	Embodied Energy (MJ/kg)	Calorific Value (Inherent energy) MJ/kg
Paper	36	15-19
Recycled Paper	23	15-19
Food – Unprocessed plant	2.3	6.6
Food – Processed	27	6.6
Garden Organics	0.5	8.5
Hardwood/Softwood	3	15-17
Engineered Timber	10	15-17
Cotton	143	13.5

Material Type	Embodied Energy (MJ/kg)	Calorific Value (Inherent energy) MJ/kg
Synthetic Rubber	110	28.5-35
General Plastic	90	29-40
Polyvinyl Chloride (PVC)	70	22.5
Recycled Plastic	36	29-40
Coal (for comparison)	27.5	1

5.3 Recovering Highest Resource Value – Calorific or Embodied?

The report from Stage 1 "Discussion Paper on the Theoretical Concepts and Potential Surrounding Extended Producer Responsibility and Product Stewardship" identified that there are a number of recovery options for a given material, highlighting the importance of choosing the 'best' option to recover the highest resource value of that material.

The issue when choosing between recycling (recovery of embodied energy) and energy recovery (heat energy) is that calorific value is often only a fraction of the energy embodied within a material or product. For example, plastics have a calorific value, which is approximately one third the value of the embodied energy within virgin plastic, which could suggest that all plastics should be recycled.

However, one major difficulty is that products often comprise a multitude of material types. For example, end-of-life vehicles (ELVs) are composed of a raft of components including a variety of plastics, metals, fabrics / textiles and rubbers. It is complicated to work out the total calorific or embodied energy content of a vehicle, blurring the ability to clearly decide on an embodied energy basis. Metals are not readily suitable for energy recovery and are particularly amenable to material recycling, while used tyres (rubber) have been used as an energy source for cement kilns and heating plants. Nevertheless, even here there are other recycling options.

For instance, Svensk Däckåtervinning AB, the Swedish Tyre Recycling Organisation, gives a number of possible uses for used tyres including retreading, shredding for use as a construction material in noise-reduction barriers and embankments, blasting mats and crash barriers at race tracks. Other potential uses include rubber granulate and asphalt as a low-noise road surface, and recovered rubber for insulation, floor coverings, foundations for traffic signals.

Another difficulty with a total embodied energy approach is that all material types are not infinitely recyclable. For example, the molecular structure of plastics will continually degrade throughout repeated cycles of heating and extrusions, requiring the addition of virgin resin. Also materials such as paper will rapidly reduce in quality each time they pass through the size reduction processes that accompany recycling, again requiring the addition of virgin feedstock and creating a by-product of non-recyclable paper fibre.

Furthermore, consider composite materials such as composite plastic/aluminium foils (commonly used as potato chip wrappers) and plastic/paper/aluminium board (commonly used in to package fruit juice). These types of materials may require large amounts of energy and water to wash and prepare for recycling, more so than is required for virgin production. Here the choice between embodied energy and calorific is not so clear cut, especially if greater energy is required for recycling than virgin production.

This suggests that energy recovery may be preferred for materials where more energy is required to recycle than manufacture from virgin resources, especially for those materials with low embodied energy in the first instance. This thinking recommends that all wood products should be directed toward energy recovery, as wood has a low embodied energy and requires significant processing to be recycled into a composite product like particleboard.

However, this reasoning ignores the fact that energy conversion is a one-way path that loses out on 'embodied material'[5] and 'embodied water'[6] investments. Therefore, calorific value and embodied energy cannot be the sole basis for determining the desired recovery fate of a material or product. Rather other defining principles need to be applied, for example, Net Present Highest Resource Value as defined in the Stage 1 Report for this Task.

5.4 Maximising Material Uses within Given Market Conditions

Conversion of a material or product to energy is an irreversible process and is not to be undertaken lightly. At the same time, it is of limited value to be continuously waiting for a new or novel approach and taking no action to recover energy, especially when the alternative of disposal provides a zero value return. Also, given that it is physically impossible for some material types to be infinitely recycled, and the increasing trend for lightweight composite convenience packaging, it is suggested that the recovery of calorific energy from waste will always be a feature of an integrated and sustainable resource recovery system.

However, resource recovery technologies and infrastructure should be geared towards maximising the material use of recovered resources within given market conditions. This provides the greatest return on embodied energy, water and materials. This may be assisted by calculating the embodied energy recovery associated with material recycling and developing a mechanism to financially reward this form of 'recovered

[5] Embodied materials refers to measuring the cumulative physical material resources that are used to manufacture final products. For example, roughly one third of a harvested saw log is converted into a timber product, which means that there are roughly three tonnes of embodied materials for one tonne of timber product. Another example is aluminium which requires four tonnes of bauxite to make the two tonnes of alumina that are then converted into one tonne of aluminium – an embodied materials of at least four tonnes.

[6] Embodied water is a similar cumulative measurement of the amount of water used to manufacture a given product. For example, savewater.com estimate that one tonne of aluminium production has 1,340 tonnes of embodied water and one tonne of rice production has 5,000 tonnes of embodied water.

energy'. One starting point could be valuing the avoided carbon emissions brought about by recovering embodied energy. Under this approach, the purpose of calorific energy recovery is to act as a broad 'filter' ensuring that value is not lost to disposal technologies. The embodied energy implications for the value chain presented in the Stage 1 report are mapped onto Figure 5-1below.

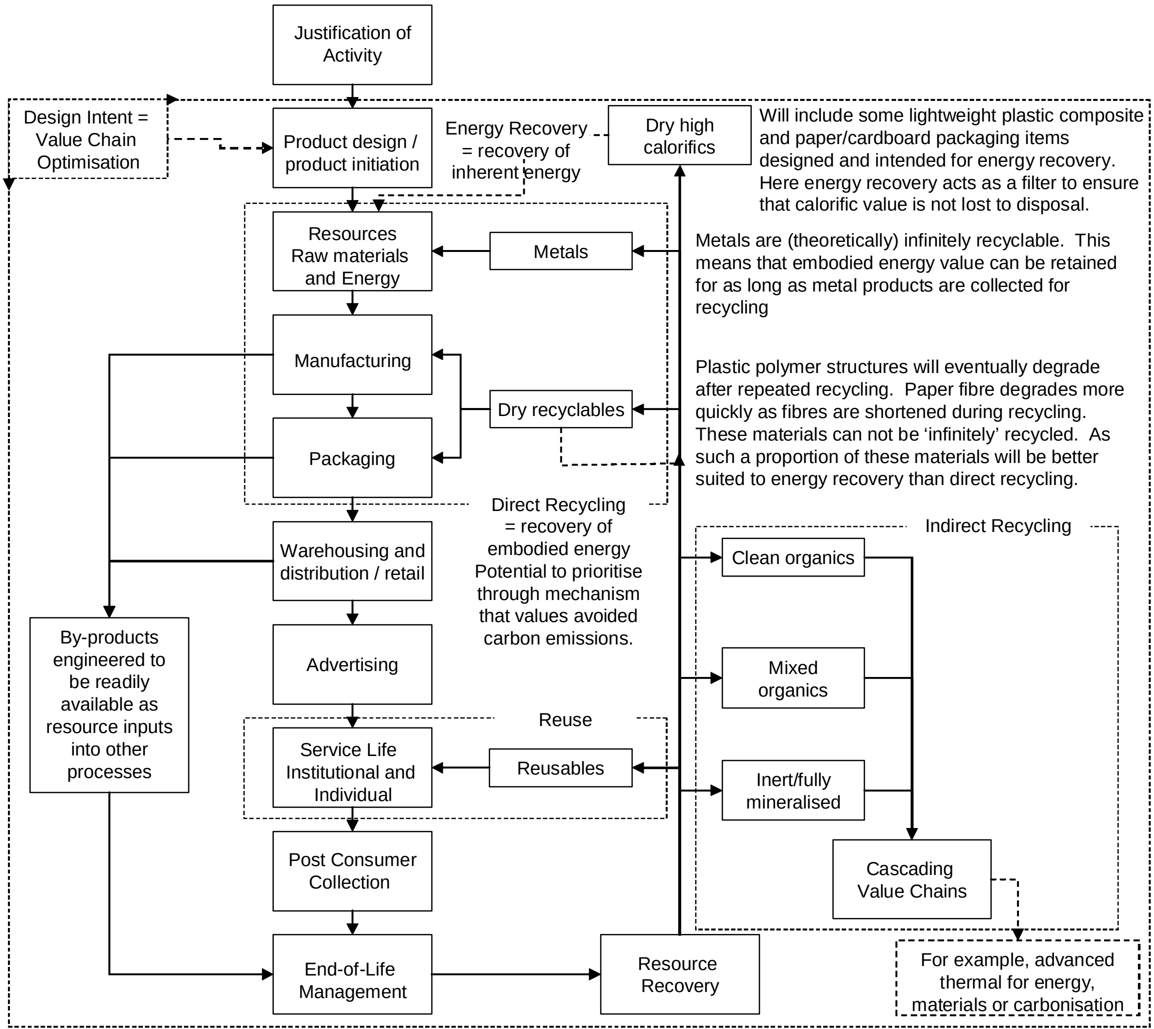

Figure 5-1 Embodied energy considerations in value chain optimisation

The composition and volumes of materials for calorific energy recovery will depend on given market conditions, materials used in product manufacture and the prevalence of non-recyclable convenience packaging within the economy. (This is a similar conclusion to that of the Energy from Waste Sustainability Guide discussed in the Stage 1 Report).

The integration of design intent with end-of-life resource recovery is all the more important as a means of removing hazardous materials that could disrupt the clean and efficient operation of energy recovery technologies, both for embodied and calorific energy.

6. Changing Composition of Urban Residual Waste

Over the past century there have been many changes in the composition of urban residual waste. These relate primarily to the substitution of coal as the primary energy source for home heating, emergence of new packaging materials and a convenience mentality, technology advances giving rise to a wide range of electrical and electronic equipment, and also to the establishment of China as a global manufacturer of cheap consumables.

The likely impact of EPR / PS schemes on urban residual waste will be to decrease the amounts of 'icon' products and hazardous materials in the waste stream. Looking to the future the residual waste stream will be dominated by plastic and paper/cardboard items, predominately related to disposable products and to lightweight convenience packaging.

The potential to integrate design and resource recovery infrastructure, however, means that a theoretical 'total resource recovery' could be achieved within major metropolitan centres, through the provision of anaerobic recovery for food and other putrescible items, energy recovery with a pre-sort for metals, and processing of inert fully mineralised residuals to be used in civil works like roads and construction. Further details on these trends and future opportunities are provided in the sections below.

6.1 Substitution of Coal for Domestic Heating

The composition of urban residual waste one century ago was dominated in many countries by coal ash, coal being used as the primary heat source for households. For example, in the UK over 60 per cent of the waste was ash from coal heating in 1905, compared to almost zero today (ICE 2006).

Volumes of waste generated per capita were also much lower one hundred years ago. Using the UK as an example again, and removing coal ash, the per capita waste generation rate was 70 kilograms per annum. This compares to the current per capita rate of 585 kilograms, an increase of over 800 per cent (ICE 2006).

Obvious changes in residue composition have occurred as a result of the technology transition from direct coal fired heating to town gas and electricity. However, there have been many new material types that have been introduced to the market place since 1905. This, in combination with a focus on convenience packaging and increased consumerism has dramatically changed the volumes of urban residual waste and the composition of these residual materials.

6.2 New Materials and Convenience Packaging

At the start of the twentieth century the majority of packaging was in the form of paper/cardboard, steel tins/cans and glass. Even as late as 1947 the majority of beverages sold were in refillable heavyweight glass bottles (ILSR 2002). However, there were many changes occurring in the composition of consumers take home shopping baskets. Some of these changes included:

- Bakelite, originally used for electrical and mechanical parts, finally coming into widespread use in consumer goods in the 1920s (Wikipedia 2006a).
- The Kleenex facial tissue is introduced in 1924 (ASTC 1998).
- Aluminium foil is invented in 1929 (ASTC 1998).
- Polyester and cotton ‘wash and wear clothing introduced 1951(FiberSource undated).
- Pourable spout milk carton introduced mid 1950s (Planet Ark undated).
- Polystyrene foam cups introduced in 1960 (ASTC 1998).
- Aluminium cans production started 1963 (AZoM 2002).
- Commercialisation of disposable batteries (Duracell formed in 1964) (Wikipedia 2006b).
- PET bottle introduced in 1973 (ASTC 1998).
- Disposable shaver and cigarette lighter and Rubik's Cube introduced in 1975 (Finkelstein 2005).
- Composite tetra pak introduced comprising paper, polyethylene and aluminium foil in 1980 (Saporito undated).
- Use of polypropylene for butter and margarine tubs 1980 (ASTC 1998).

The concept of a 'throwaway society' is not new. It was first coined in the US in 1955 in response to run away consumerism (US EPA 2006). Arguably, with the establishment of ‘mega’ shopping malls in the eighties, increasing availability of cheap DIY products for home renovations and furniture and the increase uptake of speciality items like coffee and boutique drinks, this run-away consumer train has not slowed.

If anything it has sped up, especially given the establishment of ‘convenience packaging’, those single serve food portions, firmly established as part of the Western consumer lifestyle. As a result of increased consumption and packaging per unit of food, waste generated in the urban context is dominated by packaging. However, recent technology advances and decreased costs of manufacture has created an entirely new range of ‘disposable’ technology.

6.3 Technology Advances in Electrical and Electronic Equipment

The last twenty years has seen a dramatic uptake in electrical and electronic equipment across OECD countries, particularly with mobile phones and personal computers. Since the establishment of mobile telephone networks in the eighties, there is now almost one mobile phone for every person in much of the developed world (The Economist 2005).

The sale of computers for personal home use was also established in the eighties. Now more than 50 per cent of households have access to home computers and internet in many OECD countries (OECD undated).

Alongside these technology developments, China has been firmly established as the major manufacturer for the globe. As a result electronic and electrical equipment have been drastically reduced in price, almost to the point where power tools are cheap enough to be considered disposable.[7] It is also arguable that advances in miniaturisation in technologies like computers and mobile phones have been offset by increased consumption.

These trends have resulted in greater consumption of electrical and electronic equipment, with an associated increase of these products in residual waste streams. This increase, in combination with the materials used in manufacture, is the reason behind the development of EPR / PS schemes for waste electrical and electronic scrap.

6.4 Likely Impact of EPR / PS Schemes on Residual Urban Waste in OECD Countries

Before discussing the impact that EPR / PS schemes have had on the composition of residual urban waste in OECD countries, it is necessary to acknowledge that the uptake of new collection services and recovery technologies has also had a significant impact on composition. For example, the introduction of the first bottle bill in Oregon US in 1971 removed significant amounts of beverage containers from residual waste (ASTC 1998).

The establishment of kerbside recycling services in the late eighties and early nineties removed greater amounts of recyclable packaging from residual waste – the so called 'dry recyclable fraction of the waste stream. Additional services like a separate green waste collection have removed much of the moist lignocellulosic fraction, with new food waste services, in combination with anaerobic styles of processing technology, providing the potential to remove more of the organic material in residual waste.

The assessment in Section 3 identified that EPR / PS schemes are best suited to products and industries with clearly defined participants and readily identifiable products. For example , mobile phones, electrical and electronic equipment, office paper, plastic bags, and rechargeable batteries.

It is a reasonable assumption that the future composition of residual waste will comprise those materials that are not covered by EPR / PS schemes and are not collected in a separate collection service to households. The types of materials likely to be in future urban residual waste include:

» Composite light weight convenience packaging;

» Disposable cleaning products e.g. paper towels, sponges and cleaning cloths;

» Clothing and textiles – cheap to buy undermines 'opportunity shop' resale and makes it easy to discard;

» Food – not all municipalities will offer food collection services;

» Garden waste – similarly not all municipalities will offer garden waste collection services;

[7] For example, many cordless power drills are available for $30 in Australia (Choice 2005).

- Shoes – many with synthetic soles and leather uppers;
- Disposable personal hygiene e.g. tissues, sanitary, hair brush, tooth brush, nail brush, combs etc;
- Nappies;
- Small DIY renovation materials;
- Self assemble furniture;
- Kids toys; and
- Sporting goods.

Given this mixture of materials, one likely outcome for urban residual waste is the composition outlined in the table below. (A summary diagram, showing the changes in residual waste composition and related events and trends, is presented overleaf.)

Table 6-1 Potential future composition of urban wastes

Component	**OECD Average (2005)**	**Future (c. 2015)**
Paper and board	40%	17%
Glass	6%	5%
Ferrous Metals	6%	4%
Aluminum	1%	2%
Other Non-Ferrous	1%	0%
Plastic	10%	25%
Rubber and Leather	4%	7%
Textiles	5%	8%
Wood	9%	8%
Food Waste	13%	8%
Garden Waste	3%	12%
Other	3%	3%
Total	**100%**	**100%**

Waste Composition

UK 1935

Component	Percentage
Ash/dust	57%
Vegetable/Bone	14%
Paper and Rag	16%
Metal and Glass	7%
Plastic	0%
Miscellaneous	6%
Total	**100%**

source: ICE 2006

UK 1955

Component	Percentage
Coal ash	43%
Paper/card and rags	6%
Metals	4%
Glass	3%
Food Waste	5%
Plastics	0%
Garden Waste	9%
Other	31%
Total	**100%**

source: ICE 2006

US 1975

Component	Percentage
Paper and Board	41%
Metal	13%
Glass	15%
Food Waste	26%
Plastics	5%
Total	**100%**

source: Alter 1989

USA 1995

Component	Percentage
Paper and board	32%
Glass	6%
Ferrous Metals	5%
Aluminum	1%
Other Non-Ferrous	0%
Plastic	12%
Rubber and Leather	4%
Textiles	4%
Wood	9%
Food Waste	9%
Garden Waste	14%
Misc Inorganic	2%
Other	2%
Total	**100%**

source: Franklin Associates 1997

Future

Component	Percentage
Paper and board	17%
Glass	5%
Ferrous Metals	4%
Aluminum	2%
Other Non-Ferrous	0%
Plastic	25%
Rubber and Leather	7%
Textiles	8%
Wood	8%
Food Waste	8%
Garden Waste	12%
Other	3%
Total	**100%**

source: Estimates based on this analysis

Trends

Focus on improving technology of landfill to reduce emissions to air, water and ground

Convenience packaging firmly established as part of consumer lifestyle

Increasing availability of cheap DIY products for home renovations and furniture – also increase of speciality items like coffee and boutique drinks

China established as major manufacturer for the globe – electronic and electrical equipment drastically reduced in price – emergence of the 'disposable' power drill – arguable advances in miniaturisation offset by increased consumption

Changing over from coal fired heating to town gas

Coining of phrase 'throwaway society' in 1955 in response to run away consumerism in the USA

Establishment of mobile telephone networks, personal computers for home use and 'mega' shopping malls in 1980s

More than 50% access to home computers and internet in many OECD countries

Time

<1930s – 1940s – 1950s – 1960s – 1970s – 1980s – 1990s – present – 2020-30s

Events affecting waste composition and resource recovery

- Demand for food in steel cans grows in response to developments in WWI
- Commercialisation of Bakelite (plastic) in consumer products
- Introduction of the Kleenex facial tissue
- Invention of Aluminium Foil
- 100% refillable heavyweight glass bottles
- Polyester and cotton 'wash and wear clothing introduced
- Pourable spout milk carton introduced
- Development of hydraulic powered compactor garbage trucks with ejection ram to aid efficient waste collection
- Introduction of polystyrene foam cups
- Aluminium cans introduced
- Commercialisation of disposable batteries
- Introduction of first bottle bill in Oregon US
- PET bottle introduced
- Products like the disposable shaver, cigarette lighter and Rubik's Cube introduced
- Composite tetra pak introduced comprising paper, polyethylene and aluminium foil
- Use of polypropylene for butter and margarine tubs
- Kerbside dry-recycling services start to be established
- Garden organic collection services introduced
- Introduction of food waste collection services
- One mobile phone per person in OECD

Materials unlikely to be covered by a future EPR / PS scheme

- Clothing and textiles – cheap to throw away
- Food
- Garden waste
- Shoes (synthetic and leather uppers)
- Composite light weight convenience packaging
- Disposable personal hygiene eg. tissues, sanitary, hair brush, tooth brush, nail brush, combs etc
- Nappies
- Small DIY renovation materials
- Self assemble furniture
- Kids toys
- Sporting goods
- Disposable cleaning products eg. paper towels, sponges and cleaning cloths

The historic urban residuals data shown above, and in Appendix D was collated through extensive Internet and database searches, and consultation with international contacts on the IEA Bioenergy Task 36 Energy from Integrated Solid Waste Management Systems committee. The Task 36 committee comprises representatives from the UK, Sweden, France, Australia, Canada, Finland, Japan and Norway. However little useful data was available.

It should be noted that the method for categorising waste and residuals streams seemed to vary considerably from country to country and from year to year even within individual countries. This and the fact that there have been other significant influences on waste and residuals composition, some concurrent to EPR / PS, means that it is not possible to attribute any observed changes in the characteristics of the waste / residuals streams to EPR alone or individual EPR / PS efforts.

6.5 Future Trends and Opportunities for Residual Urban Resource Recovery

The changing composition of residual urban waste, brought about by the joint influence of household recycling collection services and EPR / PS schemes has a number of implications for resource recovery technologies like Energy from Waste that rely on the quantity and quality of residual waste for their operation. The following trends and their likely impact have been identified:

» Continued increase in convenience packaging – the rage of light weight foils, films and foams used increasingly to deliver ready-to-eat food items is likely to continue to increase as this is one opportunity for product differentiation and 'value' add for manufacturers – and there is a trend towards increased take away food and less food preparation at home. Heavier packaging materials like containers and cartons are likely to be recovered through a combination of EPR / PS initiatives and household recycling collection services, thus recovering a greater amount of embodied energy. Thus there is likely to be a proportional increase in the amount of dry high calorific materials in residual waste.

» Continued increase in plastics consumption – increased consumption of disposable/short life personal hygiene products like combs and hair, tooth and nail brushes, in addition to cleaning sponges and wipes, and kids toys will increase the amounts of plastics in urban residual waste. The wide variety of plastic types, in addition to their composite nature in manufacture will restrict direct recycling opportunities.

» Removal of hazardous materials – the EU Directive on the Restriction of Hazardous Substances is likely to widen in scope across other OECD countries and will act to force out materials from the economy that could be problematic for technologies like Energy from Waste to manage. Overall this will improve the overall quality of residual urban waste.

» Removal of waste electrical and electronic equipment – EPR / PS schemes to address the wide range of electrical and electronic equipment being consumed will start to remove occurrences of these materials in the residual waste stream. Associated programs should also work to remove batteries.

The implications from a planning perspective for Energy from Waste is that residual urban waste will contain a higher quantity of materials that are suited to energy recovery and have a greater quality due to the removal of problematic component materials. The composition of residual urban waste is likely to be more than 50% renewable (from biomass sources such as paper fibre, cotton, wood and garden organics). This suggests a greater role for energy recovery in the overall provision of resource recovery services and that more than half of this energy source will be considered 'renewable biomass based energy'.

The principles of value chain optimisation suggest that product designers and initiators need to cooperate with resource recovery service providers to ensure that a network of Energy from Waste facilities is available to manage those packaging materials and disposable/short life products unable to be readily recycled. From a design perspective, this information would translate into a brief for materials selection to ensure that no problematic materials entered the market place.

7. Household Hazardous Waste and Quality of Urban Residual Material

Household hazardous wastes have the potential to disrupt resource recovery activities, and also contaminate potential waste derived fuels. Their safe and timely removal is therefore a key component of any modern resource recovery system.

7.1 Household hazardous waste

Household hazardous wastes (HHW) are products used and disposed of by residential as opposed to industrial consumers. HHW include paints, stains, varnishes, solvents, pesticides, and other materials or products containing volatile chemicals that can catch fire, react or explode, or that are corrosive or toxic (USEPA Glossary)[8]. Table 7-1 gives examples of typical HHW for various categories.

Table 7-1 Household hazardous waste typical categories[9]

HHW Category	Examples
Acids	Cleaners, descaler, disinfectant, drain opener, fertilizer, metal cement, metal cleaner, photo chemicals, polish or wax, pool chemicals rust remover, solvents.
Antifreeze	Antifreeze
Bases	Adhesives, air fresheners ammonia, cleaners disinfectants, drain opener, glue, metal cement, paint remover/thinner, photo chemicals, polish or wax, pool chemicals primer sealer, solvents, toiletries, wax stripper wood preservative.
Batteries	Alkaline battery, button battery, car/vehicle battery, lithium battery, nickel-cadmium battery.
Flammables	Adhesives, air freshener, alkyd paint, artist craft paint, brake fluid, carburettor cleaner, cleaners, concrete water sealer, contact cement paint remover/thinner, de-icer, disinfectant, driveway sealer, enamel, filler, food item, fuel, gas line antifreeze, glue, herbicide, high heat paint, inks, lacquer, linseed oil, liquid plastic, lubricants, mineral spirits, motor oil, photo chemicals, polish or wax pool chemicals, power steering fluid, primer sealer, resin or sealer, rust or metal paint, rust remover, shoe care products, solvents, specialty paints, spray pain, stain, stucco, tar or roofing patch, toiletries, transmission fluid, undercoating, varnish, wall paper prep, water repellent, wax stripper, wood finish, wood preservative.
Gas cylinders	Fuel, propane large, propane small, other.

[8] [online] accessed 8/2/06, [URL: http://www.epa.gov/OCEPAterms/hterms.html]

[9] Recycling Council of Ontario Household Hazardous Waste Fact Sheet [online] accessed 8/2/06, [URL: http://www.rco.on.ca/factsheet/hazardous.htm]

HHW Category	Examples
Oil	Motor oil, oil filters.
Other	Fire suppressants, other.
Oxidiser	Bleach, cleaners, disinfectant, fertilizer, hardener, other, photo chemicals, pool chemicals, toiletries, unknown.
Paint	Alkyd paint, enamel, latex paint.
Pesticides	Herbicide, insecticide, mixed pesticide and fertilizer, other, specialty paints, unknown.
Pharmaceuticals	Non-prescription drugs, other, prescriptions, sharps (hypodermic needles), unknown.

HHW typically constitutes a small percentage of the total municipal solid waste stream (in the order of 1 per cent or less)[10]. Figure 7-1 shows a typical composition of HHW. The majority of HHW are paints, followed by flammables, oil and automotive and household batteries.

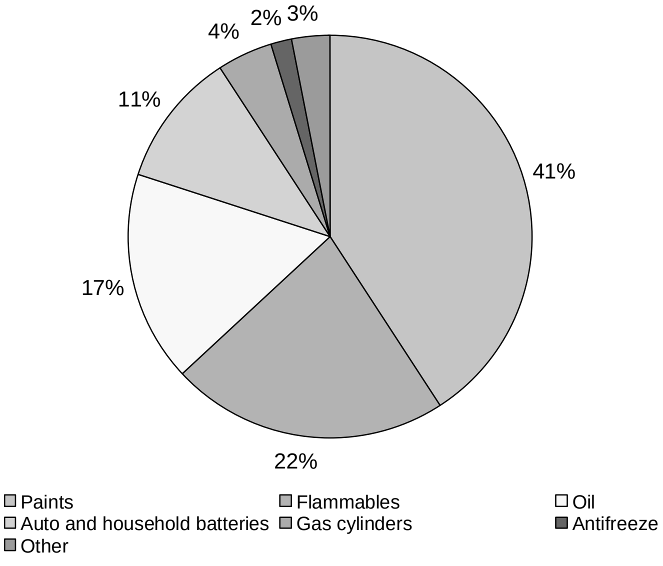

Figure 7-1 Typical composition of household hazardous waste[11]

If no management program is in place for households to recycle / dispose of their HHW separately, or for brand owners / companies to take responsibility for the wastes, then the HHW will remain in the waste stream – ending up at resource recovery facilities or in landfills or incinerators.

[10] Recycling Council of Ontario Household Hazardous Waste Fact Sheet [online] accessed 8/2/06, [URL: http://www.rco.on.ca/factsheet/hazardous.htm]

[11] Recycling Council of Ontario Household Hazardous Waste Fact Sheet [online] accessed 8/2/06, [URL: http://www.rco.on.ca/factsheet/hazardous.htm]

7.2 Impacts of household hazardous waste on resource recovery options

While new municipal solid waste landfills are designed to handle small amounts of household hazardous wastes, the presence of these materials can impact on resource recovery options.

HHW are problematic for alternative waste technology (AWT) facilities, since they contaminate compost products (sometimes making them unmarketable due to high heavy metals content), and they can also affect the biological processes in mechanical biological and anaerobic digestion type plants, leading to plant breakdowns.

Furthermore, the toxicity of some HHW can mean that waste streams containing certain quantities may not be permitted to be processed using energy from waste technologies due to potential toxic air emissions.

The presence of HHW in the waste stream can also have an impact on the efficiency and effectiveness of materials recovery facilities (MRFs), for example sharps are a problem for occupational health and safety reasons (especially if the MRF requires manual separation / sorting).

7.2.1 Types of household hazardous waste programs

Typical existing designated programs for collection, processing or recycling for HHW collection are:

- Temporary collection days;
- Permanent collection facilities;
- Mobile call-up programs; and
- Kerbside collections.

Local government or similar jurisdictions generally administer the above listed types of systems for the management of HHW. However, EPR or PS schemes for some HHW also exist, for example the Paint Stewardship Programs in Canada (refer Appendix A for details). In Australia there are some voluntary industry take-back schemes for unwanted rural chemicals that would otherwise end up in the waste stream (ChemClear).

There are a number of schemes for the collection and or recycling of used oil (automotive) such as in various States in the United States, Canada, and Australia for example. More recently, EPR / PS schemes for mobile phones and batteries (see Appendix A for details) have also been introduced in various OECD countries to help remove these types of HHW from the waste stream. The structure of the programs for HHW vary, but generally include collection / drop-off facilities.

Some countries or lower level jurisdictions can have quite stringent requirements in terms of HHW; including banning certain wastes from the municipal incinerators and landfills.

8. Conclusions

There are a wide variety of Extended Producer Responsibility / Product Stewardship (EPR / PS) schemes including take-back requirements, economic instruments, performance standards and other complementary measures. The aim of these schemes is to involve the product supply chain in taking responsibility for the full environmental and economic impacts of a given product. Outcomes from these types of approach include the prevention or reduction in waste generated, the reduction of toxic material usage, an increase in recycling and markets for secondary materials.

EPR / PS schemes are effective at removing 'icon' (readily identifiable) products manufactured by known industry operators. Schemes are well established in OECD member countries for materials and products such as general packaging, plastic bags, end-of-life vehicles, mobile phones, paint, tyres, paper, rechargeable batteries, oil and pesticides. Further development is expected around electrical and electronic equipment (EEE) and hazardous materials.

All indications point to increased requirements for producers to address end-of-life considerations. The main challenges to overcome for the ongoing effectiveness of EPR / PS schemes include:

- Reverse logistic infrastructure to facilitate product take-back from consumers as an integral and normal part to everyday consumer life (for example as simple as filling a car with petrol);
- Innovative technologies for product and material dissimilation and processing to meet quality specifications to facilitate resource assimilation back into the economy;
- Elimination of 'free-riders' through a combination of co-regulatory and regulatory approaches;
- Development of markets for recovered resources to add market pull to the desired cyclical flow of materials;
- Development of principles for Value Chain Optimisation to assist the integration between design intent and resource recovery service provision (there is some current evidence of integration between design and resource recovery, however this appears to occur only at the fringes).

If these challenges can be met the end result of EPR / PS actions will be a decrease in the amount of readily recyclable material in the urban waste stream and a decrease in the amount of household hazardous materials disposed of in urban waste.

Looking to the future the residual urban waste stream is likely to be dominated by plastic and paper/cardboard items, predominately related to disposable products and to lightweight convenience packaging.

The potential to integrate design and resource recovery infrastructure, means that Energy from Waste would be a significant contributor to an integrated system of 'total resource recovery'. Total resource recovery (recovering value from every 'waste' material through transformative technologies) could be achieved within major metropolitan centres, through the provision of anaerobic recovery for food and other putrescible items, energy recovery for the residual 'dry high calorifics' with a pre-sort for recyclable metals, plastics and inert materials, and then processing of inert fully mineralised residuals for use in civil works like roads and construction.

The principles of Value Chain Optimisation suggest that product designers and initiators need to cooperate with resource recovery service providers to ensure that a network of Energy from Waste facilities is available to manage those packaging materials and disposable/short life products unable to be readily recycled and that are suited for energy recovery.

From a design perspective, participation in this dialogue would translate into a brief for materials selection to ensure that no problematic materials entered the market place. From a planning perspective government planners would need to consult with product designers and resource recovery service providers to ensure that provision for required infrastructure is made in the preparation of urban plans. This is also an opportunity for government planners to add to the level of integration between product designers and resource recovery service providers.

In order to deliver these required planning, design and resource recovery services a new range of capabilities is required. For example: an understanding of materials currently in service within the economy, their stock life and recovery options at end-of-life; the ability to design products to be readily assimilated into existing reverse logistic resource recovery pathways; and the provision of infrastructure to keep pace with the changing composition of the urban waste stream.

These capabilities are required to scope the generic systems and infrastructure needs that should be available if energy recovery (embodied and calorific) from residual urban wastes is to be put on a sustainable footing.

9. References

ADEME (Agence de l'Environnement et de la Maitrise de l'Energie). 2003, *European Overview of Producer Responsibility Organisations and Bodies Assuming Producer Responsibility in managing End-Of-Life Products*, ADEME, France

Alter, H. 1989, 'The Origins of Municipal Solid Waste: The Relations Between Residues from Packaging Materials and Food', *Waste Management & Research Vol 7, pp. 103-114*

ASTC (Association of Science-Technology Centers Incorporated) 1998, *A Garbage Timeline,* ASTC, accessed online February 2006 [URL: http://www.astc.org/exhibitions/rotten/timeline.htm]

AZoM (A to Z of Materials) 2002, *Aluminium Cans – History, Development and Market*, AZoM, found online February 2006 [URL: http://www.azom.com/details.asp?ArticleID=1483]

CCME (Canadian Council of Ministers for the Environment). 1996, *Guiding Principles for Packaging Stewardship*, CCME, accessed online 3/8/05 [URL:

ChemClear website, accessed online 20/07/2005 [URL: http://www.chemclear.com.au/index.htm]

Choice 2005, *Cheap Cordless Drills*, Choice, found online February 2006 [URL: http://www.choice.com.au/viewarticleasonepage.aspx?id=104667&catId=100168&tid=100008&p=1]

Department of Environment. 2005, *Extended Producer Responsibility Policy Statement*, accessed online 20/07/2005 [URL: http://www.wastewa.com/Uploads/Images/EPR_Policy_Statement_June2005.pdf]

Department of Environment and Heritage (DEH) website, accessed online 20/07/2005 [URL: http://www.deh.gov.au/settlements/publications/waste/tyres/national-approach/p2ch2.html]

FiberSource undated, *A Short History of Manufactured Fibers*, FiberSource, found online February 2006 [URL: http://www.fibersource.com/f-tutor/history.htm]

Finkelstein 2005, *The History of Props: A Timeline of Props and Product Usage,* Artslynx International Arts Resources, found online February 2006 [URL: http://www.artslynx.org/theatre/props2.htm]

Franklin Associates 1997, 'Characterization of Municipal Solid Waste in the United States - 1996 Update', US EPA, accessed online February 2006 [URL http://www.epa.gov/epaoswer/non-hw/muncpl/pubs/msw96rpt.pdf]

ICE (Institute of Civil Engineers) 2006, *The Case for a Resource Management Strategy,* ICE, accessed online January 2006 [URL: http://www.ice.org.uk/knowledge/specialist_document_details.asp?Docu_id=1256&FacultyID=17]

ISLR (Institute for Local Self Reliance). 2000, *Extended Producer Responsibility Tools*, ISLR, accessed online 20/7/05 [URL: http://www.ilsr.org/recycling/epr/tools.html]

ISLR (Institute for Local Self Reliance). 2002, *America's Experience with Refillable Beverage Containers*, ISLR, accessed online February 2006 [URL: http://www.grrn.org/beverage/refillables/USrefill.html]

Lindhqvist, T. 1992, Extended Producer Responsibility. In T. Lindhqvist, *Extended Producer Responsibility as a Strategy to Promote Cleaner Products.* (1-5). Lund: Department of Industrial Environmental Economics, Lund University.

OECD (Organisation for Economic and Cooperative Development). 1996, *Extended Producer Responsibility in the OECD Area Phase 1 Report, Legal and Administrative approaches in member countries and policy options for EPR programs*, Group on Pollution Prevention and Control, Environment Policy Committee, OECD, Paris

OECD (Organisation for Economic and Cooperative Development) Working Party on Pollution Prevention and Control. October 2000, *Extended Producer Responsibility: A Guidance Manual for Governments.* OECD, Paris

OECD (Organisation for Economic and Cooperative Development), undated, *OECD Key ICT Indicators,* OECD, found online February 2006 [URL: http://www.oecd.org/document/23/0,2340,en_2649_37409_33987543_1_1_1_37409,00.html]

Plantet Ark undated, *Milk carton recycling - the history of cartons,* Planet Ark, found online February 2006 [URL: http://www.planetark.org/cartons/carthist.html]

Reardon, C. 2005, *Technical Manual Design for Lifestyle and the Future,* Australian Greenhouse Office, Canberra [URL http://www.greenhouse.gov.au/yourhome/technical/fs31.htm]

Saporito undated, *Juice Box,* How Products are Made, found online February 2006, [URL: http://www.madehow.com/Volume-7/Juice-Box.html]

The Economist, 2005, *Mobile-phone penetration,* The Economist, found online February 2006 [URL: http://www.economist.com/printedition/displayStory.cfm?Story_ID=4351974]

Tojo, N. 2004, *Extended Producer Responsibility as a Drive for Design Change – Utopia or Reality?*, Doctoral Dissertation, Lund University

Total Environment Centre. 2003, *Can a State Lead the Way On EPR?*, accessed online 20/07/2005 [URL: http://www.tec.nccnsw.org.au/member/tec/projects/Waste/sl.html]

US EPA (United States Environmental Protection Agency) 2006, *Milestones in Garbage - A historical timeline of municipal solid waste management*, US EPA, found online February 2006 [URL: http://www.epa.gov/epaoswer/non-hw/muncpl/timeline_alt.htm]

Warnken Industrial and Social Ecology Pty Ltd. 2003, *The Great Waste Debate: Discussion Paper on Extended Producer Responsibility and Waste Avoidance*, prepared for Total Environment Centre's Green Capital Program.

Wikipedia 2006a, *Plastic,* Wikipedia – The Free Encyclopedia, found online February 2006 [URL: http://en.wikipedia.org/wiki/Plastic]

Wikipedia 2006b, *Battery (electricity),* Wikipedia – The Free Encyclopedia, found online February 2006 [URL http://en.wikipedia.org/wiki/Battery_(electricity)#Cell_vs._battery]

Appendix A

Overview of Selected EPR/PS/PR Schemes

Overview of Selected EPR/PS/PR Schemes

A total of 12 schemes were identified for detailed analysis. These are presented in the following case studies. Each scheme is assessed on the basis of legislative framework, financial framework, operational structures and details, social issues, technical issues, participation and outcomes, relationship of schemes to design intent and impacts on kerbside.

EPR for Packaging Waste – United Kingdom	
Product types:	Packaging: *"all products made of any materials of any nature to be used for the containment, protection handling, delivery and presentation of goods, from raw materials to processed goods, from the producer to the user or consumer, including non-returnable items used for the same purpose but only where the products are:* » *sales packaging or primary packaging, that is to say packaging conceived so as to constitute a sales unit to the final user or consumer at the point of purchase;* » *grouped packaging or secondary packaging, that is to say packaging conceived so as to constitute at the point of purchase a grouping of certain number of sales units whether the latter is sold as such to the final user or consumer or whether it serves only as a means to replenish the shelves at the point of sale; it can be removed without affecting its characteristics; or* » *transport packaging or tertiary packaging, that is to say packaging conceived so as to facilitate handling and transport of a number of sales units or grouped packagings in order to prevent physical handling and transport damage; for the purposes of these Regulations transport packaging does not include road, rail, ship and air containers."* Source: Environment Agency & SEPA (1999) *The Agencies' Interpretation of Packaging*, 2nd Edition [online] available: http://www.environment-agency.gov.uk/commondata/acrobat/pr_edn2_518816.pdf
Legislative framework	Compulsory for UK companies that produce (or handle) more than 50 tonnes of packaging a year and achieve an annual turnover of more than £2 million (approximately € 3.3). Initiated through: » The Packaging (Essential Requirements) Regulation 1998; and » The Producer Responsibility Obligations (Packaging Waste) Regulations 1997.
Financial framework	Registration with environmental agencies through compliance organisations has a fee in the order of € 600. Operational costs borne by the producers/handlers.
Operational structures	Packaging Waste Directive (94/62) came into force in 1994 and was transposed into UK law in 1997 If a company meets both the turnover and 'packaging handled' thresholds, they are legally obligated to register with the relevant environment agency (which includes provision of data relating to the packaging handled by the company) or join a 'compliance organisation'. Valpak Ltd is one such organisation.

EPR for Packaging Waste – United Kingdom	
	A compliance organisation concludes agreements with recycling firms, and hence obtains the requisite certification on behalf of its members. There are approximately 20 compliance organisations in the UK and about 80 per cent of businesses register with them (Macrory 2004). Various sectors of the packaging chain must meet certain recovery quotas (including recycling, and energy from waste) on a pro rata basis: » Production of raw material for packaging – 6 per cent » Production of packaging – 9 per cent » Filling in packages – 37 per cent » Sales of packages to consumers – 48 per cent Both individually registered companies and registered compliance companies must demonstrate annually that they have achieved the required recovery targets by presenting a sufficient quantity of Packaging Recovery Notes (PRN) to the relevant environment agency (the Environment Agency in England and Wales, SEPA in Scotland or EHS in Northern Ireland). PRNs are certificates which state the tonnage of material recycled, issued by registered waste reprocesses such as paper mills, and plastic businesses. They may be sold on the open market as a tradeable instrument.
Social issues	Free riders – the UK Environment agency has set up a 'free-rider hotline' for reporting any producers who are not complying with their obligations to register or recover/recycle packaging waste.
Technical issues	Recycling/recovery infrastructure must be sufficient to enable all companies to meet their recovery and recycling requirements.
Participation and outcomes	Recycling rates in the UK are low compared to other European countries. However, the recycling rate for packaging material rose form 30 per cent in 1997 to 38 per cent in 1999, and reached 42 per cent in 2000. Also, the number of free riders (companies which neither register nor join a compliance organisation that are obliged to under law) was in the order of 400-650 in 2000. Source: Wollny, V. (no date) Packaging Waste Recovery in the United Kingdom: Do tradable certificates solve the ecological and economic problems of packing waste recovery? [online] available: http://gruener-punkt.de/uploads/media/studie_en.pdf
Influence on design decisions	All packaging in this scheme are treated alike, hence there seems to be no controlling effects in terms of a targeted optimum balance between recycling properties and packaging properties.
Kerbside influence	N/A. While there are increased packaging recycling rates, there are not at the kerbside, but rather at a commercial level.

End of Life Vehicles Take-Back System – Germany	
Product types:	End of life vehicles (ELVs)
Legislative framework	A combined regulatory-voluntary framework. Regulatory aspect governed by the German End-of-life Vehicle Act 2002.
Financial framework	Costs borne by industry, though thought to be offset by saved disposal costs and saved materials through reuse and recycling – however expenditures and saving resulting from ELV take back are not available.
Operational structures	The Regulations require manufacturers to: » set up a national network of collection points, » reuse parts and materials when technically and economically feasible; » disassemble ELVs to meet recycling targets; » carry out dismantling and de-pollution measures; » remove specific parts; » encourage the reuse and recycling of removed parts and drained liquids; » encourage the removal of at least 15 per cent by weight of the ELV; and » design new vehicles with the objectives of waste minimisation and end-of-life treatment of ELVs in mind. It also includes: » waste reduction targets; » an allowance for the consideration of automobile shredder residue energy recovery to count towards the recycling targets; and » the requirement that certificates of disposal be issued by registered dismantlers to the last owner of the vehicle. Free take back of ELVs applies under certain conditions as well. Voluntary agreements to undertake ecologically compatible disposal and recycling of used motor vehicles in accordance with the German law on Recycling and Waste Management have also been signed by a number car manufactures, importers, automotive industries and dismantlers. The government and the voluntary agreement jointly govern the overall ELV take-back system.
Social issues	Customer acceptance of used parts.
Technical issues	Modernised infrastructure including receiving stations and recycling plants for end-of-life vehicles have been established since 1998 and now comprises in the order of 1,400 accredited recycling plants and some 15,000 accredited receiving stations. Nation-wide infrastructure has also been set up for taking back and recycling end-of-life parts following vehicles repairs. Technical barriers exist in terms of the quality of recycled plastics and the applications that they are suitable for.

End of Life Vehicles Take-Back System – Germany	
	Another issue in terms of reuse is ensuring that the quality of used parts is appropriate to the model and the condition of the vehicle. Also, the establishment of a distribution system of reusable or remanufactured parts remains a barrier. There is no incentive for dismantlers to provide a cleaner hulk to shredders to assist with more efficient recycling.
Participation and outcomes	Detailed quantitative information is not available. However studies have shown that the portion of ELVs that are recycled has increased, but only slightly since the ELV Ordinance was enforced by law. Also, the take-back system has slightly increased plastic recycling.
Influence on design decisions	Vehicle manufacturers have become more involved in design for recycling and disassembly as a result of ELV ordinances, regulations and voluntary agreements. For example: » BMW's front grill is now composed of two plastic parts that can be unclipped easily compared to the earlier design consisting of numerous aluminium and plastic parts that required time-intensive disassembly. » Ford has reduced its use of types of nylon from 150 different grades to 20 and aims to reduce this number further
Kerbside influence	No kerbside influence, as ELVs do not generally go through the kerbside systems.

EPR Scheme for WEEE (Waste Electrical and Electronic Equipment) – Sweden	
Product types:	» Household appliances, hand tools, gardening tools; » IT equipment and office equipment; » Telecom equipment; » Televisions, radios, video recorders etc; » Cameras, and photographic equipment; » Clocks and watches; » Games and toys; » Electric fittings and other sources of light; » Medical technical equipment; and » Laboratory equipment. Presently refrigerators and freezers are not included as these items are to be handled by the municipal authorities according to law
Legislative framework	Ordinance SFS 2005:209 on Producer Responsibility for Electrical and Electronic Equipment – based on Directive 2002/96/EC (the WEEE Directive) now being implemented in all Member States of the EU. The above Ordinance replaces previous Swedish legislation implemented in 2001, and expands the types of equipment covered and responsibility of the producers, e.g. supervision and checking requirements are more stringent. The legislation applies to all producers. A producer under the Ordinance is: » Any person who manufacturers and sells under his own name electrical and electronic products. » Any person who under his own brand sells electrical and electronic equipment which lacks a brand that can be related to a manufacturer as above » Any person who imports and then sells electrical and electronic equipment » Any person who sells directly to the end-user in another country in the EU, where there is no producer in the recipient country ('distance selling') At the moment, companies registered in Sweden can be considered producers according to Swedish legislation. However it is not expected to remain this way. *Source:* Swedish Environmental Protection Agency (Naturvårdsverket) website – *Producer Responsibility for Electrical and Electronic Products* [online] available: http://english.environ.se/index.php3?main=/documents/issues/technic/electric.htm
Financial framework	Industry funded through fees to a collective scheme (like El-Kretsen) or producers may self-fund their own schemes. Fees to El-Kretsen are determined in part by the company's sales volume, and also by which sort of product. The Swedish EPA has powers to levy environmental penalty charges for inadequate reporting.

EPR Scheme for WEEE (Waste Electrical and Electronic Equipment) – Sweden	
Operational structures	Effective from 13 August 2005, though reporting to the Swedish EPA will not start until April 2006, producers must: » Report to the Swedish EPA (including records of solid, collected and treated quantities); » Label their products; » Establish a collection system; » Deal with the end-of life equipment in a correct manner; » Allocate financial guarantees; » Supply information on the equipment to recyclers; » Inform persons other than private household how they can return their waste; and » Consult local authorities affected. Recovery targets between 70 and 80 per cent are also set.
Social issues	The European Commission estimates an average cost increase of between 1 per cent and 2 per cent for most WEEE products and 3 per cent to 4 per cent for a few large or more complex products. However, some suppliers have no plans to increase prices in the short term, and it is likely to vary from product area to product area. *Source:* CPC Website – RoHS & WEEE Info Pages: FAQs [online] available: http://cpc.farnell.com/jsp/bespoke/bespoke3.jsp?bespokepage=cpc/en_CC/info/tools/rohs/rohs_home.jsp
Technical issues	A number of collection points have been established
Participation and outcomes	Sweden is already the second-best country in the world in collection of electrical waste à almost 12 kg per person per year (only Norway collects more). Many producers join an organisation such as El-Kretsen AB which handles their producer responsibility obligations for a fee (El-Kretsen members account for 90-95 per cent of total EEE sales in Sweden). Over 600 companies are affiliated with El-Kretsen, who provide approximately 1000 collection points. After implementation of the first WEEE producer responsibility legislation in 2001, recycling of white good increased from 49,000 tonnes to 57,000 tonnes in 2002. Other WEE such as computers, televisions, lamps etc increased by 36 per cent over the same period. Increasing participation rates more recently are also evident.
Influence on design decisions	This EPR scheme has the potential to encourage design for re-use or recycling.
Kerbside influence	Less waste electronic and electrical equipment in kerbside collection

Paint Stewardship – British Columbia, Canada	
Product types:	Consumer paints, varnishes, stains and aerosols for home and commercial use. Includes both leftover products as well as empty containers.
Legislative framework	Regulatory mandate through the Post-Consumer Paint Stewardship Program Regulation (British Columbia Reg. 200/94) enacted in 1994 under the Waste Management Act. The regulation was amended 26 June 1997 to include all paints sold in pressurised containers (aerosols)
Financial framework	Funded through an eco-fee that is listed as a separate line item on purchase bills. Revenue generated is managed by The Paint and Product Care Association (PPC) and set by PPC and the Tree-Marking-Paint Stewardship Association (a second non-profit association formed by some producers of industrial paint aerosols). The fee is related to container size, not paint type. Many forestry companies use large amounts of aerosol paint. Several of these companies process used aerosols on site. Eco-fees are waived for forest companies that own and operate onsite processing equipment.
Operational structures	The scheme has been in place since 1994. In response to the general public's concern over household hazardous waste, a study was produced by the provincial government which showed that 70 per cent of household hazardous waste is paint. The Post-Consumer Paint Stewardship Program regulation was created based on a general political will to shift the costs of waste management from the municipalities to the producers – reflecting community concerns. Brandowners: » collect eco-fees from retailers and develop and distribute educational material to them regarding their approved stewardship program; » provide information regarding access to return collection facilities as well as the environmental and economic benefits of participating in the stewardship program; and » are responsible for ensuring the collection and management of used paint through a network of collection sites. Retailers: » Collect the eco-fees; and » Are responsible for posting visible signs to provide information to consumers about the program. Consumers must bring their paint and containers to the collection sites. The provincial government is responsible for enforcing and monitoring compliance. Annual reports must be provided to the Ministry of Water, Land and Air Protection including information on paints sold and collected, processed, and detail on collection facilities etc.

Paint Stewardship – British Columbia, Canada	
	131 collection depots have been established, the majority managed through the Product Care Association representing more than 60 paint brand owners. Although Product Care and the Tree-Marking –Paint Association manage the depot collection system, actual operation are contracted out to recycling businesses, municipal transfer stations, landfills and fire departments.
Social issues	Only real impact socially is direct increase in consumer prices in the form of eco-fees – currently in the order of (in Canadian Dollars) C$0.10 for containers with 250 mL or less of paint up to C$1.00 for containers between 5.01 L to 23 L of paint.
Technical issues	Network of collection points has been established. Technological innovations to recycling aerosol paint containers by the Product Care Association resulted in a reduction of "eco-fees" on aerosols from C$0.40 to C$0.10 per container. The unit cost for managing leftover paint has also decreased significantly. Source: Ministry of Environment, *Post-Consumer Paint Stewardship Program Regulation:* Annual Report by the Director (1998 Reporting Period) [online] available: http://www.env.gov.bc.ca/epd/epdpa/ips/paint/reports/paint1998.html
Participation and outcomes	Since its inception, the program has seen constant increases in paint recovery. Paint Care reported an annual 1 per cent increase in the amount of collected paint that is recycled for the last three years and a 3 per cent increase from 1999 to 2000 in the quantity of collected paint that is re-used. The Tree-Marking-Paint Association reported a 31 per cent capture rate of aerosol containers for 2001.
Influence on design decisions	None known to date.
Kerbside influence	Less paint in kerbside collections

Mobile Phone Industry Recycling Program - Australia	
Product types:	Mobile phone handsets, batteries and accessories
Legislative framework	Voluntary industry led initiative
Financial framework	Participating members provide the necessary funding by paying a levy on each handset sold into the Australian market.
Operational structures	The Australian Mobile Telecommunication Association (AMTA) initiated the program in 1998 voluntarily. AMTA is a not-for-profit organisation and it adjusts the levies on manufacturers and carriers to ensure that at all times there is sufficient funding to undertake all recycling. A network of collection points have been set up around the country, the mobile phone handsets, batteries and accessories are then recycled under contract.
Social issues	A study of consumer attitudes and behaviour, undertaken on behalf of the industry found that more than 12 million mobile phones no longer in use have been stored away by owners as a "just in case" back up. Many Australians see a value in their old phones and are reluctant to dispose of them. The challenge therefore is to ensure that when it comes time for people to move house or have a spring clean that they dispose of their old mobile in an environmentally-safe manner. *Source:* AMTA (2005) *Mobile Phone Recycling Update: New Survey Sheds Light on the Recycling Habits of Australia's Mobile Phone Users*, Media Release 5 May 2005 [online] available: http://www.amta.org.au/aoi.asp?ID=Recycling
Technical issues	Over 1600 drop-off points have been established around the country
Participation and outcomes	Over 260 tonnes of mobile phone handsets, batteries and accessories have been collected for recycling in Australia. This represents more than a 400,000 handsets and over 900,000 batteries. Of these, 40 tonnes of batteries containing cadmium have been collected. *Source*: http://www.amta.org.au (AMTA website)
Influence on design decisions	EPR for mobile phones has the potential to affect product design – particularly in terms of ease of disassembly, recyclability etc. This voluntary scheme levies an equal amount on all carriers, service providers and manufacturers so there is no real reward for one company to make efforts above and beyond others.
Kerbside influence	Less mobile phones and mobile phone batteries etc in kerbside collection.

Plastic Bag Environmental Levy - Ireland	
Product types:	All plastic shopping bags, though some exemptions exist including: » Smaller plastic bags used to store non-packaged goods such as dairy products, fruit, vegetables, nuts, confectionery, cooked food (whether hot or cold), and ice; » Smaller plastic bags that are used to store fresh meat, fish and poultry, both packaged and unpackaged; » Bags for life costing more than 70 cents; » Bags supplied to intending passengers in airports and ports and passengers on board commercial aircraft and ships; and » Items sold in the secure 'duty free' zone of airports in Ireland.
Legislative framework	The levy is outlined in Ireland's *Waste Management Environmental Levy (Plastic Bag) Regulations 2001*, making it a mandatory economic instrument scheme
Financial framework	A 15 cent levy is applied per bag carrying goods that are not exempt. Retailers are obliged by law to pass on this charge to the consumer at the point of sale. The charge for each plastic shopping bag must be itemised on all invoices, receipts or dockets issued to customers.
Operational structures	The levy scheme was initiated 4 March 2002. Revenue generated from the levy goes into the new Environmental Fund. This fund is used to support waste management, litter and other environmental initiatives.
Social issues	A national survey carried out in 2003 revealed that 91 per cent said the levy was a good idea, though 6 per cent did not believe the levy was a good idea – they missed having plastic bags about the house, and were frustrated if they forgot to take re-useable bags to the shops. This contrasts with a similar survey carried out in 1999 where 40 per cent said they would not be willing to pay a levy. *Source:* Swanson, I. (2005) *Plastic Tax Did Not Leave Ireland Down In the Dump* [online] available: http://news.scotsman.com/scitech.cfm?id=2183012005
Technical issues	N/A
Participation and outcomes	The Irish Government is reported to have raised a total of €46 million in revenue since its inception. Figures suggest that the use of plastic bags has been reduced by over 90 per cent. According to Irish Government officials, plastic bags used to account for 5 per cent of litter, but since the levy, they account for only 0.22 per cent. In a written submission by Ireland's biggest supermarket group (including SuperValu and Centra in Ireland and Budgens and Londis in the UK), it was noted that Irish stores under a plastic bag tax handed out ten times fewer plastic bags per euro of turnover than their UK counterparts (no plastic bag tax). *Source:* Swanson, I. (2005) *Plastic Tax Did Not Leave Ireland Down In the Dump* [online] available: http://news.scotsman.com/scitech.cfm?id=2183012005
Influence on design decisions	Possible influence is move towards the production of long-life bags.
Kerbside influence	Some suggestions that plastic rubbish (kerbside collected) has not reduced as people now buy conventional bin liners instead of using plastic bags, however no statistics to support this.

Green Dot Program for Packaging - Germany	
Product types:	Packaging
Legislative framework	Introduced after many years of political discussion in Germany After voluntary measures failed to make an impact, the German Ordinance for the Avoidance of Packaging Waste was introduced in June 1991. Further reinforced with the European Commission's (EC) 1994 adoption of the Packaging and Packaging Waste Directive (PPWD) (Directive 94/62/EC) which requires EU Member States to adopt national measures to attain specific recovery and recycling targets for packaging waste.
Financial framework	The Green Dot license fee finances the disposal services provided by DSD (see below for explanation). The license fee is now based on the packaging material, the weight of the item, and the recycling expense. The costs for the Green Dot have been significantly reduced over recent years and, depending on the type of packaging and disposal method involved, further license fee reductions are expected.
Operational structures	In its initial form, the EPR scheme was introduced in 1991, and has evolved over time. German legislation mandates the separate management and recycling of all types of sale packaging outside the public waste disposal system. It also sets mandatory quotas for recycling, collection and sorting in accordance with the waste management hierarchy. The Duales System Deutschland (DSD) was organised in September 1990 by 95 firms from the retail, consumer goods and packaging industry, in anticipation of the passing of the Packaging Ordinance. The DSD was organised to collect, sort and transport material to recyclers – a type of Producer Responsibility Organisation. The DSD system permits manufacturers to use a trademark "green dot" which signifies that the DSD fee has been paid, thereby ensuring that products are not excluded from retail stores. To the consumer, the Green Dot now indicates that the packaging material is recyclable and that the product price includes the cost of packaging collection and sorting for recycling.
Social issues	The OECD report titled *Extended Producer Responsibility Phase 2: Case Study on the German Packaging Ordinance* (1998) states that the Green Dot may be incorrectly recognised by consumers as a sign of environmentally improved packaging. This could have created sales advantages for Green Dot products initially – but since most products now carry the symbol, competitive advantages are minimal. However the report also indicates that consumers continue to be misled in this was by use of the Green Dot label. Success of the program depends on efforts of consumers to separate waste for recycling. Also, consumer acceptance of products with minimal display and sales packaging, and refillable and returnable packaging influences producer decisions to switch to environmentally improved packaging. Information and education campaigns were helpful, and also proved to assist create a more environmentally aware public generally.

Green Dot Program for Packaging - Germany	
Technical issues	Some problems with infrastructure not being in place to handle the amounts of packaging materials being collected, particularly during the first few years, leading to stockpiling or export at subsidised prices (which in turn impacted on the recycling efforts of other countries). Increased recycling requirements under the Packaging Ordinance, as helped result in the development of new technologies, particularly in the area of plastics. For example, the BASF Pyrolysis Process, Hydrogenation in the Kohle-Öl-Anlage, Synthesis Gas Production Technology, and Plastics as a Reducing Agent in Steel Production.
Participation and outcomes	Early on, problems arose due to the unexpectedly enthusiastic response from the public – larger amounts of material than expected were collected, leading to high waste management costs and financial crisis in August 1993 and extensive occurrences of free-riders. When establishing recycling collection systems, DSD consults with, and coordinates its activities with local authorities. In 2002 approximately 6.32 million tonnes of used sales packaging was collected through Green Dot kerbside collection and drop-off centres. This equates to 76.7 kilograms of packaging per person. In 1995, the Packaging Recovery Organisation Europe ("PRO EUROPE") was founded by DSD with the aim to avoid trade barriers in Europe. The main purpose of PRO EUROPE is to "distribute the Green Dot trademark to national collection and recovery systems within the EU Member States and the European Economic Area member countries in accordance with uniform rules and regulations". Over 20 countries now use the Green Dot trademark. Source: Baughan & Evale (2004) The Green Dot System: Promoting Recycling In The European Union Green Dot system is evidence that principle of producer responsibility is achieving success throughout the EU [online] available: http://packaginglaw.com/index_mf.cfm?id=151
Influence on design decisions	The license fee is based on the packaging material, the weight of the item, and the recycling expense. The system thus gives industry an incentive to develop and produce packaging that is easily recycled and also to reduce the quantity of packaging and packaging material.
Kerbside influence	Increased packaging being recycled from kerbside collection (and drop-off centres).

National Packaging Covenant – Australia	
Product types:	Packaging
Legislative framework	The National Packaging Covenant is a voluntary agreement. The regulatory underpinning is provided by the National Environmental Protection (Used Packaging Materials) Measure (NEPM), designed to deal with free riders and non-signatories and applied at the jurisdictional level.
Financial framework	Industry / company signatories are required to contribute to an Industry fund. Required contributions to the fund are based on annual turnover as well as the company role in the packaging product chain (raw material supplier, manufacturer / household paper supplier, packaging user, wholesaler / retailer). *Source:* http://www.packcoun.com.au/CovtAch/Industry_FundContrib.doc A cornerstone of the funding arrangements for the Covenant has been the requirement for matched funding between the packaging supply chain and government. The latest National Packaging Covenant arrangement continues this trend, however there is also flexibility for co-funded projects with non-Covenant signatories. Under the Covenant, the packaging supply chain seeks to raise a minimum of $3 million per annum over *Source:* http://www.deh.gov.au/settlements/publications/waste/covenant/pubs/covenant.pdf These funds are earmarked for “studies and other measures aimed at improving the cost-effectiveness of kerbside collection programs, and at strengthening and expanding markets for collected materials” (Department of Environment and Heritage). The Covenant specifically precludes these funds from being spent on subsidising kerbside recycling.
Operational structures	The National Packaging Covenant is the voluntary component of a co-regulatory arrangement based on the principles of shared responsibility through product stewardship, between key stakeholders in the packaging supply chain and all spheres of government - Australian, State, Territory and Local. The National Packaging Covenant Mark I was established in 1999 for five years. The National Environment Protection Measure (NEPM) on Used Packaging Materials was also introduced to act as a regulatory safety net to prevent non-signatories from gaining any competitive advantages (free-riders). The National Packaging Covenant Mark II commits signatories to a national recycling target of 65 per cent for packaging and no further increases in packaging waste disposed to landfill by the end of 2010. The Covenant and its Schedules set out commitments each signatory is required to undertake. These commitments are flexible, with sectors having different Covenant responsibilities in the life cycle of a packaging product. Individual signatories are able to determine what actions are appropriate for their organisation.

National Packaging Covenant – Australia	
	Within 90 days of signing the Covenant, signatories are required to develop and submit an Action Plan detailing how they propose to implement their Covenant commitments. Action Plans can be developed for a 12-month period or up to the five-year life of the Covenant. They can be submitted either as an individual or a joint Action Plan through an industry association or group of companies or with mentors.
Social issues	Free-riders – as this is a voluntary industry scheme, there are risks that non-signatories could gain competitive advantages. However the NEPM was introduced to help deal with this potential problem
Technical issues	Since the National Packaging Covenant is non-prescriptive, companies can develop their own initiatives to reduce packaging or change packaging materials. Hence, a variety of technology changes or developments resulting from participation are possible.
Participation and outcomes	Over 600 signatories to the NPC Mark I, with A$12 million raised in funding. *Source:* WISE Briefing Notes (2005) *Container Deposit Legislation and the National Packaging Covenant* It is not prescriptive, does not tell companies how to make their packaging or what type of packaging to use; nor does it implement regulations requiring businesses to take back materials recovered from kerbside recycling collection programs. Recent initiatives have been described in Action Plans. Examples from specific company actions include: » 17 per cent reduction in outers (outer packaging, such as cardboard); » reductions in 40 tonnes of packaging material per annum from packaging trials; » down gauging of paper cores by 25 per cent for kitchen tidy bags; and » decreased overall virgin board consumption by 6 tonnes per year. *Source:* Environment Protection and Heritage Council *(2005) Consultation Regulatory Impact Statement on Revised National Packaging Covenant*, Ref: 4130-02 One of the criticisms of the scheme, however, is that it lacks any mandatory independent auditing of the Action Plans making it difficult to confirm what the Covenant has achieved.
Influence on design decisions	Commitments in the Action Plans include redesign to lightweight products and to reduce total amounts of packaging used. For example, National Foods Limited has, under the National Packaging Covenant, reduced material use through changes in packaging design. For example, cardboard boxes for Yoplait 1 kg yogurt tubs were redesigned to remove the boards on side panels, leading to a monthly reduction of cardboard use by 5,000 kg. *Source:* www.packcoun.com.au/CovtAch/natfoods.htm (Packaging Council of Australia)
Kerbside influence	Potential reduction in packaging materials for kerbside collection

EPR for Tyres - Sweden	
Product types:	» Car and motorcycle tyres; » Swedish retreaded car tyres; » Construction vehicle and large tractor tyres; » Truck tyres; and » Construction tyres larger than 29".
Legislative framework	Implemented under a National Directive (1994:1236). Any company that places tyres on the market must also accept liability for how they are dealt with at the end of their service lives. This came out of the EU Landfill Directive (EC Directive on the Landfill of Waste 1993/31/EC), which mandates provisions for the banning of tyres to landfill by 2003.
Financial framework	Consumers pay a recycling charge when purchasing new tyres.
Operational structures	» In 1994, the Swedish tyre industry set up Svensk Däckåtervinning AB, SDAB (the Swedish Tyre Recycling Organisation), which participated in the process that led to the Directive. » The SDAB is responsible for organising tyre collection and recycling. It is run as a non-profit organisation, owned by DF (the Swedish Association of Tyre Suppliers) and DRF (The Swedish National Association of Tyre Specialists).
Social issues	Consumers meet the cost of the program through the extra charge paid upon purchase.
Technical issues	New or improved technologies to process and recycling / reuse waste tyres have been developed, partially in response to the increase in waste tyres collected.
Participation and outcomes	Since the beginning of January 1995, the volume of tyres collected and recycled has continuously increased. SDAB reports that: "in recent years, the level of collection and recycling has, to all intents and purposes, been 100 per cent. This translates into a significant volume of tyres – approximately 60–65,000 tonnes every year." *Source:* SDAB (no date) *Come Back* [online], available: [http://www.svdab.se/Pdf/064-43original_engelskt.pdf
Influence on design decisions	None known to date
Kerbside influence	There may be an influence at the kerbside in terms of (reduction in) numbers of used domestic tyres.

EPR for Waste Electrical and Electronic Equipment (WEEE) – Norway	
Product types:	**The scheme covers:** » Large household appliances » Small household appliances » IT and telecommunications equipment » Consumer equipment (incl. mobile phones) » Lighting equipment » Electrical and electronic tools (with the exception of large-scale stationary industrial tools) » Toys, leisure and sports equipment » Automatic dispensers **The scheme does not cover:** » Medical equipment or monitoring and regulating instruments; » Military EEE, i.e. equipment that is specifically designed and produced for military purposes » Products that form part of equipment that is not covered by the directive (including products specifically designed for installation in aircraft, boats, cars or other means of transport); » EEE produced or imported into the European Economic Area prior to 1 July 2006 and spare parts for such equipment; or » Cables to fixed installations (excluding cables as part of EEE).
Legislative framework	Based on the requirements of the EU's Directive 2002/96/EC (the WEEE Directive). Implemented under the Product Control Act 1976. The purpose of the Product Control Act is to prevent products from causing damage to health or disturbance of the environment in the form of pollution, waste, noise or the like.
Financial framework	Industry funded via a collective scheme (e.g. El-Retur) or producers may self-fund their own schemes. The individual Trade Association responsible for each product group determines the financing method for the El-Retur collective. Environmental costs are either paid in advance by charging a set fee per item (e.g. 17" TV = € 5.60; hairdryer = € 0.56; mobile phone € 0.25) or paid in arrears according to the individual producer's market share calculated on basis of the kilos of products imported/produced into the Norwegian market the previous year. *Source:* Loken, H. (2004) *Take back and re cycling of WEEE in Norway: The Collective Experience after five years of full scale operation,* presentation [online] available: http://www.environ.ie
Operational structures	Norway became the first country in Europe to pass legislation setting up free take-back provisions for all discarded electronic and electrical (WEEE) products. Private consumers can deliver all types of WEEE free of charge to distributors who sell the same types of products, or to municipal collection points.

EPR for Waste Electrical and Electronic Equipment (WEEE) – Norway	
	El-Retur is responsible for approximately 80 per cent of the market across all WEEE categories. It is made up of two non-profit waste management companies (Hvitevareretur AS and Elektronikkretur AS), owned and controlled by four National Trade Associations. El-Retur continuously collects WEEE from approximately 3000 points including retailers, municipality sites, repair shops and other major users. Source: http://www.elretur.no
Social issues	'Free-riders' represent a significant economic and social problem if not dealt with seriously by the EPA. A survey conducted by MMI for El-Retur in 2004 showed that young people aged between 15-24 are far less environmentally aware than their parents' generation. More than half of the young people surveyed did not know where they could deliver small electrical appliances. Hence, education and information about the EPR for WEEE in Norway for the younger generation is an important social issue to consider in maintaining and improving the WEEE take-back system. *Source:* El-Retur (2004) *Environmental Report 2004*, [online] available: http://www.elretur.no/MiljorapportEN2004.pdf
Technical issues	Over 80 per cent of collected WEEE in Norway is recycled, some is treated with energy recovery and the remainder is disposed or thermally destructed. Hence there is a large infrastructure requirement for recycling all the collected WEEE.
Participation and outcomes	The Norwegian waste management scheme for WEEE waste is a great success and Norway collects more than three times as much WEEE waste per capita than is demanded by the EU regulation. *Source:* http://www.loop.no/in_english/the_system/ In 2003, El-Retur collected 11.1 kg/capita and achieved a WEEE recovery rate of 89 per cent (compared to the EU's requirement of 75 per cent recovery). This consisted of 82 per cent recycled and 7 per cent utilised for energy recovery.
Influence on design decisions	*"The key to a closed-loop system is product design. For example, the recycling of plastics from discarded cell phones and other electronic equipment is today severely limited because of the brominated flame retardants these products contain. Instead, recycling can be facilitated by redesigning the products: removing these and other toxic constituents, using a smaller number of plastic resins, labeling the plastics, and using fasteners that allow for easy disassembly. These strategies lead to increased recycling rates and can, in many cases, make recycling profitable."* *Source:* Fishbein, B. (2002) *Waste in the Wireless World: The Challenge of Cell Phones,* Inform, Inc, New York [online] available: http://www.informinc.org/WWWfindrec.pdf
Kerbside influence	Less waste electrical and electronic equipment in the kerbside systems]

Restriction of Hazardous Substances Directive – European Union	
Product types:	The directive applies to: » Large household appliances » Small household appliances » IT and telecommunications equipment » Consumer equipment (including mobile phones) » Lighting equipment — including light bulbs » Electronic and electrical tools » Toys, leisure and sports equipment » Automatic dispensers
Legislative framework	The Restriction of Hazardous Substances Directive (the RoHS Directive) 2002/95/EC became European Law in February 2003. The RoHS Directive concerns six hazardous materials: » Lead, Mercury, Cadmium, Chromium VI; and Polybrominated biphenyls (PBB) and Polybrominated diphenyl (PBDE) (flame retardants used in some plastics). The use of these materials is restricted in the manufacture of various types of electronic and electrical equipment (such as those listed above). The Directive is closely is closely linked with the Waste Electrical and Electronic Equipment Directive 2002/96/EC which sets collection, recycling and recovery targets.
Financial framework	Up to individual EU member states to address
Operational structures	The maximum concentrations are 0.1 per cent (except for Cadmium which is limited to 0.01 per cent) by weight of homogeneous material. This means that the limits do not apply to the weight of the finished product, or even to a component, but to any single substance that could (theoretically) be separated mechanically — for example, the sheath on a cable or the tinning on a component lead. Certain applications are exempt and there is also an exemption for spare parts for the repair of equipment put on the market before 1 July 2006. The restrictions also do not apply to the re-use of equipment that was put on the market before this date. *Source:* http://en.wikipedia.org/wiki/RoHS
Social issues	The RoHS Directive also means that any company wishing to sell electrical and electronic equipment in the European market will be able to do so only if it removes the hazardous substances specified in the RoHS Directive. Hence the RoHS is likely to have an impact in other countries outside the EU such as the United States, Japan, China etc.
Technical issues	According to Intel, 90 per cent of electronic components contain lead, mainly lead solder. Finding alternatives to lead solder is a massive undertaking because of product reliability, component compatibility, energy use, and cost issues. *Source:* Inform, Inc (2003) *WEEE and RoHS: Highlights and Analysis* [online] available: http://www.informinc.org/fact_WEEE.pdf

Restriction of Hazardous Substances Directive – European Union	
Participation and outcomes	All 25 EU member states must transpose the EU RoHS Directive into law in their own Country.
Influence on design decisions	The RoHS Directive is already having a major impact on the design of electrical and electronic products as industry invests in finding alternatives to key substances such as lead and brominated flame retardants. But there is continuing debate on the environmental impact of the banned substances, along with pressure for more exemptions. *Source:* Inform, Inc (2003) *WEEE and RoHS: Highlights and Analysis* [online] available: http://www.informinc.org/fact_WEEE.pdf
Kerbside influence	Eventually less hazardous materials in any electrical and electronic products that may be disposed of in the kerbside system by householders.

“Charge Up To Recycle!” – United States and Canada	
Product types:	All rechargeable batteries, and, specifically, Nickel Cadmium, Nickel Metal Hydride, Lithium Ion and Small Sealed Lead (up to 2 pounds per 1 kg per battery)
Legislative framework	“Charge Up To Recycle” is a voluntary program, however there are numerous regulatory and non-regulatory supports, dependent on the jurisdiction. For example, “in May 1996, U.S. Congress enacted Federal legislation known as the Mercury-Containing and Rechargeable Battery Management Act. This Act streamlines state regulatory requirements for collecting Ni-Cd batteries and encourages voluntary industry programs to recycle them”. The program in Canada was developed in conjunction with Environment Canada, Natural Resources Canada, Transport Canada and also the provincial and territorial Ministry of the Environment. *Source*: Deh website [online] available: http://www.deh.gov.au/settlements/publications/waste/electricals/infrastructure/appendix-d.html
Financial framework	The program is funded through fees collected from brandowners who are licensed to use the Rechargeable Battery Recycling Corporation (RBRC) Seal. A license fee is paid for each cell within a battery or battery pack that displays the RBRC Seal. Fees are paid by companies based on the weight of batteries put on the market during the previous calendar quarter. The fees are set by RBRC. The RBRC budget is negotiated with the largest licensees. Once funds are allocated for the different budget items such as education, collection and recycling and the total is determined, the revenues needed are divided by the amount of batteries placed on the market, to calculate the fees.
Operational structures	This voluntary program was founded in the United States in 1994 and was established in Canada in 1997. Battery manufacturer members of the Portable Rechargeable Battery Association (PRBA) set up the RBRC to physically administer the collection and recycling of rechargeable batteries and to license its seal to fund the system. RBRC has two divisions: 1) the Recycling Division that administers the public education, collection, and recycling programs; and 2) the Finance and Seal Administration Division that licenses and administers the RBRC Seal to raise the funds to finance the system. Licensees can apply for rebates on cells not sold in the North American market or those exported before final retail sale. They can also apply for partial rebates if they set up their own collection system and ship the batteries directly to an RBRC recycling facility so that double payment is avoided. RBRC has set up four separate collection systems from: 1) retailers; 2) communities; 3) business and public agencies; and 4) licensees. Batteries from the collection systems are transported to consolidation points. From these consolidation points the batteries are shipped to the International Metals Reclamation Company (INMETCO) in Ellwood City, Pennsylvania, where they are recycled.

“Charge Up To Recycle!” – United States and Canada	
Social issues	Despite the fact that over 200 Rechargeable Battery Recycling Corporation licenses represent about 90 per cent of the producers of rechargeable batteries in North America, the program accepts all eligible rechargeable batteries. The producers that do not pay for, and thus do not display the Rechargeable Battery Recycling Corporation seal are free-riders
Technical issues	At INMETCO, cadmium is reclaimed through a thermal process and used as a raw material in the manufacture of new batteries. The recovered nickel and iron are used to make stainless steel products. Other materials are refined to their raw state and sold for various uses. At present this facility processes all collected batteries. The program would not be possible without the processing / recycling infrastructure in place to handle the quantities and various types of batteries collected.
Participation and outcomes	In 2000, the Rechargeable Battery Recycling Corporation reported the following collection amounts for rechargeable battery collection programs in the United States and Canada: In 1995, 2,700,000 pounds were collected; in 1996, 3,100,000 pounds were collected; in 1997, 3,000,000 pounds were collected; in 1998, 3,700,000 pounds were collected; and in 1999, 3,500,000 pounds were collected.
Influence on design decisions	None known to date. However, since the fees for the program depend on the weight of batteries put on the market, it would be in a company’s best interest to design light-weight batteries. However this would not necessarily equate to more efficient or less toxic battery designs.
Kerbside influence	Less rechargeable batteries in kerbside collections

Appendix B

Reference List of EPR/PS/PR Schemes

Country	EPR scheme	Inception	Reference
Ireland	Plastic Bag Environmental Levy	4 March 2002	http://oasis.gov.ie/public_utilities/waste_management/plastic_bag_environmental_levy.html
Australia	National Packaging Covenant	Mark I – 1999 Mark II – 2005	http://www.deh.gov.au/settlements/waste/covenant/index.html
	South Australian Container Deposit Legislation	1975	http://www.deh.gov.au/pcepd/economics/incentives/deposit.html
	DrumMUSTER	2000	http://www.drummuster.com.au
	ChemClear	1999	http://www.chemclear.com.au
	Waste oil product stewardship	2001	http://www.oilrecycling.gov.au
	Mobile phones	1998	http://www.amta.org.au/aoi.asp?ID=Recycling
United Kingdom	Producer Responsibility for Packaging Waste	1997	http://www.environment-agency.gov.uk/business/444304/444641/595811/136872/?lang=_e
	WEEE	In progress	http://www.sepa.org.uk/producer/weee.htm
Sweden	Motor Vehicles	1975	http://www.internat.naturvardsverket.se/index.php3?main=/documents/issues/prodresp/prodresp.htm
	Packaging	1994	http://www.internat.naturvardsverket.se/index.php3?main=/documents/issues/prodresp/prodresp.htm
	Tyres	1994	http://www.internat.naturvardsverket.se/index.php3?main=/documents/issues/prodresp/prodresp.htm
	Waste Paper	1996	http://www.internat.naturvardsverket.se/index.php3?main=/documents/issues/prodresp/prodresp.htm
	Office Paper	1997	http://www.internat.naturvardsverket.se/index.php3?main=/documents/issues/prodresp/prodresp.htm
	Electrical & Electronic Products	2001	http://www.internat.naturvardsverket.se/index.php3?main=/documents/issues/prodresp/prodresp.htm
United States (& Canada)	Charge Up To Recycle – program for batteries	US – 1994 Canada – 1997	http://www.rbrc.org/retail/index.html
	National Beverage Producer Responsibility Act of 2003	2003	http://www.grrn.org/beverage/jeffords/index.html

Country	EPR scheme	Inception	Reference
Germany	DSD – Green Dot Program for packaging End-of-Life Vehicles Take-Back	1991 1998	http://www.gruener-punkt.de/DER_GR_NE_PUNKT.50+B6Jkw9MQ__.0.html http://www.bmu.de/comm.ch/waste_management/downloads/doc/3240.php
European Union Member States	End of Life Vehicles Directive 2000/53/EC	2000	http://europa.eu.int/comm./environment/waste/elv_index.htm
European Union Member States	Packaging Directive 94/62/EC	1994	http://europa.eu.int/comm./environment/waste/packaging_index.htm
European Union Member States	Waste Electrical and Electronic Equipment Directive 2002/96/EC	2002	http://europa.eu.int/comm./environment/waste/weee_index.htm
European Union Member States	Restriction of Hazardous Substances Directive 2002/95/EC	2002	http://europa.eu.int/comm./environment/waste/weee_index.htm
Norway	EPR for WEEE	2005	http://www.environ.ie/DOEI/DOEIPol.nsf/wvNavView/Waste+Electrical+&+Electronic+Equipment?OpenDocument&Lang=
Japan	The Container and Packaging Recycling Law The Electric Household Appliance Recycling Law	1997 2001	http://www.jemai.or.jp/english/dfe/pdf/19_1.pdf http://www.jemai.or.jp/english/dfe/pdf/19_1.pdf
Canada	Batteries Beverage containers Electronic & Electrical Equipment General solid & hazardous waste Multi-materials Oil & Oil-related Products	Various	http://www.ec.gc.ca/epr/inventory/en/sector.cfm

Country	EPR scheme	Inception	Reference
	Paint Paper Pesticides Pharmaceuticals Refrigerants Tyres		
Netherlands	Dutch Packaging Covenant	1991	http://www.oecd.org/LongAbstract/0,2546,en_33873108_33873626_2674905_1_1_1_37425,00.html

Appendix C

Embodied Energy and Inherent Energy References

Embodied Energy and Inherent Energy References

Material Type	Embodied Energy (MJ/kg)	Calorific Value (Inherent energy) MJ/kg
Paper	36[2]	15-19[9]
Recycled Paper	23[2]	15-19[9]
Food – Unprocessed plant	2.3[3]	6.6[10]
Food - Processed	27[4]	6.6[10]
Garden Organics	0.5[5]	8.5[9]
Hardwood/Softwood	3[6]	15-17[11]
Engineered Timber	10[7]	15-17[11]
Cotton	143[2]	13.5[12]
Synthetic Rubber	110[1]	28.5 - 35[9]
Glass	13[1]	0
General Plastic	90[1]	29-40[11]
Polyethylene Terepthalate (PET)	107[2]	29-40[11]
High Density Polyethelene (HDPE)	103[2]	29-40[11]
Polypropylene	64[2]	29-40[11]
Expanded Polystyrene	117[2]	29-40[11]
Polyvinyl Chloride (PVC)	70[2]	22.5[9]
Recycled Plastic	36[8]	29-40[11]
Steel General	32[2]	0[13]
Steel Recycled	10[2]	0[13]
Aluminium	170[1]	0[13]
Recycled Aluminium	8[2]	0[13]
Concrete	2[1]	0
Coal (for comparison)[14]	1	27.5

[1]Technical Manual Design for Lifestyle and the Future (2004) - http://www.greenhouse.gov.au/yourhome/technical/fs31.htm

[2]Centre for Building Performance Research, Victoria University of Wellington, New Zealand http://www.vuw.ac.nz/cbpr/documents/pdfs/ee-coefficients.pdf

[3]Stepping Forward (2005) 'Deriving the ecological footprint results: Component by component' - http://www.steppingforward.org.uk/tech/compbycomp.htm - conservative average of Pulses 5, Cereals 4, Starchy root 2, Vegetables 1, Fruits 1, Eggs 1 = 2.3

[4]Stepping Forward (2005) 'Deriving the ecological footprint results: Component by component' - http://www.steppingforward.org.uk/tech/compbycomp.htm - average of Confectionary 43, Vegetable Oils 21, and Miscellaneous 17 = 27

[5]Garden Organics use air dried sawn hardwood = 0.5 from [1] as proxy to account for transportation and energy in cutting

[6]Hardwood/softwood = average of Kiln dried sawn softwood 3.4, Kiln dried sawn hardwood 2.0, Air dried sawn hardwood 0.5 = 2.0 from [1]

[7]Engineered Timber = average of Hardboard 24.2, Particleboard 8, MDF 11.3, Plywood 10.4, Glue-laminated timber 11, and Laminated veneer lumber 11 = 12.5 from [1]

[8]Based on a study where recycled polyethylene carrier bags reduced energy consumption by two thirds. Waste Online (2004), 'Plastic Recycling Information Sheet', http://www.wasteonline.org.uk/resources/InformationSheets/Plastics.htm

[9]C-tech Innovation (2003), 'Thermal methods of municipal waste treatment', http://www.hm-treasury.gov.uk/media/C43/44/Thermal_Methods_mass_balance.pdf

[10]Andersson, C., Gough, C., Hedlund, J. and Paz A. (2001), 'Municipal Waste for Energy Production at Uppsala Energi', http://www-sml.slu.se/sve/kurser/aktsopu.pdf

[11]WRc, IFEU, ECOTEC and Eunomia (2003). 'Refuse Derived Fuel, Current Practice and Perspectives (B4-3040/2000/306517/Mar/E3) - Final Report', http://europa.eu.int/comm/environment/waste/studies/pdf/rdf.pdf – assumes moisture content of 10 – 15 per cent

[12]Andersson, *et al* (2001) – figure for textiles

[13]However it is noted that thin foils and filings, when in composite materials or subjected to high enough temperatures, have the ability to oxidise and release energy.

[14]Fording Coal Limited 1999 Report to the Voluntary Challenge and Registry Inc. http://www.ghgregistries.ca/registry/out/C0657-FORDINGCOAL-PDF.PDF - note that embodied energy was rounded up to 1 MJ/kg.

Appendix D

Survey of Urban Residual Data

Survey of Urban Residuals Data

Method

The following data was collated through extensive Internet and database searches, and consultation with international contacts on the IEA Bioenergy Task 36 committee. The Task 36 committee comprises representatives from the UK, Sweden, France, Australia, Canada, Finland, Japan and Norway. Little data was available regarding the composition of urban residuals, as demonstrated in the following summary of data collected (see following page).

Limitations

During the research phase it became clear that the method for categorising waste and residuals streams varied significantly from country to country and from year to year even within individual countries. This means that direct comparisons between years and countries is not entirely meaningful. Moreover, the data which presents average residuals compositions for individual countries is not sufficient to provide any indication of the effects of regional or state / province based EPR / PS efforts. Nor is it really sufficient to confirm any real cause and effect for on a countrywide basis.

As noted in Section 6, there have been other significant influences on waste and residuals composition, some concurrent to EPR / PS. Hence it is not possible to attribute any observed changes in the characteristics of the waste / residuals streams to EPR alone or individual EPR / PS efforts.

UK 1935

Component	Percentage
Ash/dust	57%
Vegetable/Bone	14%
Paper and Rag	16%
Metal and Glass	7%
Plastic	0%
Miscellaneous	6%
Total	**100%**

source: ICE 2006

UK 1955

Component	Mass (M/tn)	Percentage
Coal ash	4.60	43%
Paper/card and rags	0.70	6%
Metals	0.40	4%
Glass	0.30	3%
Food Waste	0.50	5%
Plastics	-	0%
Garden Waste	1.00	9%
Other	3.30	31%
Total	10.80	**100%**

source: ICE 2006

US 1975

Component	Mass (kg)	Percentage
Paper and Board	0.29	41%
Metal	0.09	13%
Glass	0.10	15%
Food Waste	0.18	26%
Plastics	0.03	5%
Total	0.70	**100%**

source: Alter, H. 1989, The Origins of Municipal Solid Waste: The Relations Between Residues from Packaging Materials and Food, Waste Management & Research Vol 7, pp. 103-114

USA 1995

Component	Percentage
Paper and board	32%
Glass	6%
Ferrous Metals	5%
Aluminum	1%
Other Non-Ferrous	0%
Plastic	12%
Rubber and Leather	4%
Textiles	4%
Wood	9%
Food Waste	9%
Garden Waste	14%
Misc Inorganic	2%
Other	2%
Total	**100%**

source: Franklin Associates 1997

Switzerland 2001/2002

Component	Mass kg	Percentage
Organic	60.3	30%
Minerals	11.1	5%
Non-ferrous metal	2.6	1%
Iron	3.3	2%
Electonics and electrical	1.2	1%
Paper	35.5	18%
Packaging	8.7	4%
Total plastics	30.4	15%
Cardboard	8.7	4%
Composite materials	25.7	13%
Glass	9	4%
Textiles	6	3%
Total	**202.5**	**100%**

source: Composition of waste in rubbish bags in Switzerland (2001/2002), Swiss Agency for the Environment, Forests and Landscape (SAEFL)

Component	Mass kg	Percentage
Paper / cardboard	5,170	17%
Putrescibles	12,202	40%
Textile	1,063	4%
Fines	1,254	4%
Miscellaneous combustible	3,124	10%
Miscellaneous non-combustible	1,342	4%
Metals	1,740	6%
Glass	1,802	6%
Plastics	2,635	9%
Total	30,332	100%

Source: Oakdene Hollins. 2005, *Quantification of the Potential Energy from Residuals (EfR) in the UK*, Commissioned by The Institution of Civil Engineers and The Renewable Power Association

Household residual waste data is available (1998-1999) for the Netherlands for the 15 main components of residual household waste:

Component	1998%	1999%
Bio-waste and undefined residue	33.50%	32.30%
Paper/cardboard	32.20%	32.90%
Plastics	11.80%	12.30%
Glass	4.00%	3.50%
Ferrous metals	3.50%	3.70%
Non-ferrous metals	0.70%	0.70%
Textiles	2.70%	3.50%
Bread	2.00%	2.00%
Animal refuse	2.50%	1.90%
Ceramics	2.50%	2.80%
Carpeting/mats	1.00%	0.20%
Leather/rubber	0.90%	1.20%
Wood	2.30%	2.40%
Special waste	0.30%	0.40%
Small chemical waste	0.40%	0.30%
Total	100%	100%

samenstelling ven het Nederlandse huishoudelijk restafval RESTULTATEN 1998 en 1999, RIVM rapport 776221005/2002

New Zealand 1995

Component	Mass kg	Percentage
Paper		19%
Plastic		7%
Glass		3%
Metal		6%
Organic		50%
Potentially hazardous		1%
C&D non wood		6%
C&D wood		4%
Other		4%
Total		**100%**

source:http://www.mfe.govt.nz/publications/waste/greenhouse-gas-

France 2002

Component	Mass kg	Percentage
putrescible waste	104.4	29%
papers paperboards	90	25%
glass	46.8	13%
plastic	39.6	11%
metals	14.4	4%
other	64.8	18%
Total	**360**	**100%**

source: http://www.reduisonsnosdechets.org

Australia 1994

Component	Mass kg	Percentage
Putrescibles		46%
Paper		24%
Plastics, glass, metals		26%
Other		4%
Total		**100%**

source: http://rise.org.au/reslab/refiles/biomass/text.html

USA 1997

Component	Mass kg	Percentage
Paper and Paperboard		39%
Glass		6%
Ferrous Metals		6%
Aluminum		1%
Other Non-Ferrous		1%
Plastic		10%
Textiles		4%
Wood		5%
Food Waste		10%
Yard Waste		13%
Rubber & Leather		3%
Other Waste		3%
Total		**100%**

source: http://www.epa.gov/greenkit/2swaste.htm

Australia 1995: the domestic waste stream

Component	Mass kg	Percentage
Putrescibles		56%
Paper		19%
Plastics		6%
Glass		5%
Metals		3%
Other		11%
Total		**100%**

source: http://www.epa.nsw.gov.au/soe/97/ch5/4_2.htm

Residual MSW = Total MSW – (recycled or composted MSW)

Phillipines 2003

Component	Mass kg	Percentage
putrescible waste		45%
paper		16%
glass and wood		9%
plastic		15%
metals		
other		15%
Total	**360**	**100%**

source: http://www.sea-uema.ait.ac.th/snp/tp3/Cardenas_Issues.pdf

UK 2003

Component	Mass kg	Percentage
Paper and card		35%
Plastic film		4%
Dense plastic		5%
Textile		2%
Misc. combustible		8%
Misc. non-combustible		2%
Glass		7%
Putrescibles		19%
Ferrous		6%
Non-ferrous		1%
Fine fraction (<10mm)		11%
Total		**100%**

source: http://www.ieabioenergy.com/media/40_IEAPositionPaperMSW.pdf

UK - Various dates

Year	Total	Paper	Glass	Metals	Screenings	Unclassified	Putrescibles	Textiles	Plastics	Volume/H.w	Density kg/m^2
1930										69.6	
1931	24.5									69.6	
1932	20									56.8	
1933											
1934											
1935	18.8	2.1	0.6	0.7	11.1	1.2	2.9	0.35		53.4	352
1936	14.3	2.4	0.4	0.4	7.5	1.2	2.4	0.2		42.9	333
1937	16.45	2.7	0.5	0.6	9.7	0.9	1.6	0.3		49.1	335
1938	16.3	2.4	0.8	0.7	6	1.6	1.4	0.2		44.7	365
1939											
1940											
1941											
1942											680
1943											
1944											
1945											
1946	11.1										
1947											
1948	10.8	0.7	0.4	0.4	7.8	0.9	0.3	0.2		24.9	433
1949	12.5									32.6	383
1950	11.7	1.1	0.5	0.7	8.2	0.7	0.6	0.2		36.8	320
1951											346
1952	12.3	0.8	0.7	0.6	7.2	2	1	0.1		32.5	378
1953											329
1954											336
1955	10.5	1.2	0.7	0.6	6.6	0.6	0.7	0.1		31.9	329
1956											
1957											
1958	12.45	3.15	1.1	0.8	6.9	1.6	0.7	0.3		65.2	191
1959				.							
1960	14.2	2.4	0.8	0.6	5	0.5	3	0.2		55.9	254
1961											
1962	10	3.3	0.8	0.8	4.2	0.5	1.4	0.2		42.4	246
1963	14.1	4.25	1	0.5	6.9	0.8	2.3	0.3		70.5	200
1964	12.8	3.8	0.9	0.7	0.9	1.3	2.2	0.3		83.3	153
1965		2.4	0.9	0.8	6.9	0.9	1.2	0.2			230
1966											
1967	13	4	1	1.2	3.5	0.5	2.3	0.3	0.2	81.2	160
1968	13.3	4.9	1.2	1.2	2.9	0.3	2.3	0.3	0.2	84.7	157
1969	12.8	5.4	1	1	2	0.3	2.3	0.3	0.2	89.5	143
1970	13	6.1	1	1	1.9	0.3	2.5	0.4	0.2	92.5	166
1971											
1972	11.7	5	1.2	1	2.3	0.7	2.3	0.4	0.2	76.5	153
1973	11.7	3.6	1.2	1	2.2	0.7	2.1	0.4	0.2	76.6	151
1974	10.7	3.8	1	1.4	2	0.9	2	0.5	0.3	66.5	161
1975	11.4	3.8	1	0.9	2.1	0.8	1.9	0.5	0.5	70.7	164
1976	10.2	2.6	1	0.8	1.7	1	2.4	0.3	0.5	67.1	152
1977	10.1	2.9	1.2	0.9	1.3	0.6	2.5	0.5	0.5	80.2	126
1978	10.9	3	1	0.8	1.2	0.7	3.2	0.4	0.6	77.3	141
1979	11	3.6	1.1	0.9	1.5	0.5	2.5	0.4	0.8	78.2	141
1980	11.2	4	1	1	1.4	0.4	2.4	0.3	0.8		
1981	9.8	3.6	1.2	0.7	0.5	0.6	2.7	0.3	0.7		
1982		3.2	1.1	0.9	1.5	0.4	2.9	0.4	0.8		

source: Bridgewater, A. V. 1986, *Refuse Composition Projections and Recycling Technology* , Resources and Conservation, vol 12, pp. 159-174, Elsevier Science Publishers, Amsterdam
Provided by Grace Gordon (UK)

Various countries - various dates

Coutry	City	Year	Paper and board	Metal	Glass	Food waste	Plastics
Austria	Vienna	1975	0.383	0.081	0.092	0.186	0.061
Austria	Vienna	1982	0.403	0.049	0.081	0.224	0.09
Belgium	Average	1976	0.3	0.053	0.08	0.4	0.05
Bulgaria	Sofia	1977	0.1	0.017	0.016	0.54	0.017
Columbia	Medellin	1979	0.22	0.01	0.02	0.56	0.05
zechoslovak	Prague	1975	0.134	0.062	0.066	0.418	0.042
Denmark	Average	1978	0.329	0.041	0.061	0.44	0.068
England	Average	1970	0.45	0.04	0.08	0.13	
England	Average	1969	0.38	0.097	0.106	0.195	0.014
England	Average	1935-6	0.143	0.04	0.034	0.138	
England	Average	1963	0.23	0.082	0.086	0.141	
England	Average	1967	0.295	0.08	0.081	0.155	0.012
England	Average	1968	0.369	0.089	0.091	0.176	0.011
England	Doncaster	1985	0.21	0.07	0.06	0.15	0.05
England	Doncaster	1982	0.24	0.08	0.08	0.28	0.05
England	Doncaster	1985	0.28	0.09	0.08	0.2	0.07
England	London	1980	0.421	0.11	0.117	0.17	0.04
England	Stevenage	1979	0.33	0.07	0.09	0.16	0.03
Finland	Average	1978	0.55	0.05	0.06	0.2	0.06
France	Laval	1985	0.34	0.05	0.12	0.3	0.06
France	Paris	1979	0.34	0.04	0.09	0.15	0.04
Gabon	Average	1977	0.06	0.05	0.09	0.77	0.03
Germany	Asschen	1974	0.308	0.069	0.135	0.164	0.045
Germany	Aachen	1979	0.31	0.03	0.13	0.16	0.04
Germany	Berlin	1978	0.218	0.049	0.191	0.314	0.06
Germany	Dusseldorf	1974	0.278	0.044	0.164	0.342	0.062
Germany	Hamburg	1975	0.231	0.045	0.227	0.3	0.046
Germany	Munich	1974	0.406	0.061	0.069	0.075	0.075
Germany	Stuttgart	1974	0.147	0.053	0.099	0.524	0.062
Germany	Tubingen	1974	0.137	0.047	0.138	0.443	0.076
India	Calcutta	1976	0.03	0.01	0.08	0.36	0.01
India	Lacknow	1980	0.02	0.03	0.06	0.8	0.04
Indonesia	Bandung	1979	0.1	0.02	0.01	0.72	0.06
Indonesia	Bandung	1978	0.096	0.022	0.004	0.716	0.055
Indonesia	Bogar	1985	0.06			0.8	0.04
Indonesia	Jakarta	1975	0.02	0.04	0.01	0.82	0.03
Indonesia	Jakarta	1978	0.08	0.014	0.005	0.795	0.037
Indonesia	Surabaya	1983	0.02	0.005	0.01	0.94	0.02
Iran	Teheran	1978	0.172	0.018	0.021	0.698	0.038
Italy	Average	1979	0.31	0.07	0.03	0.36	0.07
Italy	Milan	1984	0.3	0.03	0.08	0.39	0.1
Italy	Rome	1980	0.25	0.025	0.013	0.5	0.06
Italy	Rome	1979	0.18	0.03	0.04	0.5	0.04
Japan	Gifu	1985	0.21	0.057	0.039	0.5	0.062
Japan	Mito	1985	0.301	0.015	0.011	0.418	0.056
Japan	kai (new ar	1985	0.23	0.022	0.053	0.541	0.081
Japan	ıkai (old are	1985	0.295	0.039	0.049	0.404	0.071
Japan	Tokyo	1972	0.382	0.041	0.071	0.224	0.073
Japan	Tokyo	1978	0.436	0.012	0.01	0.34	0.056
Japan	Utsonomiya	1985	0.249	0.016	0.015	0.502	0.073
Kenya	Mombasa	1974	0.122	0.027	0.013	0.426	0.01
Netherlands	Amsterdam	1979	0.26	0.03	0.14	0.46	0.06
Netherlands	Average	1974	0.341	0.036	0.055	0.376	0.057
Netherlands	Average	1978	0.222	0.032	0.119	0.5	0.62
Netherlands	Average	1971	0.223		0.081	0.536	0.068
Nigeria	Kano	1980	0.17	0.05	0.02	0.43	0.04
Nigeria	Lagos		0.14	0.05	0.03	0.6	
Norway	Oslo	1985	381	0.02	0.075	0.304	0.065
Pakistan	Lahore	1980	0.04	0.04	0.03	0.49	0.02
Philippine Is	Manilla	1978	0.17	0.02	0.05	0.43	0.04
Spain	Average	1978	0.18	0.04	0.03	0.5	0.04
Spain	Madrid	1979	0.19	0.06	0.03	0.5	0.08
Sri Lanka	Colobo	1981	0.08	0.01	0.06	0.8	0.01
Sudan	Khartoum	1984	0.04	0.03		0.3	0.026
Sweden	Average	1977	0.5	0.07	0.08	0.15	0.08
Sweden	Stockholm	1985	0.39	0.05	0.14	0.15	0.08
USA	Average	1975	0.289	0.093	0.104	0.178	0.034
USA	Average	1973	0.427	0.092	0.103	0.146	0.017
USA	Berkely, CA	1967	0.446	0.087	0.113	0.125	0.019
USA	Estimated	1975	0.29	0.091	0.104	0.178	0.034
USA	Estimated	1971	0.295	0.091	0.096	0.176	0.034
USA	Estimated	1975	0.272	0.153	0.103	0.154	0.032
USA	Estimated	1971	0.293	0.155	0.09	0.164	0.026
USA	Estimated	1975	0.272	0.153	0.103	0.154	0.032
USA	Estimated	1971	0.293	0.155	0.09	0.164	0.026
USA	hnson City,	1968	0.349	0.093	0.09	0.346	0.034
USA	w Orleans,	1972	0.394	0.122	0.146	0.189	0.038
USA	Little Rock,	1978	0.541	0.117	0.082	0.068	0.087
USA	Several	1970	0.442	0.087	0.085	0.166	0.012
USA	ilmington, D	1973	0.337	0.066	0.147	0.165	0.033

source: Alter, H. 1989, *The Origins of Municipal Solid Waste: The Relations Between Residues from Packaging Materials and Food*, Waste Management & Research Vol 7, pp. 103-114
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