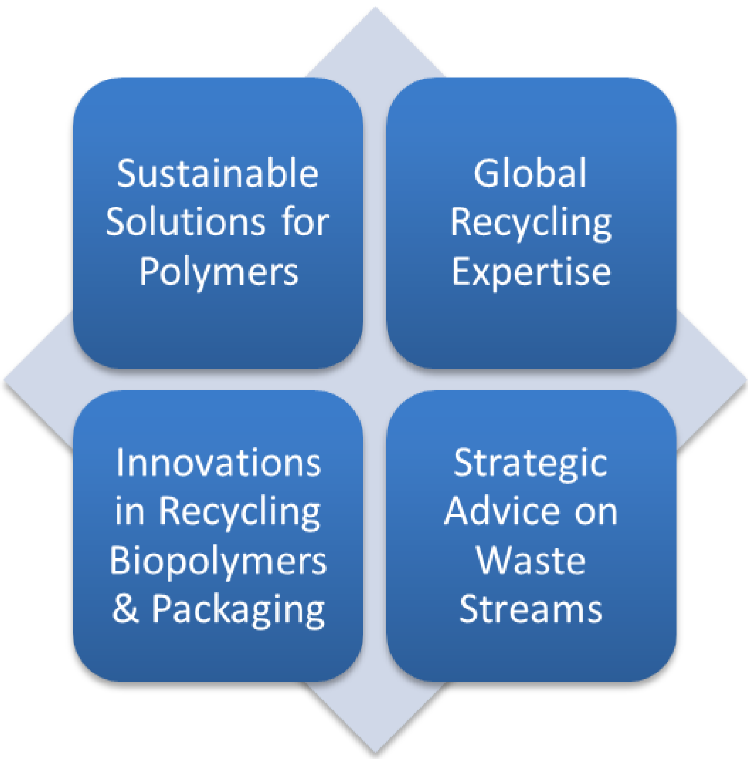
Zero Waste SA

Study on the South Australian plastic packaging resource recovery sector – Stage 2.



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Zero Waste South Australia

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Disclaimer

This report has been prepared for Zero Waste SA. The results and findings are based upon Nextek and Equilibrium's professional judgment, experience and training. These findings are also based upon the reliance of information provided by industry and government respondents and from a range of government and other studies used to prepare this report.

Nextek and Equilibrium have limited the assessment to the scope agreed upon with Zero Waste SA. Nextek and Equilibrium believe that the findings are reasonably supported and that they have been developed according to the professional standard of care for the environmental and sustainability consulting profession in this area at this time.

Executive Summary

Opportunities exist for increased end-of-life plastic packaging recovery and recycling in South Australia. There are significant volumes of end-of-life plastic packaging (and other plastics) going to landfill. There is a high level of collection of waste material, however most of this material is sent directly to landfill or minimally processed, leaving valuable resources in the landfill residue.

Identifying the immediate opportunities for increased recovery is influenced by factors such as the granularity of available data, data quality, ownership and securing materials, material quality specifications, regulatory demands and end-markets. Pathways to increased recovery and recycling have been identified where current information indicates that there is likely to be reasonable amounts of material available for recovery, where financial drivers suggest such recovery is feasible and where technology is available to facilitate recovery in a safe and economical process.

This study has examined the opportunities within three waste streams where plastic packaging (and other plastic) is found by modelling the inputs, cost of processing and value of products produced from:

- Municipal Solid Waste (MSW), recyclables stream
- Municipal Solid Waste (MSW), residual stream
- Commercial & Industrial (C&I) stream.

The assessment looked at whether investment in enhanced primary processing is economically viable in each of the three streams and the benefits of secondary processing after further separation of plastics through a Plastics Recovery Facility (PRF). Investment in the Material Recovery Facility (MRF) is not considered to be viable for any of the streams if only plastics packaging was being recovered. Also none of the three streams contained sufficient volumes of plastic packaging or total plastics to economically justify additional plastics processing after MRF separation. Secondary processing is only viable with a centralised PRF processing material from a number of sources. The Construction and Demolition (C&D) stream was not included in the assessment because the level of packaging plastics is very small, as shown in the stage 1 report.

The summary table below shows the estimated commercial return for the MRF section of the three waste streams modelled.

Total Plant	MSW Recyclables 60,000 tonne MRF	MSW Residuals 120,000 tonne MRF	C&I total 200,000 tonne MRF
[1]Capital Costs	$2,060,438	$2,914,313	$3,682,800
[2]Total Sales	$9,419,077	$6,605,341	$16,070,669
[3]Total Costs	$6,071,703	$16,521,046	$9,207,084
Operating Costs	$101 (per tonne)	$138 (per tonne)	$46 (per tonne)
EBIT	$3,347,374	-$9,915,705	$6,863,585
Profit / Sales ratio	36%	-150%	43%
Payback	0.6 (years)	Loss making	0.5 (years)

1) Excludes building and service connection costs
2) Includes the sales value of materials to PRF section
3) Includes landfill cost of residual after processing

The modelling finds that a modern automated MRF for the MSW recyclables and the C&I stream will recover more plastic packaging in a commercially viable process (along with the recovery of the full range of recyclable materials). There is currently a lack of data on the amount of plastic packaging in the residual fraction from current MRFs that is going to landfill which does not allow the modelling to predict the increased quantity of plastics that can be recovered from these streams.

A modern automated MRF would provide an increased opportunity for secondary processing of the mixed plastic fraction either locally, nationally or internationally, in a PRF process that would separate plastics by material and value-add to a pelletised material or finished product. Since the percentage of plastics in the waste streams is relatively low, a PRF facility would be more viable if it were centrally located and able to take mixed plastics from different locations and suppliers. This function may be more appropriately associated with a secondary processor rather than with the MRF, where the separated and washed plastics can be value-added by conversion to a plastic pellet or finished product.

The financial results from the model shown above are based on a $0 gate fee for the MSW waste streams and a $15/tonne gate fee for the C&I stream. The value of recyclable materials is estimated at a recovery efficiency of 80%, with the remaining 20% of recyclables, as well as all contaminants such as organics, hazardous and other materials being landfilled at a cost of $100/tonne. A transfer price of $100/tonne is used for the mixed plastic being sold from the MRF to the PRF sections. The value of the non-CDL mixed plastics fraction is shown in the table below and represents 4% of the total sales value reinforcing the point made earlier that further separation will not yield significant revenues. The cost of disposal of the landfill fraction is a major factor in the viability of the MRF sorting process, and improved recovery yields can help minimise that cost. Plant operating efficiencies and the composition of the in-feed are other important cost components.

Value of all Recyclable fractions separated at the MRF stage for all three waste streams modelled

Recyclable Fraction	MSW Recyclables $ / 60,000 tonnes processed	MSW Residuals $ / 120,000 tonnes processed	C&I total $ / 200,000 tonnes processed
Steel	$466,106	$670,656	$9,836,288
Aluminium	$85,658	$311,691	$2,694,025
Aluminium CDL	$565,387	$1,171,770	
Glass	$177,962	$66,726	$24,432
Glass CDL	$857,407	$503,110	
LPB	$42,770	$20,373	$534,613*
LPB CDL	$175,449	$173,451	
Paper / Cardboard	$5,648,513	$2,170,019	$2,128,600*
PET CDL	$925,869	$560,019	
HDPE CDL	$65,993	$207,130	
PVC CDL	$21,888	0	
All non-CDL plastics	$386,075	$750,395	$9,927,351*

* Separated in the auto NIR section after MRF section

The definition of the volume and type of packaging plastics and other materials that are currently being landfilled after processing through existing MRF facilities would be improved with additional data and enable further recommendations to be made. Strict enforcement of landfill bans may result in an increased effort to extract additional plastics through existing processes, however without investment in automated sorting systems, the additional costs of that extraction operation may have an overall negative impact.

Increased constraints on material exported to China based on the recent "Green Fence" initiative by Chinese authorities may also impact the local and national market, forcing additional sorting and processing, or it may result in additional landfilling of materials that are low value and not cost effective to process further and can no longer be exported.

Other interventions to improve the demand for products with recycled materials include updating of specifications and regulations to enable recycled products to be more easily used by engineers and more prominent for purchasers by having recycled materials specified as suitable products for a wide range of applications.

Interventions can also be made on the supply side of the issue by providing consumers with means to enhance existing recycling practices.

Key findings

The Stage 2 study has determined that there are significant amounts of plastic packaging in the Municipal Recycling, Municipal Residual and C&I streams, consistent with findings from the Stage 1 study. However the concentration and commercial value of these materials is low, and of itself the value of the plastic packaging fraction does not justify the cost of separation. Modelling the MRF process as a whole operation separating all of the recyclable materials, with the separation of all plastics (including plastic packaging) into a mixed stream as just one of the material fractions sorted, the MRF process is estimated to be commercially viable for the MSW recyclable and C&I streams. The MSW Residual stream remains unviable.

The promotion of improved source separation, by having food waste placed in the green (organics) bin and soft film plastic material into the recyclable bin for the Municipal kerbside collection, would reduce the contamination of the residuals bin and reduce contamination of the soft film plastics making recovery possible at lower cost. The Municipal Recyclables MRF would need to be designed to handle soft film waste either as a loose element or with a "Bag in Bag" program that consolidates such plastics for improved quality, lower sorting costs and easier separation.

The use of new sorting technologies, including automated Near Infra-Red (NIR) sorting, would provide improved recovery of the low value plastic packaging fraction, which otherwise would be more expensive to recover by manual sorting. There may also be automated vision systems capable of selecting the many types of CDL containers reducing the labour cost of the sorting operation of the MRF. Commercial modern automated MRF operations can be identified in a number places in the world. The Viridor MRF at Ford in West Sussex UK is a good example.

The mixed plastic fraction from the MRF can be further processed by washing and pelletisation processes to manufacture materials suitable for a range of applications. The modelling shows that a PRF is not viable as a stand-alone business if the plastics are sorted into polymer types and sold as baled materials.

Due to the relatively low percentage of plastic packaging materials in the waste streams a single large MRF does not generate sufficient plastic material to justify its own PRF and secondary processing. Having a centralised PRF and associated secondary processing able to accept material from a range of sources, for secondary processing and value adding is estimated to be a more viable proposition.

There are large residue fractions after MRF sorting consisting of a range of what is currently considered contamination which, on industry advice, is mostly organic material. The disposal cost of these materials to landfill represents a significant cost to the MRF operation, and the possibility of using an alternative waste treatment to generate energy could also be considered to enhance materials recovery and commercial viability.

Recommendations

- Conduct audits of current waste streams going to landfill from MRFs to determine what additional material could be extracted using a modern automated MRF operation, and improve the model estimations.
- Review investment options for a modern MRF facility of about 60,000 tpa capacity for the Municipal recyclables stream.
- Review investment options for a modern MRF facility of about 200,000 tpa for the Commercial & Industrial (C&I) stream.
- Develop strategies to commence the collection of soft plastic film in the Municipal Recyclable stream, in concert with a soft film capable MRF and possible consolidation of such plastics with a "Bag in Bag" type program.
- Promote wider implementation of the diversion of food waste into the green waste bin.
- Develop supply chain strategies (supermarkets, convertors and recyclers) to reduce the level of plastics going to landfill by ensuring that plastics that enter the consumer household are readily recyclable within current MRFs/PRFs.
- Promote the testing of products using recycled plastics to establish their technical characteristics and performance capabilities, to remove unnecessary barriers based on material specifications and regulatory guidelines.
- Assist local recyclers with the development of business plans and the implementation of strategies for a plastics recycling facility (PRF), as a front-end process to the manufacture of pelletised recycled plastics or finished goods.
- Encourage continuity of supply through longer term collection and recovery contract arrangements in order to attract the required capital investment in MRF / PRF facilities from private businesses.

Table of Contents

Tables and Figures

Abbreviations

Alternative fuel	**A fuel usually derived from renewable sources, used as an alternative to fossil fuels.**
APC	Australian Packaging Covenant; A co-regulatory initiative by Australian governments and industry to reduce the environmental effects of packaging
CDL / **Container deposit**	Sometimes referred to as container deposit legislation or CDL. A refundable charge imposed on a range of recyclable beverage containers. The deposit is included in the retail price and refunded when the container is returned to a collection point
Commercial and industrial waste (C&I)	Comprises solid waste generated by the business sector as well as solid wastes created by state and federal government entities, schools and tertiary institutions. Unless otherwise noted, C&I waste does not include waste from the construction and demolition (C&D) sector
Construction and demolition waste (C&D)	Includes waste from residential, civil and commercial construction and demolition activities, such as fill material (e.g. soil), asphalt, bricks and timber. C&D waste excludes construction waste from owner/occupier renovations, which are included in the municipal waste stream. Unless otherwise noted, C&D waste does not include waste from the commercial and industrial waste stream.
e-waste	End-of-life electrical and electronic equipment, including computers, televisions, monitors, household electrical appliances, batteries (but not automotive).
Expanded Polystyrene (EPS)	A foam version of polystyrene used in packaging.
Gasification	Gasification is where organic and carbonaceous materials are converted in a controlled oxygen environment to produce gases (syngas) that can then be burnt in gas engines or converted to liquid fuels.
High density polyethylene (HDPE)	A member of the polyethylene family of plastics and is used to make products such as milk bottles, pipes and shopping bags. HDPE may be coloured or opaque.
Kerbside collection	Collection of household waste, recyclable materials (separated or co-mingled), and organic waste that are left at the kerbside for collection by local council collection services.
Low density polyethylene (LDPE)	A member of the polyolefin family of plastics. It is a flexible material and usually used as film for packaging or as bags.

Melt filter	Process of removing small unmelted contaminants from the plastic melt during the extrusion process to improve quality.
Mixed/Other Plastics (MIX)	Plastics containing material that cannot be classified by PIC Codes 1-6 and/or cannot be identified by polymer and/or which is aggregated or too contaminated so it cannot be easily separated and recycled as an individual polymer.
MRF	Materials Recycling or Recovery Facility – A resource recovery facility where mixed or comingled waste material is separated into constituent materials to enable recycling.
Municipal solid waste (MSW)	Solid waste generated from domestic (household) premises and council activities such as street sweeping, litter and street tree lopping. May also includes waste dropped off at recycling centres, transfer stations and construction waste from owner/occupier renovations.
NIR	Near infra-red.
PACIA	Plastics and Chemical Industries Association of Australia.
Packaging	Material used for the containment, protection, marketing or handling of product.
Plastics	Can refer to materials made from a range of synthetic or natural organic materials, including polymers, cellulose derivatives, casein materials, and protein, which can be shaped when soft and then hardened. Plastics are widely used to make many industrial and consumer goods. The most commonly used plastics are manufactured from industrial chemicals derived from oil and gas – including ethylene, styrene and propylene.
Plastics Identification Code (PIC)	Numeric system of labelling of plastic materials by polymer, voluntarily used and imprinted on plastic packaging by plastics manufacturers in Australia and overseas.
Polyethylene terephthalate (PET)	A clear, tough, light and shatterproof type of plastic, used to make products such as soft drink bottles, film packaging and fabrics.
Polypropylene (PP)	A member of the polyolefin family of plastics. PP is light, rigid and glossy and is used to make food packaging containers, film and products such as washing machine agitators.
Polystyrene (PS)	A member of the styrene family of plastics. PS is easy to mould and is used to make refrigerator and washing machine components. It can be foamed to make single use packaging, such as cups, meat and produce trays.
Polyvinyl chloride (PVC)	A member of the vinyl family of plastics. PVC can be clear, flexible or rigid and is used to make products such as fruit juice bottles, credit cards, pipes and hoses.

Post-consumer material	Material generated by households or by commercial, industrial and institutional facilities in their role as end-users of the product which can no longer be used for its intended purpose. This includes returns of material from the distribution chain.
Pre-consumer material	Material diverted from the waste stream during a manufacturing processes for reprocessing at a different site. Excluded are waste materials that are reclaimed and reutilised within the same manufacturing processes that generated it as a matter of course to the efficient operation of the site (i.e. process scrap).
PRF	Plastic recovery facility.
Primary Processing	This term generally refers to the initial or primary resource recovery steps for waste material, which usually includes separation and aggregation of material(s) so that it can be re-processed for recycling.
PEF / Processed Engineered Fuel	A fuel derived from waste materials that is used as a partial replacement for fossil fuels. Also called Resource Derived Fuel / Solid Recovered Fuel / Specified Recovered Fuel.
Product stewardship	An approach whereby the producer of a product takes responsibility for the life-cycle management of that product, including end-of-life management. Such systems can be voluntary, co-regulatory or mandatory.
Pyrolysis	An oxygen free process that converts waste materials, including plastics, into syngas and liquid fuels.
Recovered material	Material that would have otherwise been disposed of as waste, but has instead been collected and reclaimed as a material input, in lieu of a new primary material, for a recycling or manufacturing process.
Recycling	Material that has been reprocessed from recovered material by means of a manufacturing process and made into a final product or into a component for incorporation into a product.
Reprocessing	Changing the physical structure and properties of a waste material that would otherwise have been sent to landfill, in order to allow it to be reused or re-incorporated into manufactured products.
Resource Derived Fuel	See Processed Engineered Fuel.
Secondary Processing	The secondary stage of resource recovery where recovered materials are further separated and/or re-processed into the form of a substitute to virgin material which can be recycled.
Solid waste	Waste materials ranging from municipal garbage to industrial waste, but excluding gaseous, liquid, hazardous, clinical and intractable wastes.
Syngas	Also called synthetic gas and refers to fuel gas that is derived from biomass or waste-to-energy gasification processes.
W2REPP	SA Environment Protection (Waste to Resources) Policy 2010.

WRAP	Waste and Resources Action Programme, A United Kingdom initiative facilitating waste recovery and recycling programs, studies and activities.
XRT	X-ray transmission.

1. Scope of work and methodology

The scope of this stage 2 study is to identify the potential to improve the value, volume and market opportunities for recycled plastics in South Australia and to optimise the use of such resources. It is to develop an understanding of new and emerging processing technologies and recommend opportunities for local plastic packaging resource recovery industry development.

The starting point for this project has been to ensure detailed and accurate gathering of information with respect to current plastic packaging volumes and types, test the opportunities for increased recovery, review options for expansion of current recycling / reprocessing operations and identify potential for application of new technologies.

An in-depth analysis of the current and potential future plastics packaging resource recovery and recycling opportunities has been undertaken.

A. Market analysis

The approach taken employs both top-down and bottom-up methods to ensure information is complete and accurate.

The top-down approach uses the *Stage 1 Final Report – Study on the South Australian Plastics Packaging Resource Recovery Sector* as a foundation as it provides a comprehensive start to understanding the types, volumes and streams of plastics in South Australia. Nextek and Equilibrium augmented the Study with industry market intelligence (locally and nationally) to form a big picture view of the current South Australian and Australian market, highlighting current market drivers, opportunities and barriers.

The bottom-up approach entailed more detailed on-the-ground assessment. Through face-to-face meetings and electronic communications, Nextek and Equilibrium used existing contacts and desk-top research to examine in detail:

- Material recovery facilities (volume, quality, contamination, market conditions, commercial drivers, planned changes and general operating conditions)
- Other plastics feedstocks (industrial sources of "waste" plastics that may be available for recovery and recycling)
- Current processors and recyclers (local beneficiation and processing facilities general operating, opportunities and barriers)
- End-users and demand (local and national sell price, quantity, quality and general competitive environment)
- Supply chain options
- Other measures.

This work provides a comprehensive picture, as far as possible by polymer type, of opportunities for increased recovery in South Australia, increased recycling (in South Australia and nationally) and end-markets for recycled polymers.

In accordance with the Specification for this stage 2 study, the focus is on plastic packaging however Nextek and Equilibrium also bring to the project existing industry knowledge of other "waste" plastic streams as any such volumes may impact the potential for expansion of existing facilities or establishment of new ones.

B. Technology review

In recent years there have been a large number of advances in the development of technologies used in the collection and processing of recycled materials. Automation of a large number of processes, coupled with increased reliability capacity and efficiency has provided opportunities to recover and process a larger number of materials at lower cost and with improved purity. As a result of these developments recycled materials of high quality can be produced for a wider range of applications including food grade application, low odour products and high purity streams not previously available.

A comprehensive list of available systems and their capabilities that are suited to the material and operational environment in the South Australian market has been developed. Nextek has significant experience with the design and operation of both MRF processes (primary processing) as well as value adding to recycled materials through PRF systems, that may involve cleaning / washing, melt filtering, removal of volatiles, pelletising and conversion (secondary processing).

By reviewing the market analysis, technologies and processes best suited to the material and end market application, opportunities that can be utilised by local reprocessors can be identified.

C. Recommendations for equipment and processing.

Based on the market analysis data, some technologies may be better suited to the requirements of the South Australian recycling market place given volumes, ratios of particular materials in the recycled stream and targeted end market applications. Using the market data, target materials / applications can be identified as opportunities and examples provided for how selected recycling and processing systems can provide an optimal outcome for recycling and reprocessors.

Nextek has relationships with key European equipment suppliers and their local agents, and is able use its own extensive experience to work with these suppliers to identify systems and technologies most suited to the specific materials and target applications.

2. Process technology

Process technologies for mechanical recycling have improved over the last 10-15 years, from relatively small scale operations with specialist equipment that required a high degree of support and intervention, to current designs with high capacity 24/7 fully automated units that are low maintenance and very productive. There are a wide range of equipment sizes and options tailored to specific in-feed materials available from a number of suppliers who are able to deliver turnkey installations. These advances and higher throughputs have reduced the operating costs to process comingled waste and delivered improved purity and quality of the final product, so that the maximum value of recovery of recycled materials is achieved and landfill residues are minimised.

Technologies required to optimise the recovery of packaging plastics and other materials are well established and are in common use in many parts of the world for a range of in-feed materials including MSW and C&I streams. The technical risk associated with these technologies is low when the process is well planned and designed and the in-feed materials and target outputs are understood. The cost / benefit is discussed in detail in section 3 of this report, with modeling summaries of a number of scenarios for municipal and C&I waste streams.

2.1 Separation and sorting

The technology improvements to recover individual materials from comingled streams still utilize the same separation principles of size, density, and ferro-magnetic properties to affect an initial selection of material fractions.

- Over Belt Magnets (OBMs) are most commonly used to extract steel and iron materials and Eddy Current devices are used to extract aluminium. Both technologies are highly effective when correctly positioned and operated.
- Trommel (screening drum) designs and size have evolved from being basic screens and they can now be specified with features to accommodate particular compositions and materials. The correct size and design of a trommel at the early stage of the process will provide a consistent level of performance when in-feed composition varies that enable subsequent processes to continue to perform at optimal efficiency. Using a graded trommel to separate a number of fractions based on size will minimize material going to landfill and provide a defined product for further separation.

The increased sophistication and use of automated spectroscopic sorting to separate different types of material and different types of plastics has been one of the key developments that enabled large quantities of high purity fractions to be recovered from comingled streams. For plastic identification, Near Infra-Red (NIR) spectroscopy is typically used to identify materials or classes of materials, like PE or PET, and then eject that material into a separate fraction by a timed jet of air. By repeating this process through a series of NIR units each targeting a different type of material, the comingle stream can be separated into fractions that can then be further processed.

Other spectroscopy techniques to sort based on colour, X-ray transmission, atomic weights, and ElectroMagnetic properties for specific metal detection can be used. These different detection systems can be configured for sorting rigid and soft film plastics, shredded or granulated material down to 10mm in size, as well as a broad range of other material such as glass, paper and metals. Vision systems to sort based on shape and appearance are a further option that that is used in many industrial applications and may be applicable for automated sorting of CDL containers.

With an appropriate plant design, material streams can be resorted through recovery loops to provide a complete extraction of all target materials into high purity streams. Such systems operate in several countries such as the UK, Germany, France, Netherlands and Spain processing large volumes of material into value added fractions and resulting in minimal landfill residues. Viridor operate a plant in Ford, West Sussex UK that provide a good example.

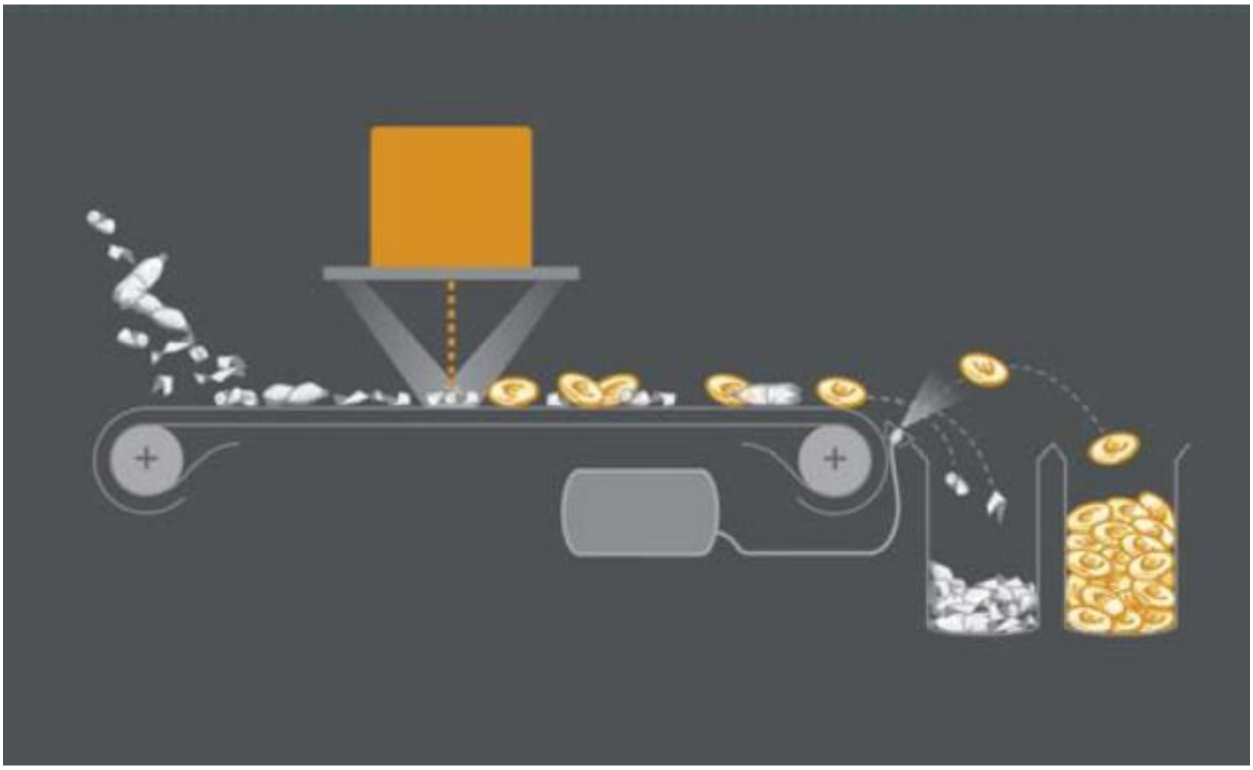

Figure 1: Schematic of NIR unit positively sorting gold coloured material (Source: TITECH)

The use of manual sorting is still required, most often at the start of the process to remove the large, bulky or hazardous items (for example car batteries, LPG cylinders) that are occasionally present. In South Australia manual sorting is also used to separate CDL containers from other non-CDL packaging, which is not able to be accomplished with standard automated NIR detectors. Manual inspection of sorted material as a final quality check is also common (and recommended) to ensure product consistency and a rapid response to equipment failures or other process issues.

The separation of the two-dimensional materials such as paper (copy, newsprint, board and corrugated) and plastic film is also an area where manual labour is still commonly used. The persistence of this practice is for two reasons:

- Firstly, with the very high percentage of recycling of paper products, there is often a low level of soft plastic film material that can be readily identified and manually removed, aided by systems such as overhead vacuum extraction units to improve productivity.
- Secondly, due to the larger size and the flat two dimensional aspect of many of the paper products, the efficiency of automated sorting is reduced and may require a reduced speed and / or multiple passes to obtain an acceptable separation quality, which adds further capital and operations costs.

Alternatively, these two-dimensional materials can be coarse shredded to reduce it to a uniform size and then automatically sorted by NIR detectors. In either case the capital investment and the increased operational costs required for multiple pass or size reduction can be significant to remove only a small amount of film that could be more easily removed manually on a sorting conveyor.

2.2 Cleaning and washing

Cleaning end-of-life plastics including packaging plastics has become an important stage of the recycling process to increase material value prior to sale or to improve properties so that the recovered materials can be utilised in a wider range of applications. The type and degree of cleaning is dependent on the source, previous uses and the targeted application.

2.2.1 Dry cleaning

Dry cleaning is a technology that has come into greater use in recent years as the recovery of more heavily contaminated materials and the demand for high purity recycled products increases. Dry cleaning for recycled materials does not use any solvent, but it removes moisture and creates intensive interaction of the shredded materials to create friction to dislodged surface contamination that is then separated through a screen. A number of suppliers produce equipment for the dry cleaning process, which is suitable for rigid and soft plastics (and other materials) but is not effective at removal of fats, oils and grease contamination. As such it is not currently readily applicable for rigid food and beverage containers. Dry cleaning has proven to be effective for cleaning a wide range of agricultural film by removing the surface dirt, and also as a pretreatment before wet washing to reduce water usage and water treatment costs.

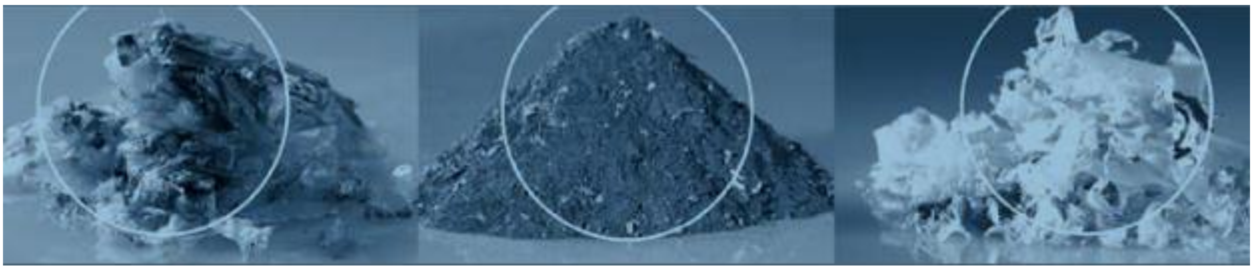

Figure 2: Example of the dry cleaning of soft film waste (Source: MAS)

2.2.2 Wet washing

Conventional wet washing is effective with plastics, and when combined with the use of additives, surfactants and heated water, agitated systems clean recycled plastics leaving very low levels of surface contamination. Wet washing does carry a significant process cost due to the need for chemicals, heating if required, water filtering and treatment and ultimately waste water discharge. For heavily contaminated materials, a combination of dry cleaning to remove gross surface contamination prior to wet washing is often utilized to reduce wet washing process costs and achieve a higher quality recyclate. Conventional agitated bathes are still the most common form of wet washing, often followed by a Sink/Float process to separate polyolefinic plastics (density less than 1.0) from other plastic such as styrenics and polyesters (density greater than 1.0). New intensive washing systems require lower water consumption and improved operation combined with hydrocyclone technology that also provides a density separation based on water.

Figure 3: Intensive wet washing and hydrocyclone technology (Source: Herbold Meckesheim GmbH)

2.3 Melt filtering and pelletisation

An extrusion process with melt filtering, vacuum venting and pelletisation is used to produce pellets of recycled material ready for reuse. Improved devolatilisation techniques, automated fine screen change filters below 100um are now available with a choice of pelletisation systems to produce quality recycled plastic material from well-separated and washed materials. A number of suppliers provide either single or twin-screw designs in a range of capacities and configurations to suit specific applications. Feed sections are designed for low bulk density soft film plastic materials to improve outputs or venting of excess surface moisture to reduce pre-drying requirements. Vacuum vented sections extract volatiles from residual contaminants and their decomposition to improve subsequent processing, and it enables an increased level of recyclate to be used in some applications. Positioning, residence time and exposed surface area all influence the final quality and systems need to be well researched and trialed to obtain the best results. Melt filtering and pelletisation is the final stage of reprocessing and it depends on sufficient volumes of good quality feedstock and therefore needs to be employed in co-ordination with increased recovery, sorting and cleaning of waste plastics.

Figure 4: Modern extrusion, melt filter, degassing and pelletisation process (Source: Erema)

2.4 Conclusion

All of the process technologies outlined in this section have potential application in South Australia. What is critical for South Australia is how any such technologies may be employed within existing resource recovery and recycling facilities or how they can be best employed in new facilities to enhance waste plastics recovery and recycling.

Existing MRF facilities in South Australia already use trommel and metal separation systems in their processes. These could form the basis of an upgraded MRF operation if they are of suitable design and capacity or they may require replacement in any plant upgrade. As shown in the modeling in section 4, large facilities operating at capacity on a 24/7 basis are the most commercially viable.

Also with respect to existing facilities there is potential to use NIR units to increase plastics recovery and sort materials into high purity streams / polymers. Such equipment is commonly used in material recovery facilities and plastics recovery facilities around Australia and globally. The relative cost of such equipment has been declining based on throughput and the functionality improving, meaning they are more affordable. As noted above, the requirement for manual sorting to separate CDL containers is not possible with NIR systems, however vision systems may offer an option for further automation.

With respect to the cleaning technologies outlined, dry cleaning may present a short-term opportunity in South Australia, especially due to barriers around licensing of wet wash plants and associated trade waste regulations and costs. The dry cleaning technology is most applicable for agricultural and industrial waste plastics, not plastic packaging that is heavily contaminated with oils and grease that might arise from food waste. Wet washing is still required to obtain the best quality recycled materials, and is a recommended process option.

3. Alternative treatments for waste plastics

Alternative waste treatment (AWT) technologies convert the waste plastics into new substances that are used directly or indirectly in industrial processes. The most simplistic process is incineration, where the waste plastic material is utilised as an alternative fuel source to generate energy from waste (EFW). Plastic wastes can also be used in Processed Engineered Fuel (PEF), Refuse-Derived Fuel (RDF) or Solid Recovered Fuel (SRF), a fuel produced by shredding and dehydrating of solid waste from municipal, C&I and C&D sources. RDF consists of combustible components such as plastic wastes mixed with biomass based wastes such as timber. In Europe PEF/RDF is used in the cement kiln industry, provided that the strict standards of the EU Directive on Incineration of Waste are met. South Australia also utilises PEF via the SITA / ResourceCo operation, supplying Adelaide Cement with 75,000tpa of PEF.

Alternative thermal treatments for plastics are used to produce a range of gas and liquid hydrocarbon fuel products. In summary, the most common treatments are:

- Incineration where materials are simply burnt together with other fuel sources such as coal and waste material, producing heat to generate steam for electricity or other industrial processes like cement kilns. EFW processes reduce the volume of waste to landfill and emission controls and technologies have improved the overall environmental performance. Incineration is still considered an inefficient way to produce electricity, generating as much as 30% more CO_2 than gas-fired power stations
- Pyrolysis processes in which materials are thermally decomposed in the **absence of oxygen** (i.e. no combustion) to produce hydrocarbon gases and oils that can be used to produce electricity or further refined into specified liquid fuels.

Gasification where materials are converted in a controlled oxygen environment to produce gases (syngas) that can then be burnt in gas engines or converted to liquid fuels

In comparison to mechanical recycling, alternative thermal treatments such as pyrolysis or chemical recycling of plastics back into monomers are still emerging technologies that are continually being further developed and enhanced to improve costs and efficiencies. Gasification and pyrolysis technologies, already implemented in some parts of the world are nonetheless in their infancy and consequently there is significantly less historical and commercial experience that can be referred to. It is expected that in the next five years these systems will become more common and become more economically competitive. These systems hold great potential for treatment of heavily contaminated plastic waste streams and other fractions of the waste stream and their evaluation is recommended as part of a holistic medium to long term waste management system.

3.1 Energy from waste (EFW) plastics via incineration

In South Australia, approximately 130,000 tonnes of waste from C&D and C&I sources is being converted to 75,000 tonnes of Processed Engineered Fuel (PEF)for the Adelaide Brighton Cement kiln. It is estimated that 4% of the PEF is plastic (other than PVC) from both packaging and non-packaging that adds to the calorific value of the PEF. The process can tolerate an increased level of plastic up to 10%, but at those levels there would be additional process and handling difficulty due in part to the reduced bulk density of the plastic component and those levels cannot be sustained on an ongoing basis. However it might be considered that the amount of plastic could be increased from 3,000 to 5-6,000 tonnes if suitable process modifications were made to accommodate the change in composition.

The amalgamation of materials to a solid fuel for incineration reduces the level of processing required compared to mechanical recycling, and is a suitable end-of-life for heavily-contaminated and mixed plastic materials unsuitable for mechanical recycling. Energy recovery from plastic wastes is more common in many parts of Europe, where these plants recover energy from wastes that have calorific values and can be safely burnt to produce energy. The new incineration plants are significantly more efficient at energy recovery and also have significantly cleaner emissions than incinerators built in the 1970s, only a few of which remain in operation.

3.2 Blast furnace coke substitute

The use of waste plastic with coking coal in the production of steel has been in use in many countries around the world. The process takes advantage of the high carbon content of plastic to act as a reductant in the steel making process in the same way as coking coal. The low cost of coking coal in Australia has limited the development of this application; however it remains of significant potential on a national scale.

Similar to incineration the process can use a wide range of mixed plastics, other than PVC, without sorting, however there are stringent quality standards particularly related to trace metals to ensure the final steel quality is not affected. This would require some minimal treatment of the plastic to ensure it is free of residual materials from the comingled stream, and processing to form the plastic into solid blocks that can be added directly to the blast furnace.

3.3 Fuel from waste plastic –pyrolysis and gasification

Chemical recycling in which plastics are depolymerised to form feedstock chemicals or intermediates is an alternative approach that can broaden the potential application for materials.

However chemical recycling plants require large volumes of plastics to be viable and typically need to be co-located near petrochemical plant facilities making this system less suited to the South Australian situation.

Alternative treatments such as pyrolysis or gasification can be operated at both large and smaller volumes and some newer technologies offer a modular design that can provide waste solutions in regional areas where waste transportation costs make other treatments unviable.

These technologies have continued to be developed and now offer a viable and preferable process to incineration methods. Using heat under specific conditions, plastics are converted back to hydrocarbon fuel and gases that can be utilised for electricity generation. These methods decompose the plastic under controlled conditions and emissions are controlled and are significantly reduced compared to incineration.

Historically, capital costs were very high and commercial returns limited, which played a significant part in why mechanical recycling has often been a preferred path. Commercial viability is heavily dependent on the costs of oil and electricity and if these continue to increase, the focus on the development of these systems will also increase.

A significant distinction between pyrolysis and gasification techniques is the preferred type of feedstock and in many instances this may determine the preferred methodology. Pyrolysis is better suited to a plastic-rich feed stock with very low levels of organic contamination. Gasification methods are able to use more varied feedstock such as MSW. While some sorting and blending would still be preferred to obtain consistency, a wider range of plastic and other organic materials can be processed, which maybe a desirable aspect for plastics packaging materials from the food and beverage sectors in which plastic waste is contaminated with food residues or mixed with other organic materials.

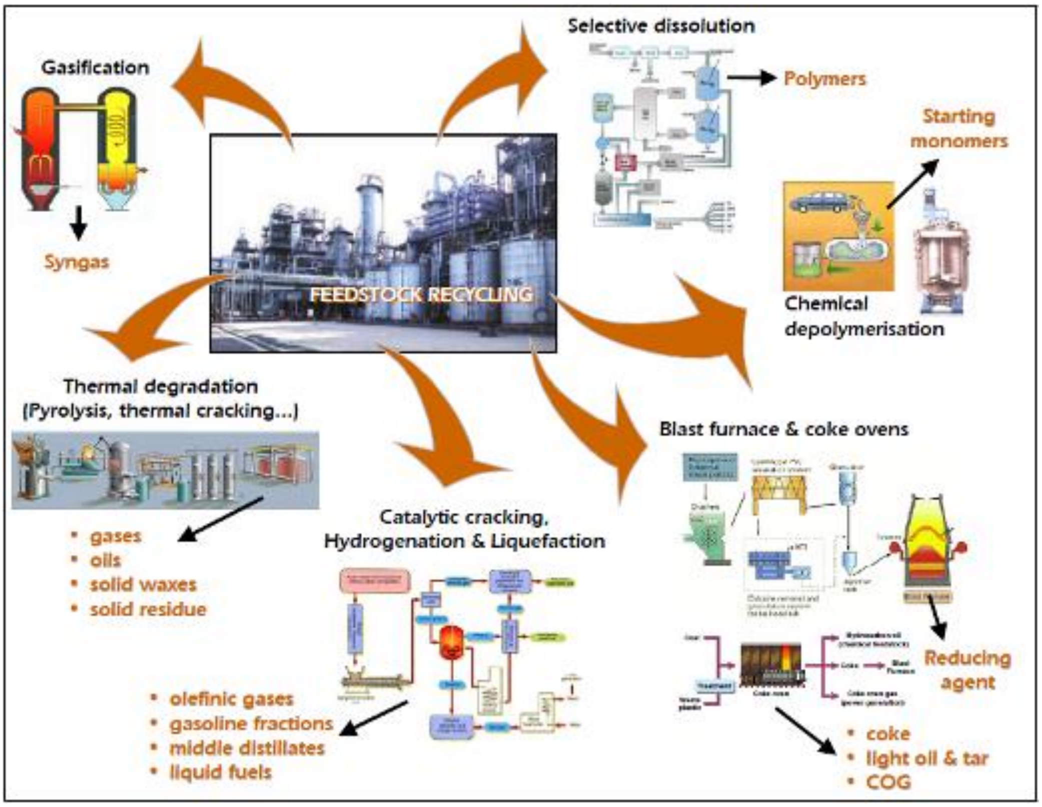

Figure 5: Feedstock recycling offers the potential to process waste plastics using a variety of techniques (Source: Virtual European Recycling Centre)

Benefits of energy from waste plastics include:

- Technology to decentralize the waste management processes by turning mixed and contaminated plastic wastes to power without it leaving operational sites
- Mixed, non-recyclables and municipal solid waste can be processed
- Thermally processed waste produces gas that can be separated and used for heat or energy in buildings or plants
- Unlike incineration, there is no oxygen or actual combustion in the thermal plant
- Potential for cost savings by reducing waste disposal contract charges, landfill taxes and power bills by turning waste into a resource that generates heat or power
- Opportunities for carbon reduction by reducing waste production, eliminating fuel used on sending waste to a central point for disposal
- Systems can be designed to be used regionally.

3.3.1 Pyrolysis

Studies have shown that pyrolysis techniques are better suited to plastic-rich feed stocks that are consistent in composition and low in contamination, which can limit their suitability to use municipal or industrial waste materials unless they are pre-sorted into a suitable feedstock. Mixed plastic materials (excluding PVC) resulting from MRF separation would then only require PVC to be removed to be well suited to pyrolysis. Different pyrolysis techniques, with and without catalysts and involving hydrogenation processes, operate in slightly different ways, but all operate in the absence of oxygen.

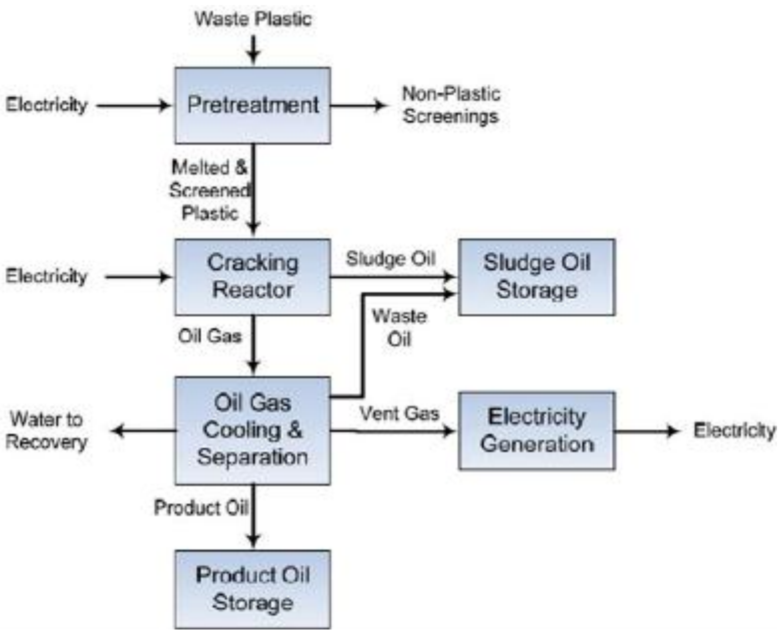

Figure 6: Process for plastic to oil thermal treatment using pyrolysis (Source: Envion)

The main product from pyrolysis can be "syngas" that can be used for energy generation, or liquid (oil) that can be converted to fuels such as diesel. By-products such as char and ash are 15-20% of input mass, much of which will require landfill, but may also be compatible with RDF for incineration. Compared to landfill, pyrolysis methods can save about 0.2 tonnes of carbon equivalent emission per tonne.

Pyrolysis Technologies – Process Conditions & Major Products

Technology	Residence Time	Heating Rate	Temp. (°C)	Major Products
Carbonisation	hours - days	very low	300 - 500	charcoal
Pressure Carbonisation	15 min - 2 hr	medium	450	charcoal
Conventional Pyrolysis	hours	low	400 - 600	char, oil, syngas
	5 - 30 min	medium	700 - 900	char, syngas
Vacuum Pyrolysis	2 - 30 sec	medium	350 - 450	oil
Flash Pyrolysis	0.1 - 2 sec	high	400 - 650	oil
	<1 sec	high	650 - 900	oil, syngas
	<1sec	very high	1000 - 3000	syngas

Figure 7: Range of pyrolysis process conditions (Source: Klean Industries)

The technology has been developed for the automatic and continuous processing of 30-50tonnes/day of a wide range of waste plastic to liquid fuel. Development of a continuous process to discharge char build up and the elimination of occupational health and safety issues have hampered the viability and commercialisation of large scale pyrolysis technologies.

Automated continuous plastic to liquid fuel process (Source: PARC)

Large scale Pyrolysis (Source: KleanFuels)

Small scale Pyrolysis (Source: QinetiQ)

Figure 8: Examples of plastic waste to energy plants

3.3.2 Gasification

Commercialisation of gasification techniques has come after pyrolysis developments and to some extent is still an emerging technology. However gasification does appear to offer some additional benefits and commercial plants have been built in several parts of the world including Spain, Canada and Australia. There are a number of variations on the technology, using higher and lower temperatures, as well as a plasma technique illustrated below. The major product is typically "syngas" that can be used for energy production and combustion engines, but liquid fuels can also be obtained depending on the technology. The level of by-products is less compared to pyrolysis due to reduced level of char, but landfill of ash and slag is still required. Depending on feedstock sources, pre-sorting to extract valuable materials and the production of a consistent feedstock to optimise the process efficiency is desirable. As well as accommodating a wider range of biomass than pyrolysis, in-feed material for gasification processes can also carry higher moisture content of up to approximately 30%, without the need for pre-drying. As well as an energy saving, the reduced level of material handling prior to the process provides an advantage. This may be advantageous for treating plastic wastes which are wet and contain high levels of residues.

Compared to landfill, gasification techniques can save approximately 0.5 tonnes equivalent of carbon per tonne, although direct comparisons with landfills not designed to produce energy are difficult.

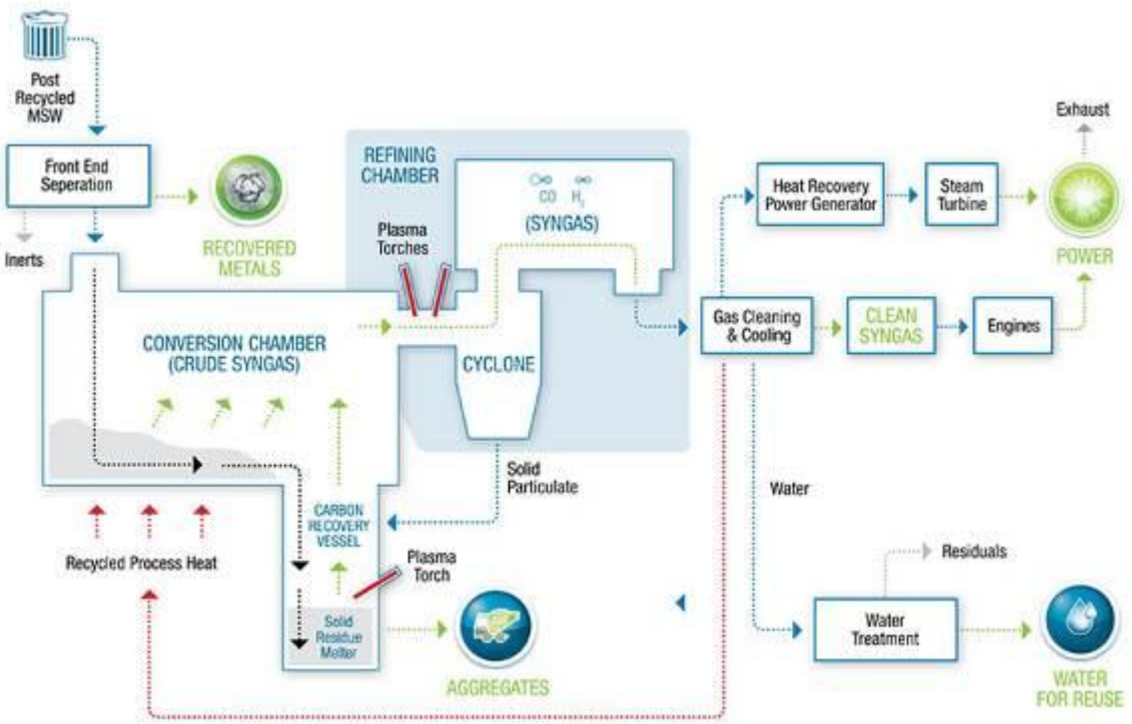

Figure 9: Plasma gasification process flow diagram (Source: Plasco Energy Group)

Costs for the processes vary significantly depending on the selected technology, feedstock quality and cost, landfill cost, plant size and product type, however it has been shown in a number of pilot facilities that total costs to convert a tonne of material to energy are typically $60-100/tonne on a dry-weight basis. Within a broad range, the estimates show that processing costs are approximately in line with landfill disposal costs of unprocessed waste materials. As discussed, plant viability depends on maintaining a consistent supply of feedstock material and a secured and contracted customer to purchase the products.

Figure 10: Rentech gasification demonstration plant Colorado USA (Source: Rentech)

Figure 11: 150,000 tonne gasification plant Ottowa Canada (Source: Plasco Energy Group)

3.4 Conclusion

It is difficult to see any of the technologies outlined in this section employed in South Australia on the current volumes of plastic packaging waste available. Gasification has the most potential to be implemented in South Australia because it can be used not only for plastic waste but for treatment of a range of waste materials including biomass. Not suitable for plastic packaging but a further technology option for biomass is anaerobic digestion that might also be considered.

The application of such technologies is also not solely a waste and resource recovery issue as it is also directly linked to energy demand and pricing.

This study has not sought to identify any specific opportunity to further investigate alternative treatments for plastic (and other) waste using these technologies but they should be considered as further waste and energy policies and programs develop, with a focus on landfill minimisation from municipal residual waste and organic waste form other streams, that cannot otherwise be recycled.

4. Cost benefit analysis

The commercial viability of a waste processing operation is very dependent on volume and process efficiency. The design, investment and operation of any Materials Recovery Facility (MRF) is based on a thorough understanding of in-feed composition, variations in that composition and recovery of target components. Section 2 discussed new technology developments that are able to increase recoveries and efficiencies which reduces operating costs and improves viability. The capital and operating costs for these systems are modeled for the municipal recyclables, municipal residual and commercial and industrial (C&I) stream to illustrate in detail the likely commercial performance.

The current recovery of packaging plastics collected in South Australia (as reported in the stage 1 study and elsewhere) compares favourably to other Australian states, particularly with a significant amount of material being recovered through the container deposit (CDL) depots. As a result of CDL, there is a reduced amount of rigid packaging plastic in the municipal kerbside and commercial and industrial (C&I) recyclables stream. This has an impact on the plant design and economics of recovering remaining packaging plastics in two ways:

- A higher cost to sort the smaller amount of remaining packaging plastics from the municipal and/or C&I stream
- A higher value from the CDL fraction of rigid plastics that are recovered.

A cost model for the separation and recovery of materials from collected waste streams has been conducted to measure the economic benefits of further processing these waste streams to extract the remaining plastics packaging and other materials, both CDL and non-CDL containers.

The models are designed to fully separate each component to illustrate the relative value of each fraction. While informative, a significant focused analysis would be required to fully audit variations within the in-feed and to design a process to provide optimal separation best suited to the market. Some of these aspects are discussed further in section 4.

Dry recyclable materials are collected by Councils from both municipal kerbside and in some cases from C&I, however most C&I recyclable materials (from sources such as retail centers, food service, offices) are collected by private contractors. It is generally reported that there is a higher level of contamination of the C&I recyclable stream making sorting more difficult and often the recovered materials are of lower value or require significant further processing costs.

Using the composition of kerbside waste obtained from the ZWSA Master Food Waste Audit Report 2010, and the volume of Municipal recyclable and residual waste provide by ZWSA, a cost model was constructed to evaluate the benefits of further processing the MSW streams to extract all plastic components and minimise materials to landfill. For C&I information was taken from the ZWSA – SA 2010-11 Recycling activity report and the amount of each materials was estimated based on the reported percentages.

4.1 Financial modeling of waste processing operations

All of the estimations made for the modeling of the processing of the different waste streams discussed below are by necessity general in nature, based on the indicated volumes and compositions. Estimations of capital and operating costs are for a generic process and these calculations and modeling should not be construed to represent any specific commercial outcome.

In discussion with stakeholders, the issue of high capital costs for equipment was discussed and lower cost equipment options were being actively pursued. As shown as part of the modeling below while the capital cost is a factor in the overall economic framework, also of importance are the operating costs which are affected by any increased downtime and the lower productivity of some equipment designs and quality, and this should be a major consideration in the purchasing decision.

A detailed costing model was used to estimate the commercial viability of the three operations and material compositions. The model takes into account both fixed and variable costs, with conservative recovery levels and publicly quoted material values. Earnings and the capital payback terms are calculated with details of the total operating costs and sales value. The modeling allows comparisons to be made between plant designs and each stage of the process, from basic material sorting, that is typically conducted by the MRF, to a more complete separation of plastic components by automated NIR systems through to full processing of the sorted materials to a finished pelletised product.

The economic performance of any of the stages and potential MRF designs is improved with increased volume so that smaller operations are less profitable and a strategy of placing fewer larger MRFs in the appropriate locations is recommended. The design and material flow path of a MRF is specific to the composition of the in-feed and materials that are targeted for separation. Many facilities follow a common path of removing metals, size separation and further sorting of the fractions. The schematic in figure 12 provides an illustration of the general layout and flow path used in the cost modeling for the municipal recyclables, municipal residual and C&I streams, although the exact process modeled does vary for the C&I model, to explore an auto sort option for removing the small amount of plastic film.

For the purpose of this study and based upon the identified sources where volumes of end-of-life plastics are going to landfill, three models have been assessed:

- MSW recyclables stream
- MSW residual / landfill stream
- C&I total stream.

The modeling shows the apparent volumes of individual materials in the three streams and enables financial assessment of the viability of the primary process to sort, separate and bale the materials. A significant amount of the residues from the process are organic materials that might be directed to alternative waste treatment processes, but in these models are sent to landfill at the indicated landfill cost.

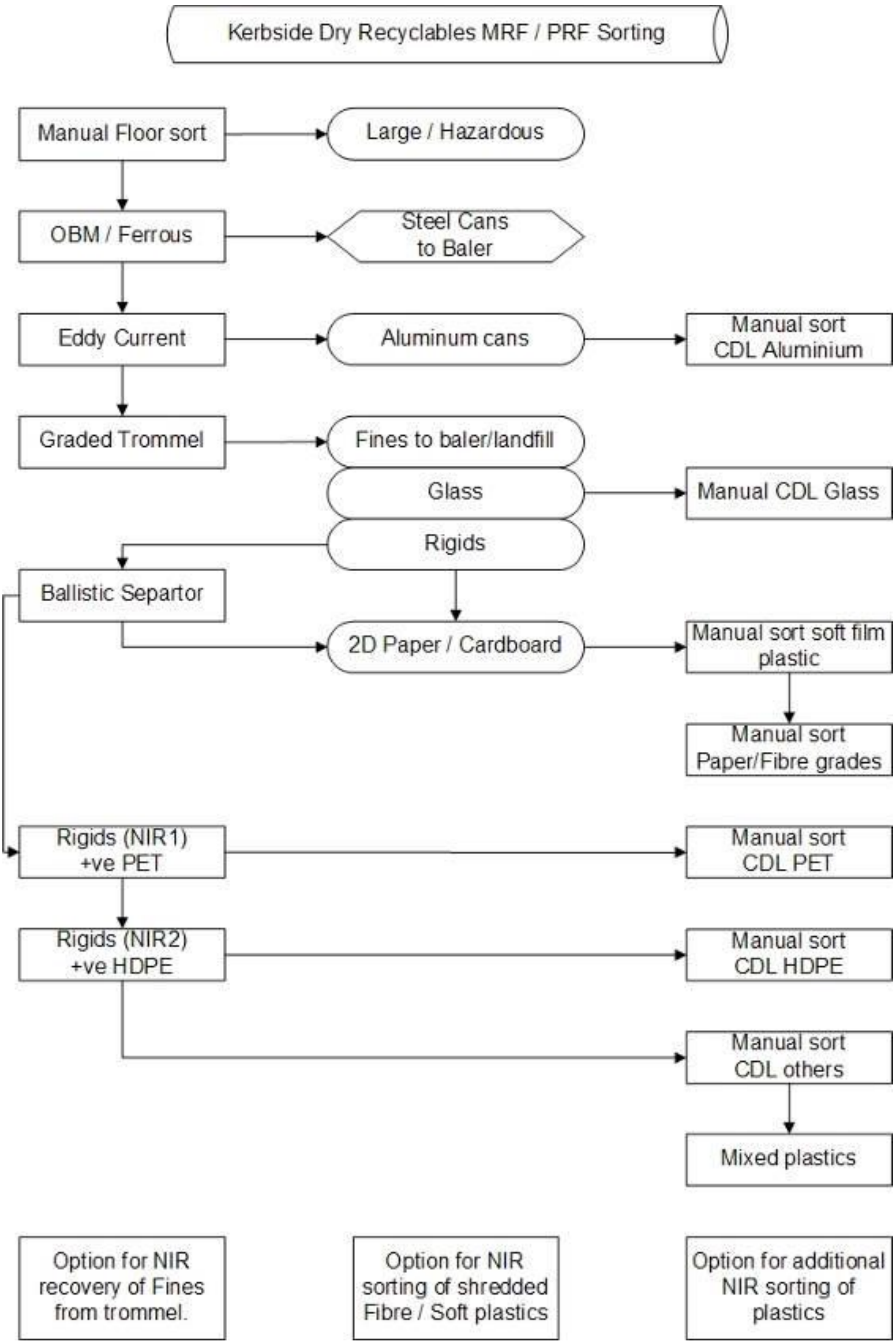

Figure 12: Schematic of generic MRF / PRF design used as the basis for the cost modelling

4.1.1 Municipal recyclables processing

An estimate of the composition of the municipal recyclable stream was made based on the bin audits conducted in the ZWSA *Food Waste Pilot Kerbside Audit 2008-2009 Master Report* and South Australian total state volumes provided by ZWSA.

Table 1. Estimated composition of municipal recyclables waste stream

Kerbside Recyclables	Composition %	Amount tpa
Organics	3.24%	5,561
Hazardous	0.32%	553
Other	2.77%	4,746
Subtotal	**6.33%**	**10,860**
Glass	12.37%	21,226
Paper / Fibre all kinds	65.02%	111,543
LPB	0.59%	1,019
Steel can	3.46%	5,940
Aluminium	0.12%	204
Subtotal	**81.57%**	**139,931**
PET CDL	0.66%	1,136
HDPE CDL	0.07%	116
Aluminium CDL	0.17%	291
Glass CDL	3.73%	6,406
LPB CDL	0.15%	262
PVC CDL	0.03%	58
Subtotal	**4.82%**	**8,269**
PET	0.73%	1,252
HDPE	2.85%	4,891
PVC	0.20%	349
LDPE	0.07%	116
PP	0.98%	1,689
PS	0.87%	1,485
Other & Film	1.58%	2,708
Subtotal	**7.28%**	**12,491**
TOTAL	**100.0%**	**171,551**

These results suggest that 8%, a total of 13,801 tonnes, of the recyclable stream is plastics and most of this would be packaging plastics that could be recovered through a suitable Material Recovery Facility (MRF). Less than 10%, or 2,708 tonnes, is estimated to be soft film plastics. Much of the soft film plastic packaging is still directed to the residual waste stream and is currently sent to landfill.

The model for this scenario uses a traditional MRF configuration to provide basic material separation and manual separation of CDL and soft film plastics from paper and board. A further operation is then considered involving automated NIR sorting in a Plastic Recovery Facility (PRF) operation to fully separate plastic material by type, and a third and final cleaning/washing/pelletisation section is considered to show the potential of the entire process.

Table 2. Model of municipal recyclables 60,000 tpa MRF / PRF / Pelletising plant.

Total Plant	MRF	PRF	Pelletise	Total
[1]**Capital Costs**	$2,060,438	$994,950	$1,740,944	$4,796,332
[2]**Total Sales**	$9,419,077	$895,569	$1,831,317	$12,145,963
[3]**Total Costs**	$6,071,703	$1,175,508	$1,071,878	$8,319,089
Operating Costs (per tonne)	$101	$228	$617	$946
EBIT	$3,347,374	-$279,939	$759,440	$3,826,875
Profit / Sales ratio	36%	-31%	41%	32%
Payback (years)	0.6	Loss making	2.3	1.3

1) Excludes building and service connection costs
2) Includes the sales value of materials to PRF and Pelletise sections
3) Includes landfill cost of residual after processing

The model results show that, with the composition indicated, there is significant value obtained from the MRF process extracting paper and CDL, however there is no commercial incentive to further sort the remaining plastics through a PRF process. The high operating cost for the PRF and wash/pelletise stages is due in part to the associated fixed overheads being applied to relatively low amounts of material being processed each year. With increased volumes (up to 24/7 operating capacity), that would come from a centralized PRF the operating cost per tonne would be reduced, see section 4.1.4 of this report.

It should be noted that there is a large variation in the data for the composition of the recycled stream. The model results above use a composition based on bin audits from the ZWSA master food waste audit report, whereas industry information on the CDL and plastic composition of the recyclable stream indicates a substantially lower amount of CDL and plastic packaging. The quantification of the model result will vary with the composition, however with a lower percentage of CDL and packaging plastics the case for PRF processing the plastic fraction is further diminished.

The conclusion from the modeling is that with the relatively low level of packaging plastics in the recycle stream, it would be most beneficial for a MRF to extract these materials as a mixed plastic fraction, and to sell this fraction where it may be more efficiently further processed in a larger operation. Locally in South Australia, that role might be filled by existing or new processors, however the operation would require polymer sorting and washing capability. Otherwise, interstate and international sale of the mixed plastic would be possible.

4.1.2 Municipal residual processing

The municipal residual waste stream is currently landfilled with no processing other than at some locations it may be baled to improve landfill utilization. Using the ZWSA master food waste audit report, the composition of the residual stream was estimated and the total amount of plastics calculated based on state volumes provided by ZWSA. Results show there is a large amount of soft film plastic waste and similar to the recyclable stream, low levels of CDL and other rigid plastics that would be predominantly packaging plastics.

Table 3. Estimated composition of municipal residual waste stream

Kerbside Residual (Garbage)	Composition %	Amount tpa
Organics	59.72%	232,687
Hazardous	5.15%	20,047
Other	7.91%	30,819
Subtotal	**72.78%**	**283,552**
Glass	2.35%	9,145
Paper / Fibre all kinds	12.48%	48,620
LPB	0.14%	553
Steel can	2.84%	11,065
Aluminium	0.21%	814
Subtotal	**18.02%**	**70,197**
PET CDL	0.20%	781
HDPE CDL	0.11%	423
Aluminium CDL	0.18%	716
Glass CDL	1.09%	4,263
LPB CDL	0.08%	293
PVC CDL	0.00%	0
Subtotal	**1.66%**	**6,476**
PET	0.24%	944
HDPE	0.48%	1,888
PVC	0.17%	651
LDPE	0.08%	293
PP	0.54%	2,115
PS	0.67%	2,603
Other & Film	5.36%	20,893
Subtotal	**7.54%**	**29,387**
TOTAL	**100.0%**	**389,612**

The high percentage of soft film plastics is consistent with the use of garbage bags and the current practice to not accept soft plastics and films in the MSW recycling stream. The percentage of plastics (7.9%) in this stream is similar to that found in the MSW recyclable stream, however it is distributed in more than twice the total amount of waste material, 60% of which is putrescible, making separation and recovery for recycling more problematic.

Using the same model parameters that were used for the recyclables MRF estimation, a "dirty" MRF model was prepared with an increased capacity of 120,000tpa. For simplicity of the comparison, the separation process used in the residual model is identical as that used for the recyclable MRF, however it should be recognised that in practice there would be some process modification and variation for the different streams of material.

The capacity for the dirty residual MRF has been doubled to handle the additional volume of material, whereas the downstream PRF and pelletisation remains the same capacity as the MSW recyclable model, with additional shifts allocated to the pelletisation to handle the additional volume of soft film plastic. The impact of lower yields in the MRF and higher volumes in the pelletisation can be seen in Table 4 below.

Table 4. Model of municipal residual MRF

Total Plant	MRF	PRF	Pelletise	Total
[1]**Capital Costs**	$2,914,313	$994,950	$1,740,944	$5,650,207
[2]**Total Sales**	$6,605,341	$1,016,018	$1,061,276	$8,682,634
[3]**Total Costs**	$16,521,046	$1,539,828	$2,431,722	$20,492,595
Operating Costs (per tonne)	$138	$307	$219	$664
EBIT	-$9,915,705	-$523,810	-$1,370,446	-$11,809,961
Profit / Sales Ratio	-150%	-52%	-129%	-136%
Payback (years)	Loss making	Loss making	Loss making	Loss making

1) Excludes building and service connection costs
2) Includes the sales value of materials to PRF and Pelletise sections
3) Includes landfill cost of residual after processing

The modeling clearly shows that the additional capital and operating costs are not recovered by the value and the low volume of packaging plastics and other materials recovered. Maximising the full capacity of the PRF and Pelletise sections by the addition of three times more in-feed material of the same composition from other MRFs would provide an almost break even process (-7% profit) for the PRF and a more profitable (50% profit) for the Pelletise section. As discussed in section 4.1.4, it is not unusual for a stand-alone PRF to struggle to be commercially viable. Most commonly the PRF is a process associated with a wash and pelletise operation or finished product manufacture from which additional value is gained.

However the MRF remains an unviable process in its own right, and additional value from the landfill fraction such as composting, anaerobic digestion or gasification would be required to justify the operation of a dirty MRF.

4.1.3 Commercial and industrial (C&I) processing

The composition of the C&I waste stream is more complicated than the municipal stream and is less well defined. Due in part to its source classification being both pre and post-consumer from a ranges of sectors such as the Retail, Hospitality, Service, Industrial and Manufacturing industries. Coupled with the broad range of privatised collection services and contract arrangements with some source separation for large businesses and comingled for smaller businesses, there is a significant challenge to describe the volumes of individual components.

Some of the complexities of the composition of the C&I stream have been discussed in the stage 1 report and an estimation of the level of packaging plastics has been made based on the available data. The ZWSA *2010-2011 Recycling Activity Report* was used to make a further estimation of the percentage of each material category shown in Table 5, and for transparency the basis of the calculation is shown in Appendix 1.5.

Table 5. Estimated composition of C&I stream

Material Classification	Recovered Total tpa	Composition C&I tpa	Amount C&I tpa
Masonry	1,105,300	0.5%	5,527
Steel	391,000	22.0%	261,970
Aluminium	19,400	1.1%	12,804
Non Ferrous	31,100	1.5%	18,038
Food	4,400	0.4%	4,400
Garden	230,000	3.5%	41,400
Timber	280,000	19.5%	232,400
Other Organics	440,000	35.8%	426,800
Other Fibre	53,800	2.3%	27,438
Cardboard	154,000	7.4%	87,780
LPB	3,500	0.0%	245
PET	4,100	0.1%	1,230
HDPE	4,600	0.3%	3,910
PVC	170	0.0%	-
LDPE	4,600	0.4%	4,186
PP	4,000	0.3%	3,600
PS	430	0.0%	413
Mixed	5,800	0.1%	1,102
Glass	58,000	0.5%	5,800
Other Materials	52,700	4.4%	52,700
Ash/Clay/Soil	1,460,	0.0%	-
TOTAL	**4,306,900**	**100%**	**1,191,742**

The total volume of recovered material by this calculation method is 1,191,742 tonnes, a lower figure than the 1,400,000 tonne estimate reported in the 2010-2011 Recycling Activity report. This estimate, however, is sufficient for the exercise of modeling a MRF operation on the C&I stream.

The modeling uses the same generic MRF process to isolate ferrous and aluminum products, followed by mechanical separation through a trommel and a ballistic separator to create fractions based on size and shape. Automated NIR and XRT sorting is then used to separate plastic, non-ferrous, glass and other residues. After size reduction, NIR sorting is also used to isolate the cardboard and film fractions, although the soft film (mixed plastics) fraction is minor and manual sorting may be a suitable alternative.

Based on a 200,000 tpa in-feed MRF, the following estimation has been made.

Table 6. Model of C&I 200,000 tpa MRF / Auto sort

Total Plant	MRF	Auto Sort	Pelletise	Total
[1]**Capital Costs**	$3,682,800	$1,952,775		$5,635,575
[2]**Total Sales**	$16,070,669	$7,433,784		$23,504,453
[3]**Total Costs**	$9,207,084	$12,275,073		$21,482,158
Operating Costs (per tonne)	$46	$247		$293
EBIT	$6,863,585	-$4,841,289		$2,022,296
Profit / Sales ratio	43%	-65%		9%
Payback (years)	0.5	Loss making		2.8

1) Excludes building and service connection costs
2) Includes the sales value of materials to Auto Sort
3) Includes landfill cost of residual after processing

The profitability of the MRF section is impacted by the high landfill disposal cost, coming from the masonry, other organics and garden fractions all separated as landfill residues in the MRF process, however it remains profitable. A gate fee of $15/tonne payable to the MRF has been provided (this is $0 for the municipal recyclables and residual stream models) and this value may differ significantly depending on the source and composition. Consistent with the previous models for municipal waste, a transfer cost of $100/tonne has been made for the material moving from the MRF to the Auto Sort section, as an estimation of the value of that material. However in this MRF design, this material includes other recyclables such as glass and cardboard that is separated in the Auto Sort section, rather than manually.

There is only a small fraction of food and other materials going to landfill from the NIR sort operation, and other fractions have a low commercial value that limits sales revenue. No additional separation or processing of the plastic fraction has been considered for these small volumes. A mixed rigid and separate soft film plastic fraction could be sold locally to a larger PRF, or for use interstate or internationally.

Overall the model shows that a large modern MRF facility to process C & I waste material would be a viable operation that would be able to recover a large amount of valuable materials, however the volume of packaging plastics is relatively low. As with the previous models the low volume and value of the plastic packaging fraction does not justify a PRF process from the mixed waste plastics.

4.1.4 Optimised PRF / pelletising operation

All of the previous models show that a PRF process taking material exclusively from the MRF used in each example is not viable due to the low volume and low value of the recovered plastic packaging and other plastic material. This model looks at the economics of a PRF /Pelletising operation supplied with 100% of the mixed plastic that could be sorted from the total 171,551 tonnes of collected MSW recyclables. Although a centralized PRF could take mixed plastics from a range of sources, this example has illustrated in a comparative way that a centralised PRF is viable, if it is able to operate at designed capacity.

The primary NIR unit in the PRF has had to be increased in size to accommodate increased volume, otherwise the design remains the same as the previous model, with additional capacity provide by going to a 24/7 operation. The capital of the wash and pelletise section remains unchanged with wash and extrusion volumes still low

Table 7. Model of centralized PRF at capacity from MSW recyclable mixed plastics

Total Plant	MRF	PRF	Pelletise	Total
[1]**Capital Costs**		$1,291,950	$2,334,944	$3,626,894
[2]**Total Sales**		$2,560,596	$3,794,863	$6,355,459
[3]**Total Costs**		$2,284,086	$3,191,990	$5,476,076
Operating Costs (per tonne)		$119	$195	$314
EBIT		$276,510	$602,873	$879,383
Profit / Sales Ratio		11%	16%	14%
Payback (years)		4.7	3.9	4.1

1) Excludes building and service connection costs
2) Includes the sales value of materials to Auto Sort
3) Includes landfill cost of residual after processing

The model calculation has shown that operating the PRF at capacity provides a positive return even with the still relatively low value of the materials. The wash and pelletise section is still not at full capacity, producing only HDPE, PP, and soft film plastic fractions, but is also a positive return, payback being more marginal. It is likely that in practice a PRF would source additional higher value materials, from C&I for example, that would improve its profitability.

4.2 Summary cost benefit

In summary, the modeling has provided an indicative cost benefit analysis in relation to operations to process municipal recyclable, municipal residual and C&I waste streams. Estimations did not allow for the presence of established commercial operations that already provide some level of processing for each of these streams, and the opportunity to start from a "green field" situation used in the model may well be limited for councils and commercial businesses. The MRF process in the models is calculated on a 24/7 operation, which maximizes profitability. In comparison, existing MRF operations in South Australia currently operate on reduced hours, mostly on a 5 day week and 12-16 hour day.

Cost effective technologies to minimize the volume going to landfill would assist the viability of all of the operations. This report discusses opportunities to extract additional value from waste stream other than from the packaging plastic fraction, and the merit of this to avoid the cost and wasted resources associated with landfill should be considered.

The composition analysis shows that there is a significant amount of plastic in these three streams, although it is comingled with a very large amount of other material and the packaging plastics fraction itself is relatively small, and the value of the non-CDL fraction relatively low. The value of packaging plastics alone does not in itself justify the cost of the MRF separation for any of the three waste streams. However collected as part of the range of recyclables in the streams, the MRF process should be viable for the Recyclables and C&I streams.

The composition of the municipal residual stream is high in putrescible waste and the packaging plastics that are present are primarily soft film of low value. The model shows a MRF operation would not be viable due to the 78.5% of landfill residue and the high cost of processing a low volume and low value fraction. This report discusses diversion of putrescibles to the green waste stream, and for soft film plastics to be diverted to the recyclables stream so that recovery of the remaining fraction would become more practicable for the remaining plastic packaging.

For the municipal recyclable stream, there was a tradeoff between the cost of recovering the small fraction of packaging plastics, which includes some CDL containers, and the high value of CDL packaging. For non-CDL packaging plastics there was less of a financial benefit, but overall MRF viability was positive. Automated NIR sorting could be used so both CDL and non-CDL packaging plastics would be extracted together at minimal additional cost, from which CDL could then be manually sorted (NIR sorting cannot distinguish between CDL and non-CDL items) leaving a mixed plastic waste stream. With manual sorting only, extracting non-CDL plastic packaging of low value was not viable.

The C&I stream is found to have a large fraction of valuable materials, although it has a low percentage of plastics and packaging plastics in particular. For large businesses, where source separation is a viable option, these materials are readily collected and recovered with minimal processing. Comingled C&I is able to be MRF processed to provide material recovery, much of which is biomass from timber, garden and other organic waste. Diverting the biomass components from landfill would add to the viability of the process.

As far as possible the business modeling uses input data referenced from public documents on material prices and costs to provide an estimate of the viability of operating a MRF and further recycling primary process activities for the different waste streams and process options. Data sources are further detailed in Appendix A.

5. Commercial drivers

The modeling takes into account the following commercial drivers where they are quantifiable and reliable, such as the feedstock and end markets.

Some of the commercial drivers discussed below are provided for general information purposes as they are factors that need to be considered to understand the commercial viability of projects. For example, the issue noted with respect to Operation Green Fence in China needs to be understood and factored into the risks associated with a project as it may have an impact in changing the end markets and values for plastic materials.

5.1 Feedstock

The focus of this study is packaging plastics however it is apparent that in seeking to increase the recovery of end-of-life packaging plastics there are other materials that need to be analysed. The potential feedstock for facilities to increase plastic packaging recovery needs to include other non-packaging plastics and the wider range of recyclable materials.

Consideration of non-packaging plastics and other recyclables reflects real world practices, namely that packaging plastics are not source separated from other materials and are contained in mixed material streams.

Consideration of the wider range of materials also shows there are co-benefits. That is, in seeking to increase the recovery of plastic packaging there can be an increase in recovery of other recyclable materials and organics.

5.2 Quantities

This study has used the estimates provided in the stage 1 final report and also accessed other data and composition audits from Zero Waste SA in order to assess feedstock quantities.

5.2.1 Mixed plastics and individual polymers

The stage 1 final report estimated that there is 40,000 to 50,000 tonnes of plastic packaging consumed in South Australia each year. Of that, 13,000 to 15,000 tonnes is recovered and 27,000 to 35,000 tonnes of end-of-life plastic packaging is currently going to landfill each year.

Modeling for this study on packaging and non-packaging plastics indicates that there is about 58,000 tonnes of plastics in the three streams assessed (largely consistent with the stage 1 final report). It is assumed that some of this is being recovered, namely the bulk of the MSW recyclable stream and some of the C&I stream.

The following table provides further details from the modeling of the mixed plastics across the three key streams and including CDL and non-CDL plastic beverage containers.

Table 8. Plastics by stream (tonnes per annum)

Stream	Packaging plastic	Non-packaging plastic	Total all plastic
MSW recyclables	13,176	625	13,801
MSW landfill	23,244	7,347	30,591
C&I	1,444	12,997	14,441
Total	37,864	20,969	58,833

Table 9 provides further analysis and modeling based on polymer type.

It is probable that most of the high value polymers (PET and HDPE) are being efficiently sorted and sent for recycling from the MSW recyclables stream, however the PET and HDPE in the residual and C&I streams is mostly sent to landfill, and they are difficult to recover in a cost effective process.

PVC is of low value and not being collected or recycled in any significant quantities.

A large part of the LDPE in the C&I stream would be film that is being source separated and recovered for recycling, but the LDPE in the MSW streams is not being recovered in any significant quantities.

Although PP is of high value when well separated from HDPE and LDPE, it often not recovered at any significant levels for local recycling and typically forms a part of the mixed plastic fraction that is often exported.

It is not clear what fraction of the PS is Expanded Polystyrene foam (EPS) which takes up a large amount of landfill space per tonne.

Programs to densify EPS at the C&I source or from drop off centres are being evaluated, and there are domestic and international markets for densified EPS. The primary value is the improved utilization of landfill volume, by densification or elimination of EPS from landfill.

The very large amount of "Other" plastic material in the MSW residual stream is mostly LDPE plastic packaging film. Separation and reprocessing of this fraction should be further investigated with consideration of technologies to value add the putrescibles and organic in this stream that make up 78.5% of the total weight, rather than landfill, which would improve the viability of the MRF process.

Table 9. Plastic by polymer by stream (tonnes per annum)

	PET	HDPE	PVC	LDPE	PP	PS	Other
MSW recyclables	2,388	5,007	407	116	1,689	1,485	2,708
MSW residual	1,725	2,311	651	293	2,115	2,603	20,893*
C&I	1,230	3,910	0	4,186	3,600	413	1,102
Total	5,343	11,228	1,058	4,595	7,404	4,501	24,703

* This figure is based upon advice and industry intelligence and is assessed to be largely made up of plastic films, bags and flexibles of mixed and / or indeterminant polymer type, representing 5.36% of the total MSW residual stream

5.2.2 Material quality

A key determinant in the recovery of more end-of-life plastics (and other materials) is the quality of the feedstock.

The quality of the feedstock is considered on a number of levels:

- The amount of different polymers in the feedstock and / or whether the bulk of the feedstock is one polymer
- Whether the feedstock is rigid plastics or film
- The level of contamination.

The difference in respect to each of these material quality elements then has an impact on the amount of processing required to achieve a specific output specification.

At this time, based upon advice from industry in South Australia, it is considered that the MSW MRF residuals and MSW landfill streams are of poor quality as they are comprised of a mix of many polymer types and have mid to high levels of contamination.

The material quality of the plastics in the C&I stream is not well known beyond the fact that generally it contains more plastic film. The small number of industry respondents familiar with the stream indicated that unless the plastic is largely source separated (for example, plastic wrap and films), it is generally of low to mid quality.

5.3 Finance

The financing of new or upgraded plastic recovery and recycling infrastructure is a matter for the company undertaking the investment. The modeling for this study considers the following factors:

- Investment costs (for plant and equipment, but not for land and buildings as a rent is modelled to cover those inputs)
- Operating costs (fixed and variable cost for utilities, labour and other costs)
- Return on investment (what is the profit and payback on the investment).
- The modelling assumes the proponent is liable for all the above and does not include any assumptions about government support or tax treatment that may alter the financial viability of the project.
- It is not modelled but worth noting that access to finance is also an issue that needs consideration when developing a new facility. It cannot be assumed that finance is readily available for new projects or upgrades. Whether a company is seeking to internally fund a project or source external capital, any such projects will be competing with other demands for capital.
- It is noted that in some of Australia's larger waste and resource recovery companies this competition for capital can be fierce and therefore is a significant factor in building new plant and equipment. This seems to be the case primarily where such companies are diverse in their operations and have a large number of projects chasing the same pool of funding.

5.4 Legislative, policy, regulatory and co-regulatory issues

There is a range of state, national and international legislative, policy, regulatory and co-regulatory mechanisms that present opportunities and hurdles for the increased recovery and recycling of plastic in South Australia.

Individually and collectively they present an important part of any process to increase diversion from landfill and increase recycling. They provide opportunities through direct regulatory, financial or other intervention and support to increase recycling. They present hurdles to the extent that achieving required standards of environmental and human health protection in the collection, sorting, processing or sale of end-of-life plastics adds complexity and cost.

The following provides details on a range of these mechanisms.

5.4.1 Opportunities

The Environment Protection (Waste to Resources) Policy 2010 (Waste EPP)

The Waste EPP bans aggregated PET, HDPE, PVC, LDPE, PP and PS plastics from being disposed to landfill statewide in South Australia. While strategies are being developed for implementation of the policy and any associated market and infrastructure development, the Waste EPP is fundamentally intended to increase the volume of plastics recovered for recycling and decrease plastic to landfill.

Enforcement of the policy will potentially free up a supply of plastics to feed new or enhanced infrastructure.

Australian Packaging Covenant

The Australian Packaging Covenant (APC) is a co-regulatory arrangement between the packaging and brand owner supply chain and national, state and local government to decrease the negative environmental impacts of packaging.

While the APC places primary responsibility on brand-owners to reduce the whole of life impacts of packaging, it does also include support and funding for enhanced resource recovery and recycling.

Australian Television and Computer Recycling Scheme

Under the *Product Stewardship Act 2011* (Commonwealth), the Australian Television and Computer Recycling Scheme has been established as a co-regulatory arrangement. The industry-led scheme requires television and computer brand owners and importers to fund the take-back and recycling of end-of-life televisions and computers free-of-charge to householders.

While the plastics potentially available for recovery and recycling through the scheme are not packaging plastics, they may none less have a positive impact towards achieving economies of scale for the recovery and recycling of all types of plastics in South Australia.

A study for Zero Waste SA in 2012[1] based on modeling for establishment of the national scheme found that the collection rate was 1,500 tonnes in 2009-2010 whereas the amount potentially available for collection and recycling in South Australia in 2011-2012 was 10,200 tonnes.

These end-of-life products are made up of a range of materials (steel, aluminium, other metals, glass and plastics) and while the amount of plastics is not currently estimated it can be assumed that it will provide opportunities for increased plastic recovery and recycling.

Product Stewardship Act

The *Product Stewardship Act 2011* provides the basis for establishing voluntary, co-regulatory or mandatory schemes targeting the end-of-life management of a range of products and materials. As noted above, the Australian Television and Computer Recycling Scheme is one such scheme.

Other schemes under development include those to manage end-of-life tyres and mercury-containing lamps.

An independent advisory group is tasked with reporting to the Australian Government by 30 June 2013 on products to be considered for potential product stewardship action under the act. There may be other product stewardship schemes eventually that will provide further opportunities for increased plastic recovery in South Australia.

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[1] "An assessment of television and computer recycling experience and capacity in South Australia: Waste estimates and recovery and recycling capacity". Equilibrium for Zero Waste SA, April 2012. Link to report.

Container Deposit Legislation

South Australia's container deposit legislation (incorporated into the *Environment Protection Act 1993*) supports the recovery and recycling of end-of-life beverage containers, including significant amounts of PET and HDPE plastic packaging.

The legislation increases the value of the end-of-life containers as the party redeeming the container gets a 10 cent per container refund, whereas the intrinsic material value per plastic container is less than 1 cent per container.

The legislation therefore presents an opportunity to enhance recovery and recycling of all plastics packaging where the material is of a mixed variety and contains some beverage containers. For example, public place and / or commercial and industrial commingled recycling loads will have a higher value if there are container deposit materials in the load, and that may therefore enhance the financial viability of investment to capture and process such loads.

5.4.2 Barriers

It is common with plastics re-processors in Australia that they experience licensing barriers in respect to expanding current operations and capacity, in particular in relation to commissioning and operating wash plants. This situation is reportedly exacerbated in South Australia by trade waste requirements and costs.

It has also been observed in the development of this report that it is possible that environmental standards and licensing requirements may constrain current plastics processing capacity. This is an initial general comment on the state of some plastics processing operations and the observed environmental controls and standards being employed. If the environmental controls and management were found to be in contravention of environmental licensing or other regulatory requirements, it may result in orders restricting the operation of such facilities and therefore decrease plastics processing capacity in South Australia.

Licensing

Under the South Australian *Environment Protection Act 1993*, Schedule 1 - 3 (3) indicates that, with some exceptions, depots for the reception, storage, treatment or disposal of wastes are considered prescribed activities of environmental significance and require environmental licensing (see link).

This presents two fundamental issues for increasing plastic recovery and recycling in South Australia - (i) whether the cost and complexity of meeting such requirements is practical for any new investment and (ii) whether existing operations are meeting and can continue to meet such requirements (in current mode with enhanced capacity).

Washing

Increased processing of end-of-life plastics commonly requires washing to remove contamination and be able to achieve material quality specifications.

As noted, existing processors report that trade waste fees and charges in South Australia are a barrier to operating wash plants (and therefore potentially increasing capacity, throughput and quality).

SA Water trade waste fees and charges have increased in recent years (see linkSA Water Trade Waste fees and charges).

This study has not been able to determine the efficiency of current washing operations in South Australia, and therefore the immediate opportunity for more efficient and / or productive washing plant. It can be reported that based on industry input into this study there is sufficient capacity in South Australia to wash the waste plastics currently being recovered and processed locally but that local players are looking for opportunities to use existing plant more fully and / or upgrade existing plant to process more volume.

Further details about wash plants are contained in section 2.1.1

5.4.3 International

As noted in the stage 1 report, overseas markets are important for many recovered plastic packaging types[2]. The Australian Bureau of Statistics reports that China is currently the main destination for waste materials exported from Australia[3].

End-of-life plastics are globally traded commodities and have to meet certain licensing and regulatory requirements. The ability of South Australian collectors, sorters and processors to meet regulatory requirements, impacts on the ability to sell materials into those overseas markets and therefore maintain or expand this element of plastics recovery and recycling.

CCIC

The People's Republic of China has a national standard for environmental protection for imported solid waste and scrap plastic (see linkCCIC standard). The standard (commonly referred to as CCIC) has been in place since 1996 and was last updated in 2006.

The standard sets out requirements for inspection and reporting to ensure imported waste and scrap plastics are in an acceptable form and do not contain what the standard defines as restricted materials.

Operation Green Fence

New restrictions on the importation of end-of-life plastics and other recyclable materials into China may be a significant disruption to South Australian plastics recovery and recycling performance.

In early 2013, China commenced Operation Green Fence to more closely inspect and scrutinize loads of imported "waste" and recyclable materials. It is reportedly a fixed term (10 month) program to more rigorously enforce existing standards (see CCIC above).

Informal industry reports in Australia indicate that at least one Australian company has had a load of recyclables rejected and returned to Australia. Public reports from the United States of America indicate that the operation is exacerbating reduced demand from China and therefore driving up sorting and processing costs in the USA (see linkQuartz article May 2013.). In response some reprocessors are investing in technologies adding jobs and value to minimally process material to meet import requirements (PRW June 01 2013)

[2] Ibid. P20.

[3] Australia's International Trade in Waste, 4602.0.55.005 – 2013, Australian Bureau of Statistics see link

The impact for South Australia will be similar to that for any plastics recovery and recycling across Australia in that businesses may experience reduced demand or lower price for materials, or be required to undertake higher levels of sorting and processing to ensure standards are met.

While it is reported that Operation Green Fence will only exist for a set period of time and may be completed before the end of the 2013 calendar year, it is nonetheless going to be a significant change for the current period and is indicative of tighter on-going importation controls in China.

Hazardous waste

The *Hazardous Waste (Regulation of Exports and Imports) Act 1989* includes "household waste" among other materials in its definition of hazardous waste (see link). Australian Government website. Any materials meeting the definitions in the Act require a permit for export.

5.5 End markets

A large number of end market applications for recycled plastic packaging material have been established in South Australia and nationally for many years. The performance of these markets has been influenced by the international buying and exports of waste packaging plastics along with other waste materials. This section describes the market situation in South Australia, nationally in Australia and some recent international developments.

Efforts by converters to use recycled plastics have often been limited due to higher processing costs and their impact on product quality. There is a consistent message in the market place from converters and brand owners to the affect that if recycled material did not impact on quality, was competitively priced and was consistently available, they would use it in significant quantities. To enable significant growth in the use and value of recycled polymers in Australia, material quality needs to be at a high level so that significant percentages can be used by converters with a minimal loss of performance compared to virgin materials.

Sorting, washing and decontamination technologies are being used to improve the quality of recycled materials so they can be used at increased percentages and in a wider range of applications. High speed automated NIR sorting of whole packaging articles and shredded flake by polymer type and colour is used with intensive washing and decontamination to remove odour and produce very high and consistent quality recycled materials. This focus on product quality rather than minimal cost has enabled increased use and opportunities for recycled materials.

5.6 Local, national, international

5.6.1 South Australia

The South Australian market for recycled plastics has been described in the stage 1 report, and is estimated to utilize 4,500 tpa of HDPE, LDPE and PP. These materials are from post-industrial and post-consumer sources and are processed to resin, ready for conversion to finished products sold both locally and nationally, and in some cases directly to finished goods such as timber replacement products. These local and regional businesses have surplus capacity in most cases, with growth opportunities limited by sales volumes that are in competition with other materials. Sales are limited in part by the cost of the recycled plastics raw material and cost competitiveness with the alternatives. Recycled materials are generally available for production, however obtaining them at the right quality and price is problematic.

Sales are also in part limited by regulations where "traditional" products are favoured or outdated specifications prohibit the use of alternative or recycled materials and some part is due to lack of awareness and promotion of the benefits of products made from recycled materials.

The cost and quality of available recycled materials is impacted by the national and international market into which recyclers sell materials, particularly where demand pushes prices up making local manufacture more challenging.

Figure 13. Examples of South Australian recycled plastic products

5.6.2 Australia

The Australian market for packaging plastic is estimated to be worth more than $10 billion, with rigid food and beverage packaging the largest single application [BIS Shrapnel Plastic Packaging in Australia, Volume 1: Rigid Packaging 14th Edition, 2008-2010].

Post-consumer plastic packaging recycling in Australia remains largely based around rigid packaging, predominantly beverage containers. Recent work by government and private enterprises has begun to investigate mechanical recycling of soft film plastics, targeted initially at single source post industrial products that are available in large quantities, but also post-consumer from the recycling and residual garbage stream. This echoes work being done overseas where soft plastics are also now being targeted for recovery (see 6.1.3 below).

The most significant recent development for recycled plastic packaging in Australia has been the construction of a food grade rPET and rHDPE recycling plant in Sydney's western suburbs. This new plant brings to Australia for the first time food grade recycling of natural HDPE milk containers, closing the loop on this material stream and an improved quality food grade rPET. This new facility will attract an increased amount of collected packing plastics that contain HDPE and PET materials as the operation is established and capacity is maximized. The operation has a world class automated PRF facility as a front-end to ensure a high level of purity and consistent quality of in-feed materials to the food grade decontamination stage. Significant volumes of material are required for an operation of this type, making a local South Australian version an unlikely proposition. However, improved recovery of packaging plastics in South Australia sorted only to the stage of mixed plastics from a MRF that might then be utilized by a large centralized PRF locally or nationally, would be of value.

PET packaging materials are predominately soft drink bottles and post-consumer they are processed back to soft drink bottles. Post-consumer sheet and tray products are collected and included in the bottle recycling process. It is understood that very little, if any, post-consumer PET is now being used in sheet extrusion and thermoforming applications in Australia. Post-industrial thermoforming trim and production scrap is often exported directly to overseas sheet producers, when it cannot be used internally.

Natural homopolymer rHDPE is being directed to food grade rHDPE for milk bottles. Coloured and non-food grade HDPE from HIC and personal care and film (shopping bag) applications and rPP are collected and used into a range of applications nationally:

- Pipe and irrigation membranes including geomembranes
- Injection moulded to mobile garbage bins
- Materials handling such as pallets, bins, crates and slip sheets
- Timber alternatives in garden products and wood / plastic composite decking.

Most of these applications prefer a washed flake as a minimum, possibly also melt filtered and pelletised, but are price sensitive and often cheaper unprocessed material are used.

Figure 14. Examples of other Australian recycled plastic products

5.6.3 International

The European and UK markets have developed under a regulatory system that has encouraged material recovery and recycling. Under legislated recycling targets, most rigid plastic packaging materials are diverted from landfill and mechanically recycled. Soft film plastic packaging is targeted for recovery, where most of the municipal residual (black bag) waste stream is landfilled.

The end use applications for recycled materials in international markets are similar to those developed in Australia, extruded timber alternatives, film products, geo-membranes, pipes bollards and hoarding, and these are produced to similar quality standards. The significantly larger market for these products and for the availability of recycled materials for processing creates a different market situation in Europe and the UK than in Australia or South Australia. They face many of the same competitive difficulties; however there is a much higher awareness of recycling and sustainability issues in general by the consumer and this creates an increased demand in the market place.

Food grade rPET for closed loop recycling to beverage bottles is in constant demand and there have been significant investments to increase capacity in recent times. The United Kingdom Waste and Resources Action Programme (WRAP) has have also invested in further research to improve rPET quality. Food grade rHDPE for closed loop recycling back in to milk bottles has progressed on schedule since the instigation of the milk roadmap in a coordinated industry wide effort. rHDPE levels are currently at 15% in all milk bottles and set to increase again to 30% in the near future. To address this demand, additional rHDPE food grade recycling capacity investment is being planned.

Other developments for plastics from packaging have led to the development of technology for food grade recycling of rPP. This will help to create additional high value markets for rPP by enabling closed loop recycling back into food packaging such as trays, tubs and cups.

There has also been a focus on soft film plastics that represent a large portion of the packaging plastics but are difficult to recycle in a commercially viable process. Dry cleaning technologies have provided a lower cost cleaning option for film from agricultural, C&I and municipal sources, by avoiding or reducing the cost of wet washing. Demonstration trials have shown that these film products can be effectively dry cleaned without the use of water or other solvents to produce recycled material for moulding applications.

Figure 15. Dry cleaning of municipal film waste material

Thin film applications have been demonstrated but are still problematic and benefit from the additional wet washing, however thick films and membranes, injection moulding and extrusion are all possible. Depending on the source of the material, quality of separation and sorting, there may be residual odour often referred to as a "burnt paper" smell that results from residual organics such as paper.

Chemical recycling via incineration and pyrolysis are also major applications for highly contaminated and mixed plastics comingled with biomass materials.

6. Opportunities

There are significant opportunities for improved extraction of packaging plastics and other resources from the waste stream that is currently being collected. Investment in modern automated MRF equipment to fully recover all materials would deliver significant benefits.

6.1 Quantity and form of material available

ZWSA has conducted trials to divert food waste from the residual stream to the green organics stream with some success. The MSW residual stream consists of 78.3% putrescible material which is a major barrier to the separation and sorting of other materials such as packing plastics. The modeling in section 3 indicates that with the current level of organic waste it is not viable to sort and recover the other materials if the residual fraction is still required to be landfilled. Diversion of food waste to the green waste stream is one option that would improve the economics of separating and sorting the municipal residual stream. A second option is to conduct further processing on the organic waste stream via an AWT technology such as gasification or anaerobic digestion, which would also improve the commercial viability of recovery process.

Soft film plastic in the residual stream is highly contaminated because of the contact with the food waste. Diversion of soft film plastics to the recycle stream would reduce contamination and further reduce the amount of packaging plastics going directly to landfill. This would add cost and complexity in existing MRF operations because they are not currently setup to handle a large amount of soft film plastic. Increased manual sorting or installation of automated sorting would be required. Trials have been conducted in Darebin Council Melbourne of a "bag in bag" system to collate flexibles in the home before being deposited into the recycling bin. This system made it easy to identify and remove soft film material at the start of the MRF process and may be an approach that can be further explored.

6.2 Sorting and separation

The South Australian CDL system requires manual sorting to isolate CDL packaging by material and brand. Separation of CDL by brand would be improved if automated sorting were first used to separate by material type. Sophisticated vision systems may be able to sort based on shape if these were distinctive to particular brands.

Modern automated MRFs provide very effective material separation at a low process cost per tonne of in-feed and for large volumes of material. This technology is appropriate for South Australian municipal recyclables and the C&I stream to improve material recovery levels. High capital costs for these plants are a barrier to entry for a number of players, and the current status of existing MRFs and recovery centres needs to be considered, however automation of MRF processes are recommended as a necessary step in improving material recovery for packaging plastics and other materials.

The viability of a PRF facility should be considered based on the availability of a mixed plastic stream from MRF operations and the potential for secondary processing locally or nationally. PRF commercial viability requires a significant and consistent volume of material and is often associated with value adding of sorted plastics through to a pelletised or finished product.

6.3 Processing

Expanded polystyrene (EPS) volumes have not been quantified in the data, other than as some proportion of the PS fraction. Some Australian state authorities have reviewed the collection and densification of EPS for recovery and recycling.

There are commercial markets for densified EPS both nationally and internationally, however the main benefit is space saving in landfills, which is very expensive on a per tonne basis. Efforts to source separate EPS from C&I operations and collection centres should be investigated.

Section 2 refers to a number of energy from waste plastic technologies that are commercially available as well energy from biomass such as RDF. A further technology suited to biomass is anaerobic digestion to produce gas for energy and this technology should also be considered as part of the holistic approach to waste management, although not specifically relevant for waste plastics.

6.4 Chinese "Green Fence" waste plastic import inspection

The recent Green Fence regulations referred to in section 3.3.3 and 5.4.3 are already affecting sales and export of materials in local South Australian and national markets. It is still unclear to what extent or precisely how this recent adjustment to the importation process in China will influence materials and pricing in the near term, and how the Australian government might intervene if at all. It should be expected that that the "Green Fence" policy will cause changes:

- Beneficial to some elements of the supply chain, if materials are no longer able to be exported and are made available for local processing at lower prices
- Result in additional material going to landfill if it can no longer be exported, or prices no longer warrant separation
- Result in additional sorting and processing to that material quality for export, improving recoveries and value.

A wait-and-see approach may be required as the outcomes of this recent change to the export of waste plastic materials to China become apparent in the local South Australian and national market.

6.5 Collection

Opportunities for increased collection of end-of-life plastic packaging (and other plastics) are present in the household / MSW stream and the commercial and industrial / C&I stream.

6.5.1 The household / MSW stream

Targeting the plastics that are currently in the landfill bin (and therefore going to landfill and not being presented for recovery and recycling) is the first opportunity.

Potential solutions are based on infrastructure and behaviour change:

- Dirty MRF
- Education and advertising campaign to get people to put recyclables in the right bin.
- Increasing the recovery of plastics being presented in the kerbside recycling bin is another opportunity.

On current observations there is a fraction of the plastic packaging that is presented in kerbside recyclables systems that is not being recovered or recycled and is going to landfill. This is because the materials are too difficult to separate from other recyclables (eg plastic bags) contaminated with food or other matter, or are considered to have little market value (and therefore do not warrant the financial investment required for recovery).

Potential solutions are based on infrastructure and behaviour change:

- Automated sorting at MRFs
- Plastic sorting facilities (PRF)
- Aggregations of materials
- Education and advertising to reduce contamination.

With respect to the potential to increase plastic bag and film recovery through the MSW stream, the City of Darebin in Melbourne recently completed a trial of a "bag-in-bag" solution. The trial involved getting 900 households to consolidate plastic bags and plastic film in a bag, tying it off and including it in their kerbside recycling. From there the materials were sorted at a MRF and sent to a recycler.

The trial generated high participation rates by households, low contamination rates in the presented material and high recovery rates. It is estimated from the trial that a municipality of 50,000 households could reasonably recover about 150 tonnes of plastic waste per annum through such a process. It also found that the sorting activity is financially viable if the sale price of the recovered plastics is above $150 per tonne.

A recent study by the Canadian Plastics Industry Association (CPIA) on systems for plastic flexible film diversion evaluated a number of sorting technologies including the bag-in-bag option. The study provided an estimate of the potential of this technique to improve the efficiency of manual sorting in a Canadian MRF, which is represented in the following paragraphs and table 10 below[4];

The primary challenge of manually sorting plastic film is the amount of labour required and the resulting cost. Assuming a worker can make 50 picks per minute, one worker can sort a maximum of 3,000 individualized bags per hour. Using a conversion factor of 300,000 film pieces per tonne, it would take one worker 100 hours to pick one tonne. Manual sorting costs can be greatly reduced if residents can be trained to package all like plastic film (i.e., all polyethylene film) into a tied bag. To show the impact on sorting cost and efficiency, if 25 same-film items are in one bag, the productivity of the same worker can be increased from sorting 3,000 individualized film items per hour to sorting 75,000 film items per hour, and can pick a tonne in 4 hours. The degree to which film is bagged-in-bags is the single-most impactful factor on film sorting costs in a MRF. Table 10 below shows the impact on costs.

[4] Canadian Plastics Industry Association (CPIA) Analysis of Flexible Film Plastic Packaging Diversion Systems. Page 23 (Reclay StewardEdge Feb 2013)

Table 10. Sensitivity of MRF Manual Sorting Costs to Bags-in-Bags

Percent Bagged Film	Annual Capital	Labour	Operating	Cost / tonne
0% Bags in bags	$27/tonne	$1,799/tonne	$92/tonne	$1,917/tonne
50% Bags in bags	$25/tonne	$936/tonne	$92/tonne	$1,052/tonne
90% Bags in bags	$22/tonne	$245/tonne	$92/tonne	$358/tonne

Source: Resource Recycling Systems
Capital is estimated to include a pneumatic collection system with a cost of $104,769, a $36,669 bunker, and $8,382 per sort station (new MRF construction assumed). Capital is assumed to be financed over a term of 10 years at a 4 percent rate. Equipment sizing is based on a MRF with a design capacity of 20 tonnes per hour, operating two shifts per day and 260 operating days per year. All dollar values in converted to $AUD @ 1 $AUD = 0.954 $CAD.

The cost to manually sort film mixed with other recyclables in a MRF may therefore range from $358 - $1,917 per tonne. Manual sorting operating costs are highly dependent on whether best practices for film recycling are employed to keep film inside of bags up to the point that they are manually separated.

6.5.2 The commercial and industrial (C&I) stream

The C&I stream is all wastes collected from away-from-home locations but not including construction and demolition wastes. This includes waste and recyclables from retail, food service, manufacturing, offices, stadia, shopping centres and the like.

Opportunities include:

- Source separation (retail, distribution centres, other)
- Commingled recycling (public place, food service, food courts, offices)
- Dirty MRF
- Plastics recovery facility (PRF).

6.5.3 Sorting and separation

Once any end-of-life plastic packaging or other plastic is collected it needs to go through a sorting and separation process. The extent of the sorting and separation depends on the quality and type of in-feed and the potential end-market.

If, for example, the plastic packaging is film (LDPE) that has been source separated at a retail outlet, it may require very little further sorting in order to be suitable for sale to a processor (whether local, interstate or overseas). If, however, the plastic materials are commingled with other plastics and other materials, it may need extensive sorting in order to target a particular polymer, remove non-plastic recyclables and remove other contamination.

Opportunities include:

- Automated sorting at MRF
- Dirty MRF
- Plastic sorting facilities (PRF).

6.5.4 Local, national and international markets

As detailed in the *Stage 1 Final Report on the South Australian Plastics Packaging Resource Recovery Sector*[5], plastics packaging and other plastics recovered for recycling are nationally and internationally traded commodities. The report estimated that of the plastic packaging recovered in South Australia, 36% is processed locally, 26% interstate and 37.8% overseas.

The key determinants of the market(s) for end-of-life and recycled plastics are:

- Virgin polymer prices
- Petroleum production cycles, demand and supply
- End uses
- Alternative materials
- Quality and quantity of recovered materials
- Other regulatory issues.

6.5.5 Strategic roadmap for the chemicals and plastics industries

The Plastics and Chemicals Industries Association (PACIA) in association with the CSIRO and Australian Government Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education has released a strategic road map for Australia's chemicals and plastics industries.

Released in June 2013, the road map and supporting research specifically identifies increased waste plastic recovery and recycling as an economic and environmental opportunity.

Overall the road map identifies that chemicals and plastics are inputs into 109 of the 111 industry sectors present in Australia and consequently collaborative industry-government-research approaches are needed to realise many opportunities.

While this does not present a direct short-term opportunity for increased waste plastic recovery and recycling in South Australia, it flags material recycling as a critical issue and therefore may offer South Australian companies a framework and support to progress further plastic recycling projects.

[5] "Stage 1 Final Report – Study on the South Australian Plastics Packaging Resource Recovery Sector" , Rawtec for Zero Waste SA, April 2012.

7. Conclusion

The Stage 2 study has determined that a significant amount of plastic packaging waste is going to landfill via the Municipal Recyclable, Municipal Residual and C&I streams. The volume and type of packaging plastic has been determined based on kerbside and recycling activity reports. Further assessment by direct audit of the material being landfilled would validate this estimation and provide the level of detail that would be required to encourage investment in a large automated MRF operation.

The value of the remaining plastic packaging is low in comparison to similar streams in other states due to the low number of rigid containers. Although recovery of the remaining CDL containers would be profitable, the recovery of other plastic packaging materials alone would be insufficient to justify new or additional investment in MRF processing.

A modern automated MRF, which is a high capital cost commercially viable investment, would minimise manual sorting (probably still required for CDL), reduce operational costs, enable high efficiency extraction of all plastic packaging and other recyclable materials and minimise landfill residues.

Soft plastic film represents a large proportion of the plastic packaging being landfilled via the Municipal Residual stream, which is not being processed. The modelling estimates show that it is commercially unviable to process this stream through a dirty MRF if the organic fraction is still sent to landfill. Redirection of the soft plastic film fraction to the recyclables stream would enable it to be recovered in a suitably designed modern automated MRF.

Most of the high value rigid containers (both CDL and non-CDL) are being recovered from the Municipal Recyclables stream, with only a small quantity of soft film plastic material recovered. Additional auditing of the current MRF landfill fraction would better quantify the actual volume. The modelling shows it is not cost effective to manually separate this low value soft plastic film fraction in an existing MRF, however soft plastic film could be readily separated for recovery in a suitably designed modern automated facility.

Additional separation of mixed plastics and secondary processing to wash, pelletise and convert the recycled plastics could be established in South Australia as a centralised facility that could source material from a number of locations, including MRFs. The modelling has shown that the PRF process alone could be viable with sufficient volume but it would be more appropriately operated as the front-end part of a value adding operation to make pelletised or finished products.

The landscape for exporting plastic waste to China is currently being adjusted due to the effect of the “Green Fence” policy. It is unclear what impact this might have in South Australia, it may present opportunities to increase recovery and processing. Enforcement of the South Australian waste EPP bans would also impact local collection and reprocessing practices and, potentially, future contract negotiations. Existing MRFs and reprocessors are not set up to economically separate all of these materials, and would incur a financial cost if they were forced to do so.

Nationally and locally there is a range of applications for recycled plastics, but the market is demanding increased quality so that recycled materials can be utilised at higher proportions of recycled material without impacting product performance and can be used in a wider number of applications. Post-consumer materials require wet washing as part of the process to meet these quality standards which is an expensive stage which reprocessors are reluctant to invest in or expand without long term supply contracts.

8. References

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Appendix 1 Cost benefit model assumptions

With respect to the sale prices that have been used to model the value of the materials sold by a MRF operator, the study uses information obtained directly from the market which has been checked against puiblished data. This includes referencing it against the Packaging Impacts Consultation Regulation Impact Statement which presents the following market value of resources / commodities in the kerbside recycling bin (AUD$ per tonne):

Paper / cardboard	$181
Aluminium cans	$1,560
Plastic – sorted	$560
Plastic – part sorted	$530
Plastic – mixed	$372
Steel cans	$280
Liquid paperboard	$150
Weighted average	$162

Appendix 1.1 Municipal Recyclables

Dry Recyclables processing at 60,000 tonnes pa input

Total Plant	MRF	PRF	Pelletise	Total
*Capital Costs:	$ 2,060,438	$ 994,950	$ 1,740,944	$4,796,332
**Total Sales	$ 9,419,077	$ 895,569	$ 1,831,317	$ 12,145,963
***Total Costs	$ 6,071,703	$ 1,175,508	$ 1,071,878	$ 8,319,089
Operating Costs	$ 101	$ 228	$ 617	$ 946
EBIT	$ 3,347,374	-$ 279,939	$ 759,440	$ 3,826,875
Profit (before interest & tax)	36%	-31%	41%	32%
Payback	0.6	NEGATIVE	2.3	1.3

Comments:

* Exclude cost of building and services
** Include the sales value of material to PRF and Pelletise sections
*** Includes cost of landfill of residual after processing.
PRF and Pelletise are operating at about 30-40% capacity

Fixed Costs	Cost		
Rent	60	$/sqm	Estimate
Maintenance	5%	of Capital	
Office/Travel/Legal/Advert	120,000	Fixed estimate	
Insurance	3%	of capital	
Depreciation	10	years	
Variable Costs			
Input Material	0	$ / tonne	
Solid Waste	100	$ / tonne	Landfill
Electricity	0.10	$ / kWh	
Water In	1.10	$ / m3	
Water discharge	1.60	$ / m3	
Packaging /Other	5	$ / tonne	Estimate
Transport	20	$ / tonne	Estimate

Labour Costs:

Cost - (staff personnel):										
			MRF	CDL Sort	Pelletise	Total		$/month		$/yr
	annual cost $		number	number	number					
Plant Manager	$	129,300	0.33	0.33	0.33	1	$	10,667	$	128,007
Chemist/QA	$	95,250	0.33	0.33	0.33	1	$	7,858	$	94,298
Lab Assistant	$	69,850	0	0	0	0	$	-	$	-
Admin/HR/Training	$	63,500	0.33	0.33	0.33	1	$	5,239	$	62,865
Accounts/Purchasing	$	95,250	0.33	0.33	0.33	1	$	7,858	$	94,298
Sales/Mktg/Logistics	$	105,250	0	0	0	0	$	-	$	-
Maintenance Engineer	$	88,900	0.33	0.33	0.33	1	$	7,334	$	88,011
Electrician	$	88,900	0.33	0.33	0.33	1	$	7,334	$	88,011
Total Staff			**1.98**	**1.98**	**1.98**	**5.94**	**$**	**46,291**	**$**	**555,489**

Cost - (shift personnel):										
			MRF	CDL Sort	Pelletise			$/month		$/yr
	annual $		number	number	number					
Shift Leader	$	88,900	0.33	0.33	0.33	2	$	14,669	$	176,022
Sorter	$	57,150	10	1	0	32	$	152,400	$	1,828,800
Operator	$	69,850	2	1	1	9	$	52,388	$	628,650
Shifts			**3**	**2**	**1**					
Total operational staff / shift			**12.33**	**2.33**	**1.33**					
					Total operational staff	**43**				
Total									**$**	**2,633,472**

Manual Floor and mechanical sorting

Total Operative Costs Summary (excl. Capital costs):

	$/yr	$ / tonne
incl. Input purchase	$ 4,567,160	$ 76
excl. Input purchase	$ 4,567,160	$ 76

Investment Costs:	$ 2,060,438
Tonne per year (Input)	60,000

Sales value baled output	**tonne**	**$ / tonne**	**Value**
Steel	1,665	280	466,106
Aluminium	55	1560	85,658
Aluminium CDL	85	6667	565,387
Glass	5,932	30	177,962
Glass CDL	1,792	478	857,407
LPB	285	150	42,770
LPB CDL	73	2404	175,449
Paper Cardboard Fibre	31,207	181	5,648,513
PET CDL	317	2,923.98	925,869
HDPE CDL	33	2,000.00	65,993
PVC CDL	16	1,333.33	21,888
To NIR & Manual sort	3,861	100	386,075
Total	41,094		9,419,077

Fixed Costs		**Key Value**	
Staff Labour Cost	$ 185,163	33.33%	% of total
Rent	$ 198,000	3,300	sqm
Maintenance	$ 93,656	5%	of capital
Office/Travel/Legal/Advert	$ 40,000	Allowance	
Insurance	$ 56,194	3%	of capital
Depreciation	$ 187,313	10	years
sub-total	$ 760,326		

Variable Costs			
Input Material	$ -	$ -	
Solid Waste Costs	$ 1,504,543	15,045	
Labour Shifts	$ 2,221,611	84%	
Electricity	$ 45,223	452,232	kWh/yr
Gas	$ -	0	Mj
Other (Fork / Quality)	$ 40,000	140	tonnes
Water & Waste water		-	klitre
Chemicals	$ -		
Packaging	$ 300,000	6,017	tonnes of plastic
Transport	$ 1,200,000	-	tonnes of plastic
sub total	$ 5,311,378		

		$ / tonne
Sales	$ 9,419,077	$ 157
Total of Costs	$ 6,071,703	$ 101

EBIT (Sales - Costs)	$ 3,347,374
Profit before Tax and Interest%	36%
Payback (years)	0.6

Auto NIR PRF

Total Operative Costs Summary (excl. Capital costs):

	$/yr	$ / tonne
incl. Input purchase	$ 1,175,508	$ 304
excl. Input purchase	$ 789,433	$ 228

Investment Costs:	$ 994,950	
Tonne per year (Input)	3,861	From MRF

Sales value baled output	**tonne**	**$ / tonne**	**Value**
			0
			0
			0
PET	351	750	263,539
HDPE	1,401	300	420,274
PVC	0	100	0
PP	474	200	94,801
PS	412	100	41,199
Other & Film	758	100	75,757
	3,396		$895,569

Fixed Costs		**Key Value**	
Staff Labour Cost	$ 185,163	33%	% of total
Rent	$ 60,000	1,000	sqm
Maintenance	$ 45,225	5%	of capital
Office overheads	$ 40,000	Allowance	
Insurance	$ 27,135	3%	of capital
Depreciation	$ 90,450	10	years
sub-total	$ 447,973		

Variable Costs			
Input Material	$ 386,075	$100	
Solid Waste Costs	$ -	-	tonnes of plastic
Labour Shifts	$ 312,674	12%	
Electricity	$ 8,786	87,856	kWh/yr
Gas	$ -	-	Mj
Other	$ 20,000		
Water & Waste water	$ -	0	klitre
Chemicals	$ -		
Packaging	$ -	-	tonnes of plastic
Transport	$ -	-	tonnes of plastic
sub total	$ 341,460		

		$ / tonne
Sales	$ 895,569	$ 232
Total of Costs	$ 1,175,508	$ 228

EBIT (Sales - Costs)	-$ 279,939
Profit before Tax and Interest%	-31%
Payback (years)	NEGATIVE

Washing and extrusion

Total Operative Costs Summary (excl. Capital costs):

	$/yr	$ / tonne
incl. Input purchase	$ 1,065,355	$ 817
excl. Input purchase	$ 804,443	$ 617

Investment Costs:	$ 1,740,944	
Tonne per year (Input)	1,305	From PRF HDPE, PP and Film only

Sales value baled output	**tonne**	**$ / tonne**	**Value**
			0
			0
			0
HDPE	1,401	800	1,120,730
PP	474	700	331,804
Other & Film	758	500	378,783
	0	0	0
	0	0	0
	0	0	0
	2,632		$1,831,317

Fixed Costs		**Key Value**	
Staff Labour Cost	$ 185,163	33%	% of total
Rent	$ 60,000	1,000	sqm
Maintenance	$ 79,134	5%	of capital
Office overheads	$ 40,000	Allowance	
Insurance	$ 47,480	3%	of capital
Depreciation	$ 158,268	10	years
sub-total	$ 570,045		
Variable Costs			
Input Material	$ 260,912	$200	
Solid Waste Costs	$ -	-	tonnes of plastic
Labour Shifts	$ 99,187	4%	
Electricity	$ 82,936	-	kWh/yr
Gas	$ -	-	Mj
Other	$ 16,523		
Water & Waste water	$ 14,192	0	klitre
Chemicals	$ 21,560		
Packaging	$ 6,523	-	tonnes of plastic
Transport	$ -	-	tonnes of plastic
sub total	$ 240,921		
		$ / tonne	
Sales	$ 1,831,317	$ 1,404	
		$ / tonne	
Total of Costs	$ 1,071,878	$ 617	
EBIT (Sales - Costs)	$ 759,440		
Profit before Tax and Interest%	41%		
Payback (years)	2.3		

Appendix 1.2 Municipal Residuals

Residuals processing at 120,000 tonnes pa input

Total Plant	MRF	PRF	Pelletise	Total
*Capital Costs:	$ 2,914,313	$ 994,950	$ 1,740,944	$5,650,207
**Total Sales	$ 6,605,341	$ 1,016,018	$ 1,061,276	$ 8,682,634
***Total Costs	$ 16,521,046	$ 1,539,828	$ 2,431,722	$ 20,492,595
Operating Costs	$ 138	$ 307	$ 219	$ 664
EBIT	-$ 9,915,705	-$ 523,810	-$ 1,370,446	-$ 11,809,961
Profit (before interest & tax)	-150%	-52%	-129%	-136%
Payback	NEGATIVE	NEGATIVE	NEGATIVE	NEGATIVE

Comments:

* Exclude cost of building and services
** Include the sales value of material to PRF and Pelletise sections
*** Includes cost of landfill of residual after processing.
PRF and Pelletise are operating at about 30-40% capacity

Fixed Costs	Cost		
Rent	60	$/sqm	Estimate
Maintenance	5%	of Capital	
Office/Travel/Legal/Advert	120,000	Fixed estimate	
Insurance	3%	of capital	
Depreciation	10	years	
Variable Costs			
Input Material	0	$ / tonne	
Solid Waste	100	$ / tonne	
Electricity	0.10	$ / kWh	
Water In	1.10	$ / m3	
Water discharge	1.60	$ / m3	
Packaging /Other	5	$ / tonne	Estimate
Transport	20	$ / tonne	Estimate

Labour Costs:

Cost - (staff personnel):							
		MRF	CDL Sort	Pelletise	Total	$/month	$/yr
	annual cost $	number	number	number			
Plant Manager	$ 129,300	0.33	0.33	0.33	1	$ 10,667	$ 128,007
Chemist/QA	$ 95,250	0.33	0.33	0.33	1	$ 7,858	$ 94,298
Lab Assistant	$ 69,850	0	0	0	0	$ -	$ -
Admin/HR/Training	$ 63,500	0.33	0.33	0.33	1	$ 5,239	$ 62,865
Accounts/Purchasing	$ 95,250	0.33	0.33	0.33	1	$ 7,858	$ 94,298
Sales/Mktg/Logistics	$ 105,250	0	0	0	0	$ -	$ -
Maintenance Engineer	$ 88,900	0.33	0.33	0.33	1	$ 7,334	$ 88,011
Electrician	$ 88,900	0.33	0.33	0.33	1	$ 7,334	$ 88,011
Total Staff		**1.98**	**1.98**	**1.98**	**5.94**	**$ 46,291**	**$ 555,489**

Cost - (shift personnel):							
		MRF	CDL Sort	Pelletise		$/month	$/yr
	annual $	number	number	number			
Shift Leader	$ 88,900	0.33	0.33	0.33	3	$ 19,558	$ 234,696
Sorter	$ 57,150	15	1	0	47	$ 223,838	$ 2,686,050
Operator	$ 69,850	2	1	1	11	$ 64,029	$ 768,350
Shifts		**3**	**2**	**3**			
Total operational staff / shift		**17.33**	**2.33**	**1.33**			
				Total operational staff	**61**		
Total							**$ 3,689,096**

Manual Floor and mechanical sorting

Total Operative Costs Summary (excl. Capital costs):			
	$/yr	$ / tonne	
incl. Input purchase	$ 7,095,791	$ 59	
excl. Input purchase	$ 7,095,791	$ 59	
Investment Costs:	$ 2,914,313		
Tonne per year (Input)	120,000		
Sales value baled output	**tonne**	**$ / tonne**	**Value**
Steel	2,395	280	670,656
Aluminium	200	1560	311,691
Aluminium CDL	176	6667	1,171,770
Glass	2,224	30	66,726
Glass CDL	1,051	478	503,110
LPB	136	150	20,373
LPB CDL	72	2404	173,451
Paper Cardboard Fibre	11,989	181	2,170,019
PET CDL	192	2,923.98	560,019
HDPE CDL	104	2,000.00	207,130
PVC CDL	-	1,333.33	0
To NIR & Manual sort	7,504	100	750,395
Total	18,244		6,605,341
Fixed Costs		**Key Value**	
Staff Labour Cost	$ 185,163	33.33%	% of total
Rent	$ 198,000	3,300	sqm
Maintenance	$ 132,469	5%	of capital
Office/Travel/Legal/Advert	$ 40,000	Allowance	
Insurance	$ 79,481	3%	of capital
Depreciation	$ 264,938	10	years
sub-total	$ 900,051		
Variable Costs			
Input Material	$ -	$ -	
Solid Waste Costs	$ 9,425,255	94,253	
Labour Shifts	$ 3,078,861	83%	
Electricity	$ 76,879	768,795	kWh/yr
Gas	$ -	0	Mj
Other (Fork / Quality)	$ 40,000	376	tonnes
Water & Waste water		-	klitre
Chemicals	$ -		
Packaging	$ 600,000	2,400	tonnes of plastic
Transport	$ 2,400,000	-	tonnes of plastic
sub total	$ 15,620,995		
		$ / tonne	
Sales	$ 6,605,341	$ 55	
		$ / tonne	
Total of Costs	$ 16,521,046	$ 138	
EBIT (Sales - Costs)	-$ 9,915,705		
Profit before Tax and Interest%	-150%		
Payback (years)	NEGATIVE		

Auto NIR PRF

Total Operative Costs Summary (excl. Capital costs):

	$/yr	$ / tonne
incl. Input purchase	$ 1,539,828	$ 205
excl. Input purchase	$ 789,433	$ 307

Investment Costs:	$ 994,950	
Tonne per year (Input)	7,504	From MRF

Sales value baled output	**tonne**	**$ / tonne**	**Value**
			0
			0
			0
PET	233	750	174,858
HDPE	537	300	161,204
PVC	0	100	0
PP	521	200	104,221
PS	619	100	61,917
Other & Film	5,138	100	513,817
	7,049		$1,016,018

Fixed Costs		**Key Value**	
Staff Labour Cost	$ 185,163	33%	% of total
Rent	$ 60,000	1,000	sqm
Maintenance	$ 45,225	5%	of capital
Office overheads	$ 40,000	Allowance	
Insurance	$ 27,135	3%	of capital
Depreciation	$ 90,450	10	years
sub-total	$ 447,973		

Variable Costs			
Input Material	$ 750,395	$100	
Solid Waste Costs	$ -	-	tonnes of plastic
Labour Shifts	$ 312,674	8%	
Electricity	$ 8,786	87,856	kWh/yr
Gas	$ -	-	Mj
Other	$ 20,000		
Water & Waste water	$ -	0	klitre
Chemicals	$ -		
Packaging	$ -	-	tonnes of plastic
Transport	$ -	-	tonnes of plastic
sub total	$ 341,460		

		$ / tonne
Sales	$ 1,016,018	$ 135
Total of Costs	$ 1,539,828	$ 307

EBIT (Sales - Costs)	-$ 523,810
Profit before Tax and Interest%	-52%
Payback (years)	NEGATIVE

Washing and extrusion

Total Operative Costs Summary (excl. Capital costs):

	$/yr	$ / tonne	
incl. Input purchase	$ 2,403,064	$ 419	
excl. Input purchase	$ 1,256,779	$ 219	
Investment Costs:	$ 1,740,944		
Tonne per year (Input)	5,731	From PRF HDPE, PP and Film only	

Sales value baled output	**tonne**	**$ / tonne**	**Value**
			0
			0
			0
HDPE	537	660	354,650
PP	521	370	192,809
Other & Film	5,138	100	513,817
	0	0	0
	0	0	0
	0	0	0
	6,197		$1,061,276

Fixed Costs		**Key Value**	
Staff Labour Cost	$ 185,163	33%	% of total
Rent	$ 60,000	1,000	sqm
Maintenance	$ 79,134	5%	of capital
Office overheads	$ 40,000	Allowance	
Insurance	$ 47,480	3%	of capital
Depreciation	$ 158,268	10	years
sub-total	$ 570,045		
Variable Costs			
Input Material	$ 1,146,286	$200	
Solid Waste Costs	$ -	-	tonnes of plastic
Labour Shifts	$ 297,561	8%	
Electricity	$ 271,294	-	kWh/yr
Gas	$ -	-	Mj
Other	$ 38,657		
Water & Waste water	$ 28,472	0	klitre
Chemicals	$ 50,750		
Packaging	$ 28,657	-	tonnes of plastic
Transport	$ -	-	tonnes of plastic
sub total	$ 715,391		
		$ / tonne	
Sales	$ 1,061,276	$ 185	
		$ / tonne	
Total of Costs	$ 2,431,722	$ 219	
EBIT (Sales - Costs)	-$ 1,370,446		
Profit before Tax and Interest%	-129%		
Payback (years)	NEGATIVE		

Appendix 1.3 Commercial and Industrial

C & I processing at 200,000 tonnes pa input

Total Plant	MRF	PRF	Pelletise	Total
*Capital Costs:	$ 3,682,800	$ 1,952,775	$ -	$5,635,575
**Total Sales	$ 16,070,669	$ 7,433,784	$ -	$ 23,504,453
***Total Costs	$ 9,207,084	$ 12,275,073		$ 21,482,158
Operating Costs	$ 46	$ 247		$ 293
EBIT	$ 6,863,585	-$ 4,841,289		$ 2,022,296
Profit (before interest & tax)	43%	-65%		9%
Payback	0.5	NEGATIVE		2.8

Comments:

* Exclude cost of building and services

** Include the sales value of material to PRF and Pelletise sections

*** Includes cost of landfill of residual after processing.

Gate fee at $-15/tonne, transfer price at $100/tonne between MRF and NIR sorting

Fixed Costs	Cost		
Rent	60	$/sqm	Estimate
Maintenance	5%	of Capital	
Office/Travel/Legal/Advert	120,000	Fixed estimate	
Insurance	3%	of capital	
Depreciation	10	years	
Variable Costs			
Input Material	-15	$ / tonne	
Solid Waste	100	$ / tonne	
Electricity	0.10	$ / kWh	
Water In	1.10	$ / m3	
Water discharge	1.60	$ / m3	
Packaging /Other	5	$ / tonne	Estimate
Transport	26	$ / tonne	Packaging RIS Pg 126

Labour Costs:

Cost - (staff personnel):										
			MRF	CDL Sort	Pelletise	Total		$/month		$/yr
	annual cost $		number	number	number					
Plant Manager	$	129,300	0.5	0.5	0	1	$	10,775	$	129,300
Chemist/QA	$	95,250	0.5	0.5	0	1	$	7,938	$	95,250
Lab Assistant	$	69,850	0	0	0	0	$	-	$	-
Admin/HR/Training	$	63,500	0.5	0.5	0	1	$	5,292	$	63,500
Accounts/Purchasing	$	95,250	0.5	0.5	0	1	$	7,938	$	95,250
Sales/Mktg/Logistics	$	105,250	0.5	0.5	0	1	$	8,771	$	105,250
Maintenance Engineer	$	88,900	1	1	0	2	$	14,817	$	177,800
Electrician	$	88,900	0.5	0.5	0	1	$	7,408	$	88,900
Total Staff			**4**	**4**	**0**	**8**	**$**	**62,938**	**$**	**755,250**
Cost - (shift personnel):										
			MRF	CDL Sort	Pelletise			$/month		$/yr
	annual $		number	number	number					
Shift Leader	$	88,900	2	1	0	8	$	59,267	$	711,200
Sorter	$	57,150	20	6	0	72	$	342,900	$	4,114,800
Operator	$	69,850	2	2	0	10	$	58,208	$	698,500
Shifts			**3**	**2**	**1**					
Total operational staff / shift			**24**	**9**	**0**					
					Total operational staff	**90**				
Total									**$**	**5,524,500**

Manual Floor and mechanical sorting

Total Operative Costs Summary (excl. Capital costs):

	$/yr	$ / tonne
incl. Input purchase	$ 9,207,084	$ 46
excl. Input purchase	$ 12,207,084	$ 61

Investment Costs:	$ 3,682,800
Tonne per year (Input)	200,000

Sales value baled output		**tonne**	**$ / tonne**	**Value**
Manual Floor sort		400	-100	-40,000
Masonry		762	-100	-76,164
Other Oganics		57,123	-100	-5,712,295
Steel		35,130	280	9,836,288
Aluminium		1,727	1560	2,694,025
Garden		5,585	-100	-558,536
	0	-		
	0	-		
	0	-		
	0	-		
	0	-		
To NIR & Manual sort		99,274	100	9,927,351
Total		100,726		16,070,669

Fixed Costs		**Key Value**	
Staff Labour Cost	$ 377,625	50.00%	% of total
Rent	$ 420,000	7,000	sqm
Maintenance	$ 167,400	5%	of capital
Office/Travel/Legal/Advert	$ 40,000	Allowance	
Insurance	$ 100,440	3%	of capital
Depreciation	$ 334,800	10	years
sub-total	$ 1,440,265		

Variable Costs			
Input Material	-$ 3,000,000	-$ 15	
Solid Waste Costs	$ -	-	In sales
Labour Shifts	$ 4,381,500	79%	
Electricity	$ 115,319	1,153,192	kWh/yr
Gas	$ -	0	Mj
Other (Fork / Quality)	$ 70,000	57,885	tonnes
Water & Waste water		-	klitre
Chemicals	$ -		
Packaging	$ 1,000,000	92,253	tonnes of plastic
Transport	$ 5,200,000	-	tonnes of plastic
sub total	$ 10,766,819		
		$ / tonne	
Sales	$ 16,070,669	$ 80	
		$ / tonne	
Total of Costs	$ 9,207,084	$ 46	

EBIT (Sales - Costs)	$ 6,863,585
Profit before Tax and Interest%	43%
Payback (years)	0.5

Auto NIR PRF

Total Operative Costs Summary (excl. Capital costs):			
	$/yr	$ / tonne	
incl. Input purchase	$ 12,275,073	$ 124	
excl. Input purchase	$ 2,347,722	$ 247	
Investment Costs:	$ 1,952,775		
Tonne per year (Input)	99,274	From MRF	
Sales value baled output	**tonne**	**$ / tonne**	**Value**
All rigid plastic	3,735	340	1,269,760
Soft Film plastic (Mixed)	143	100	14,284
Non Ferrous	4,916	200	983,129
Glass	814	30	24,432
Paper / LPB	3,564	150	534,613
Timber	31,224	20	624,479
Cardboard	11,760	181	2,128,600
Food & Other Material	2,741	-100	-274,112
Cardboard	11,760	181	2,128,600
	70,657		$7,433,784
Fixed Costs		**Key Value**	
Staff Labour Cost	$ 377,625	50%	% of total
Rent	$ 180,000	3,000	sqm
Maintenance	$ 88,763	5%	of capital
Office overheads	$ 40,000	Allowance	
Insurance	$ 53,258	3%	of capital
Depreciation	$ 177,525	10	years
sub-total	$ 917,170		
Variable Costs			
Input Material	$ 9,927,351	$100	
Solid Waste Costs	$ -	-	tonnes of plastic
Labour Shifts	$ 1,143,000	21%	
Electricity	$ 20,866	208,658	kWh/yr
Gas	$ -	-	Mj
Other	$ 266,687		
Water & Waste water	$ -	0	klitre
Chemicals	$ -		
Packaging	$ -	143	tonnes of plastic
Transport	$ -	-	tonnes of plastic
sub total	$ 1,430,552		
		$ / tonne	
Sales	$ 7,433,784	$ 75	
		$ / tonne	
Total of Costs	$ 12,275,073	$ 247	
EBIT (Sales - Costs)	-$ 4,841,289		
Profit before Tax and Interest%	-65%		
Payback (years)	NEGATIVE		

Appendix 1.4 Optimised PRF / pelletise processing

PRF / Pelletise processing of 11,000 tonnes pa input

Total Plant	MRF	PRF	Pelletise	Total
*Capital Costs:	$	1,291,950	$ 2,334,944	$3,626,894
**Total Sales	$	2,560,596	$ 3,794,863	$ 6,355,459
***Total Costs	$	2,284,086	$ 3,191,990	$ 5,476,076
Operating Costs	$	119	$ 195	$ 314
EBIT	$	276,510	$ 602,873	$ 879,383
Profit (before interest & tax)		11%	16%	14%
Payback		4.7	3.9	4.1

Comments:

* Exclude cost of building and services

** Include the sales value of material to PRF and Pelletise sections

*** Includes cost of landfill of residual after processing.

PRF and Pelletise are operating at about 100% capacity

Fixed Costs	Cost		
Rent	60	$/sqm	Estimate
Maintenance	5%	of Capital	
Office/Travel/Legal/Advert	120,000	Fixed estimate	
Insurance	3%	of capital	
Depreciation	10	years	
Variable Costs			
Input Material	0	$ / tonne	
Solid Waste	100	$ / tonne	Landfill
Electricity	0.10	$ / kWh	
Water In	1.10	$ / m3	
Water discharge	1.60	$ / m3	
Packaging /Other	5	$ / tonne	Estimate
Transport	20	$ / tonne	Estimate

Labour Costs:

Cost - (staff personnel):								
		MRF	PRF	Pelletise	Total		$/month	$/yr
	annual cost $	number	number	number				
Plant Manager	$ 129,300	0.33	0.33	0.33	1		$ 10,667	$ 128,007
Chemist/QA	$ 95,250	0.33	0.33	0.33	1		$ 7,858	$ 94,298
Lab Assistant	$ 69,850	0	0	0	0		$ -	$ -
Admin/HR/Training	$ 63,500	0.33	0.33	0.33	1		$ 5,239	$ 62,865
Accounts/Purchasing	$ 95,250	0.33	0.33	0.33	1		$ 7,858	$ 94,298
Sales/Mktg/Logistics	$ 105,250	0	0	0	0		$ -	$ -
Maintenance Engineer	$ 88,900	0.33	0.33	0.33	1		$ 7,334	$ 88,011
Electrician	$ 88,900	0.33	0.33	0.33	1		$ 7,334	$ 88,011
Total Staff		**1.98**	**1.98**	**1.98**	**5.94**		**$ 46,291**	**$ 555,489**

Cost - (shift personnel):							
		MRF	PRF	Pelletise		$/month	$/yr
	annual $	number	number	number			
Shift Leader	$ 88,900	0.33	0.33	0.33	3	$ 22,003	$ 264,033
Sorter	$ 57,150	6	2	0	24	$ 114,300	$ 1,371,600
Operator	$ 69,850	2	1	1	12	$ 69,850	$ 838,200
Shifts		**3**	**3**	**3**			
Total operational staff / shift		**8.33**	**3.33**	**1.33**			
				Total operational staff	**39**		
Total							**$ 2,473,833**

Auto NIR PRF

Total Operative Costs Summary (excl. Capital costs):			
	$/yr	$ / tonne	
incl. Input purchase	$ 2,284,086	$ 207	
excl. Input purchase	$ 1,180,225	$ 119	
Investment Costs:	$ 1,291,950		
Tonne per year (Input)	11,039	From MRF	
Sales value baled output	**tonne**	**$ / tonne**	**Value**
			0
			0
			0
PET	1,005	750	753,506
HDPE	4,005	300	1,201,639
PVC	0	100	0
PP	1,355	200	271,054
PS	1,178	100	117,795
Other & Film	2,166	100	216,602
	9,709		$2,560,596
Fixed Costs		**Key Value**	
Staff Labour Cost	$ 185,163	33%	% of total
Rent	$ 60,000	1,000	sqm
Maintenance	$ 58,725	5%	of capital
Office overheads	$ 40,000	Allowance	
Insurance	$ 35,235	3%	of capital
Depreciation	$ 117,450	10	years
sub-total	$ 496,573		
Variable Costs			
Input Material	$ 1,103,861	$100	
Solid Waste Costs	$ -	-	tonnes of plastic
Labour Shifts	$ 640,461	26%	
Electricity	$ 23,191	231,914	kWh/yr
Gas	$ -	-	Mj
Other	$ 20,000		
Water & Waste water	$ -	0	klitre
Chemicals	$ -		
Packaging	$ -	-	tonnes of plastic
Transport	$ -	-	tonnes of plastic
sub total	$ 683,652		
		$ / tonne	
Sales	$ 2,560,596	$ 232	
		$ / tonne	
Total of Costs	$ 2,284,086	$ 119	
EBIT (Sales - Costs)	$ 276,510		
Profit before Tax and Interest%	11%		
Payback (years)	4.7		

Washing and extrusion

Total Operative Costs Summary (excl. Capital costs):

	$/yr	$ / tonne
incl. Input purchase	$ 3,154,356	$ 419
excl. Input purchase	$ 1,465,061	$ 195

Investment Costs:	$ 2,334,944	
Tonne per year (Input)	7,527	From PRF HDPE, PP and Film only

Sales value baled output	**tonne**	**$ / tonne**	**Value**
			0
			0
			0
HDPE	4,005	660	2,643,607
PP	1,355	370	501,450
Other & Film	2,166	300	649,806
	0	0	0
	0	0	0
	0	0	0
	7,527		$3,794,863

Fixed Costs		**Key Value**	
Staff Labour Cost	$ 185,163	33%	% of total
Rent	$ 60,000	1,000	sqm
Maintenance	$ 106,134	5%	of capital
Office overheads	$ 40,000	Allowance	
Insurance	$ 63,680	3%	of capital
Depreciation	$ 212,268	10	years
sub-total	$ 667,245		
Variable Costs			
Input Material	$ 1,689,296	$224	
Solid Waste Costs	$ -	-	tonnes of plastic
Labour Shifts	$ 297,561	12%	
Electricity	$ 350,399	-	kWh/yr
Gas	$ -	-	Mj
Other	$ 47,634		
Water & Waste water	$ 40,578	0	klitre
Chemicals	$ 61,644		
Packaging	$ 37,634	-	tonnes of plastic
Transport	$ -	-	tonnes of plastic
sub total	$ 835,450		
		$ / tonne	
Sales	$ 3,794,863	$ 504	
		$ / tonne	
Total of Costs	$ 3,191,990	$ 195	
EBIT (Sales - Costs)	$ 602,873		
Profit before Tax and Interest%	16%		
Payback (years)	3.9		

Appendix 2 Calculation of material quantities in C&I stream

Data taken from Zero Waste SA 2010-2011 Recycling Activity Report.

Fraction	Total Materials Diverted for resource	% from C&I Sector	Tonnes from C&I Sector	% of the C&I stream	MRF size 200,000	Recovery Efficiency 80%	
Masonry	1,105,300	0.5%	5527	0.5%	927	742	
Steel	391,000	67.0%	261970	22.0%	43,964	35,171	
Aluminium	19,400	66.0%	12804	1.1%	2,149	1,719	
Non Ferrous	31,100	58.0%	18038	1.5%	3,027	2,422	
Food	4,400	100.0%	4400	0.4%	738	591	
Garden	230,000	18.0%	41400	3.5%	6,948	5,558	
Timber	280,000	83.0%	232400	19.5%	39,002	31,201	
Other Organics	440,000	97.0%	426800	35.8%	71,626	57,301	
Other Fibre	53,800	51.0%	27438	2.3%	4,605	3,684	
Cardboard	154,000	57.0%	87780	7.4%	14,731	11,785	
LPB	3,500	7.0%	245	0.0%	41	33	
PET	4,100	30.0%	1230	0.1%	206	165	
HDPE	4,600	85.0%	3910	0.3%	656	525	
PVC	170	0.0%	0	0.0%	-	-	
LDPE	4,600	91.0%	4186	0.4%	703	562	
PP	4,000	90.0%	3600	0.3%	604	483	
PS	430	96.0%	413	0.0%	69	55	
Mixed	5,800	19.0%	1102	0.1%	185	148	
Glass	58,000	10.0%	5800	0.5%	973	779	
Other Materials	52,700	100.0%	52700	4.4%	8,844	7,075	
Ash/Clay/Soil	1,460,000	0.0%	0	0.0%	-	-	
						40,000	Diffrence
Totals	4,306,900		1191742	100.0%	200,000	200,000	