Report

Plastic Recycling Business Opportunities in Scotland

Identification and analysis of plastic recycling business opportunities in Scotland

Final Report

A report identifying business opportunities for developing new plastics recycling capacity in Scotland (based on detailed evidence on plastics arisings and existing capacity) and assessing the viability of each opportunity.

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Zero Waste Scotland works with businesses, individuals, communities and local authorities to help them reduce waste, recycle more and use resources sustainably.

Find out more at
www.zerowastescotland.org.uk

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Executive Summary

The Scottish Government's Zero Waste Plan[1] sets a vision of a closed loop economy in Scotland where the economic potential is accrued from materials arising in the waste stream. Associated targets are 70% recycling and a maximum of 5% to landfill by 2025. The Scottish Government has more recently published a policy statement for The Waste (Scotland) Regulations 2012[2] which supports its Zero Waste Plan and these regulations were passed by the Scottish Parliament in May 2012. Some of the key aspects of this legislation will require businesses to separate out specific materials from the waste streams by 1st January 2014 (including plastic), meaning that the market will change in the medium term even though targets are set to 2025. These new regulations, will place additional demands on the waste management industry and present both opportunities and challenges for businesses.

Optimat has recently assessed the evidence base for plastics recycling in Scotland[3]. That work highlighted the need for significant additional plastic recycling capacity in Scotland if future targets are to be met; it is estimated that additional capacity for recycling of more than 150,000 tonnes per annum of plastics will be required by 2014.

This study has identified potentially viable business opportunities to increase recycling capacity in Scotland and thus contribute to this infrastructure gap. It focuses on business opportunities that complement existing activity – essentially opportunities that address current "weaknesses" in the supply chain. These are generally targeting less attractive materials or materials with less well developed supply chains. The business opportunities that have been identified and analysed are:

- processing of mixed, contaminated rigid plastic waste;
- processing of mixed contaminated plastic film waste;
- collection and compaction of expanded polystyrene waste;
- processing of waste u-PVC window and door profiles; and
- processing of waste plastics from WEEE.

The plastics under these categories represent arisings of between 300,000 and 400,000 tonne per annum in Scotland.

Analysis of the business models and financial viability for these opportunities indicate that four of them *do* offer the potential of viable business opportunities but that the collection and compaction of expanded polystyrene waste currently does not. This is due to the costs of collection and processing due to the low density of the material.

It is estimated that these business opportunities can deliver an additional recycling capacity of 71,000 tonnes per annum in the short term. There are concerns regarding the limitations of the current collection infrastructure (leading to a lack of suitable materials in the plastics supply chain) that restrict the processing capacity that we believe can be viably developed and may, in fact, also inhibit the development of the opportunities identified. It is expected, however, that The Waste (Scotland) Regulations 2012 will drive changes in collection activities and that additonal recycling capacity can be developed in the medium/longer term.

We, therefore, recommend that Zero Waste Scotland undertakes the following:

1 Raise awareness of these opportunities and encourages investment in new recycling capacity in Scotland. Obviously the key next steps for any potential investor are to identify waste streams, processing technologies and markets that they believe will support an investment and to develop a detailed business plan for this investment.

2 Catalyse the development of the collection infrastructure and activities in Scotland.

This will require engagement with public and private sector organisations to extend and optimise collection activities and to enhance the management and segregation of waste collected.

3 Assess opportunities to support the development of markets for recycled materials.

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1 *Scotland's Zero Waste Plan, The Scottish Government, 2010*

2 *http://www.scotland.gov.uk/Topics/Environment/waste-and-pollution/Waste-1/latest*

3 *Developing an Evidence Base for Plastic Recycling in Scotland, Optimat report for Zero Waste Scotland, April 2012 (see http://www.zerowastescotland.org.uk/sites/files/wrap/Developing%20the%20Evidence%20Base%20for%20Plastics%20Recycling%20in%20Scotland%20-%20IFM002-001_0.pdf)*

This may include market access mechanisms for Scottish recycling companies (such as a quality based branding programme or specialised agents and distributors) and the development of novel applications for recovered plastics (for example, through demonstration projects).

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1. Introduction

1.1 Background

The Scottish Government's Zero Waste Plan[4] sets a vision of a closed loop economy in Scotland where the economic potential is accrued from materials arising in the waste stream. Associated targets are 70% recycling and a maximum of 5% to landfill by 2025. The Scottish Government has more recently introduced The Waste (Scotland) Regulations 2012[5] to support its Zero Waste Plan.

These new regulations (passed by the Scottish Parliament in May 2012) will place additional demands on the waste management industry and will present both opportunities and challenges for businesses. Focusing on plastics, these new measures offer opportunities to:

- significantly increase the tonnage of waste plastic collected separately in Scotland;
- increase the quantity of plastics made into useable feedstock and products in Scotland;
- reduce the level of plastic waste exported;
- reduce tonnage of plastics waste going to landfill in Scotland; and
- promote plastics that will displace virgin material

Optimat has recently assessed the evidence base for plastics recycling in Scotland[6]. That work developed two estimates for total plastic waste arisings. This was necessary due to the significant variation in the evidence on plastic arisings from C&I sources. The upper estimate is just over 637,000 tonnes per annum and the lower estimate is just less than 404,000 tonnes per annum. In both cases the estimate for the household plastics waste stream was 251,000 tonnes while the C&I figures were 51,000 and 284,000 tonnes in the lower and higher estimates respectively.

Two estimates were also developed for the annual tonnage of plastic recycled and sent to landfill. The lower estimate for plastics recycled is 67,000 tonnes per annum while the upper estimate is 172,000 tonnes per annum. This material is typically sold to UK based processors or to export markets. Analysis of UK based data[7] suggests that the tonnage of plastic waste arising in Scotland that was exported from the UK in 2009 was almost 74,000 tonnes. This analysis assumes that Scotland has an 8.80% share of UK wide activity[8]. The lower estimate for plastics sent to landfill or incineration is 337,000 tonnes per annum while the upper estimate is 465,000 tonnes per annum.

The lower and upper estimates of tonnages arising and recycled can be shown as follows:

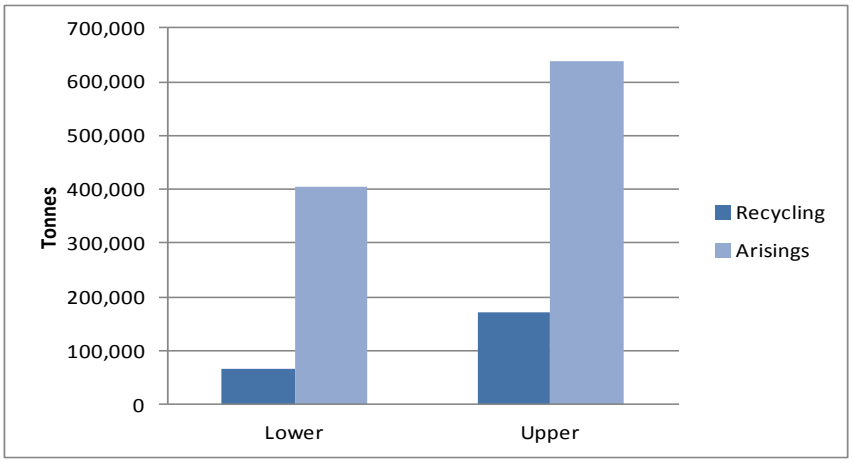

Figure 1 Comparison of Upper and Lower Estimates of Plastic Arisings and Recycling

4 *Scotland's Zero Waste Plan, The Scottish Government, 2010*

5 *http://www.scotland.gov.uk/Topics/Environment/waste-and-pollution/Waste-1/latest*

6 *Developing an Evidence Base for Plastic Recycling in Scotland, Optimat report for Zero Waste Scotland, April 2012*

7 *http://uktradeinfo.com*

8 *Business Register Employment Survey – 2009, ONS Statistical Bulletin, Dec 2010 p.2 'Total employment' category*

These figures underline that there is significant potential to increase the tonnages of plastics recycled in Scotland and that this is essential to ensure that regulatory targets are achieved.

Projected lower and upper estimates of plastic recycling by 2014 and 2025 are[9]

- Between 157,000 and 297,000 tonnes by 2014
- Between 181,000 and 328,000 tonnes by 2025

The following figure clearly shows the short term pressure to deal with projected increases in recycling by 2014:

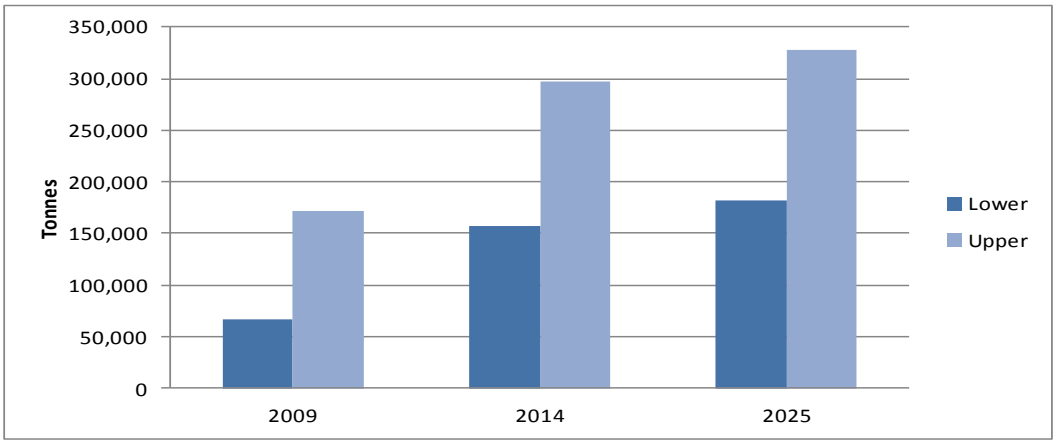

Figure 2 Lower and Upper Estimates of Plastics Recycling – 2009 Baseline and 2014/2025 Projections

This report identifies and describes business opportunities that address this increased requirement for recycling.

1.2 Scope

The purpose of this study is to identify business opportunities that will lead to recycling of **additional** tonnages of waste plastics in Scotland. It is, therefore, important to recognise that there is an established UK plastics recycling supply chain for a number of materials, such as bottles and a range of clean, uncontaminated rigid and film material. The market works for this type of material. Furthermore, it is expected that there will be future demands for more capacity to deal with these materials and that market factors will drive investment.

So it is considered, therefore, that identification of business opportunities that complement existing activity is the priority – essentially opportunities that focus on current "weaknesses" in the supply chain. These are less attractive materials or materials with less well developed supply chains.

It is recognised that such opportunities may not offer the maximum economic impact but that they will support the delivery of the Scottish Government Zero Waste Plan.

1.3 Key Issues

The need for additional recycling capacity is clearly shown above (Figure 2). The rationale for focusing on less attractive materials or materials with less well developed supply chains has also been defined. A number of issues arise, however, when focusing on these materials. These are discussed below, together with the way we have addressed these in this analysis.

- **Quality**
  The plastics recycling industry highlights material quality as the major problem for developing recycling capacity[10]. It is unclear how dirty, contaminated mixed materials can be profitably recycled in the UK. Should the priority be to

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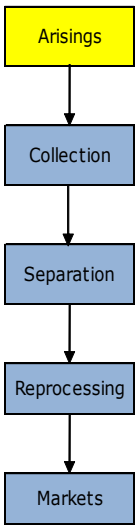
9 *Developing an Evidence Base for Plastic Recycling in Scotland, Optimat report for Zero Waste Scotland, April 2012*

10 *Several sources including: Developing an Evidence Base for Plastic Recycling in Scotland, Optimat report for Zero Waste Scotland, April 2012, "Quality not Quantity the Key to Better Waste", Packaging Week, October 2011 and Earnings, Jobs and Innovation: The Role of Recycling in a Green Economy, European Environment Agency, 2011. ISBN 978-92-9213-234-7*

improve the quality of materials and then carry out single stream processing or should mixed materials processing be prioritised?
The optimum approach is considered for each source of arisings.

- **Supply Chain Interactions**
  Development of "reprocessing" capacity alone, i.e. capacity for manufacturing secondary raw materials from waste plastic, is not enough to optimise recycling tonnages. It is important that all stages of the supply chain (as shown opposite) are developed and, where required, there must be parallel supply chain development activities.



  The focus of this analysis is on plastics re-processing. Some requirements to enhance the management of mixed materials are also highlighted.

  As highlighted above, however, development of re-processing capacity alone is not enough. It is recommended that industry support initiatives, such as awareness programmes, best practice programmes and supply chain integration activities are implemented to ensure that, where practical, other parts of the plastics recycling supply chain are operating in such a way that optimises the success of reprocessing facilities.

- **Target Outputs**
  Should the key output be a secondary raw material that can be used in product manufacture or should product manufacture be targeted?

  The initial focus is on producing secondary materials to ensure maximum impact of dealing with projected 2014 levels of recycling. However, the potential for secondary product manufacture must be considered and is discussed further in Section 3.

1.4 Methodology

This report has been prepared following assessment of the evidence base for plastics recycling in Scotland[11]. The methodology was designed to identify gaps in recycling capacity in Scotland and to identify business opportunities based on the tonnages of materials arising and analysis of best practice from elsewhere. It is based on the data from that study together with supporting desk research, an interview programme with key stakeholders in the plastics recycling industry in Scotland and elsewhere in the UK and a workshop with a selected number of key industry stakeholders.

1.5 Report Structure

Following this introductory section, the report is structured in four main sections:

- Business and financial models for each of the plastics recycling business opportunities
- Ranking of the identified opportunities
- Actions required to enable business opportunities
- Conclusions and recommendations

[11] *Developing an Evidence Base for Plastic Recycling in Scotland, Optimat report for Zero Waste Scotland, April 2012*

2. Gap Analysis – Business Opportunities for Plastics Recycling in Scotland

The difference between waste plastic arising and recycled in Scotland is significant, as shown in Figure 1. This gap in recycling activity is estimated at between 337,000 and 465,000 tonnes per annum. As indicated in the evidence base report this cannot be allocated to local areas due to issues with data quality. It can be assumed, however, that the majority of arisings are located in highly populated areas where there is associated high economic activity.

The composition of current arisings in Scotland has been analysed, as shown opposite. This shows the quality, quantity, composition and sources of waste plastic arisings; these arisings offer the "raw material" for new business opportunities that will increase recycling activity in Scotland.

Potential business opportunities, based on these materials streams, have been identified and reviewed with an expert stakeholder group. Based on this, the business opportunities that have been shortlisted for analysis are:

- Processing of mixed contaminated plastic film waste
- Processing of mixed, contaminated rigid plastic waste
- Collection and compaction of expanded polystyrene waste
- Processing of waste u-PVC window and door profiles
- Processing of waste plastics from WEEE

	Tonnes (lower estimate)	Tonnes (upper estimate)
Mixed, contaminated rigid materials		
- Household (non-bottles)	125,676	125,676
- C&I	13,219	73,954
- C&D	17,027	17,027
- ELV	11,990	11,990
Mixed contaminated films		
- Agricultural	19,008	19,008
- Household	74,475	74,475
- C&D	1,774	1,774
- C&I	37,623	210,484
Expanded polystyrene	10,907	10,907
uPVC	16,672	16,672
WEEE plastics	30,653	30,653
TOTAL	**359,024**	**592,620**

Figure 3 Estimated Current Arisings of Selected Plastic Waste Streams

The analyses of these business opportunities are included in Sections 2.2 to 2.6. Each consists of:

- **Business model**
  A description of the business activities, including sources and volumes of raw materials, the geographic scope and scale of the business, processing technology required, markets targeted, market development activities and employment estimations.
  Key constraints to the business are also identified here.
- **Financial analysis**
  A simple financial analysis that compares the cost of collection and processing (including capital cost) with the projections for income generation from sales of materials. This will enable us to assess whether a profitable business can be achieved over a reasonable (3 to 5 year) period and what the main factors affecting viability are.

Based on these models, the attractiveness of each business opportunity can be assessed and compared.

Further, these models are based on best practice recycling examples in the UK. These best practice examples are summarised in the following section.

2.1 Case Studies – UK Best Practice in Plastics Recycling

Best practice examples that may be transferable to Scotland have been identified. Key selection criteria for these examples were fit with waste plastics arising in Scotland, scale, viability and transferability (e.g. no proprietary technologies). These case studies can be summarised as follows:

Case Study 1 – Mixed Film Materials – Nextek Prototype Facility

This best practice example is described in detail in a WRAP report, published in 2011[12]. It can be summarised as follows:

Input Material:	Mixed contaminated plastic film from C&I and MRF sources
Key Processes:	Size reduction, cleaning, extrusion and pelletising
Output Material:	Pelletised material (mixed plastics)
Applications:	Numerous low grade mouldings for various construction, landscaping and other applications
Viability:	Projections indicate viability at 7,000 tonnes of output material

Opportunity 1, as described below is based on this prototype process.

Case Study 2 – Mixed Rigid Materials – UK Recycling Company (Confidential)

This facility has been established by a UK recycling company with information from the company website.

Input Material:	Mixed rigid plastics (e.g. pots, tubs and trays)
Key Processes:	Cleaning, removal of plastic film and other materials, granulation, washing, separation and segregation
Output Material:	Pelletised materials (in segregated form)
Applications:	Numerous applications such as trays, plant pots, pallets, bottles, car parts, office furniture and kitchenware
Viability:	Plant capacity of 20,000 tonnes per annum

Opportunity 2, as described below is based on this facility.

Case Study 3 – Expanded Polystyrene – Public sector operated facility in England (Confidential)

This is a public sector initiative to collect and recycle expanded polystyrene from C&I and household sources. Information is based on discussion with the operators). It can be summarised as follows:

Input Material:	Expanded polystyrene of all types, as delivered by third parties
Key Processes:	Compaction
Output Material:	Compacted polystyrene sold to UK reprocessor
Applications:	Numerous low grade mouldings for various applications
Viability:	Not commercially viable

Opportunity 3, as described below is partly based on this initiative.

Case Study 4 – Expanded Polystyrene – UK Recycling Company (Confidential)

This example is based on the company website and discussions with the owner. The identity of the company is confidential. It can be summarised as follows:

Input Material:	Expanded polystyrene of all types, as delivered by third parties
Key Processes:	Compaction
Output Material:	Compacted polystyrene sold to UK reprocessor or exported
Applications:	Numerous low grade mouldings for various applications
Viability:	Not commercially viable

Opportunity 3, as described below is partly based on this initiative.

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12 *Cleaning and Recycling of Residual Mixed Plastic Film, Nextek Ltd for WRAP, September 2011*

Case Study 5 – u-PVC – UK Recycling Company (Confidential)

This best practice example is based on data available on the company website and additional discussions with company representatives. It can be summarised as follows:

Input Material:	End of life PVC windows and doors
Key Processes:	Fragmentation, metal removal, washing, inspection, granulation and colour sorting
Output Material:	Pelletised material (mixed plastics)
Applications:	Manufacture of PVC profiles for window and door manufacture
Viability:	Optimat projections indicate viability at 8,000 tonnes of output material

Opportunity 4, as described below is based on this company's activities.

Case Study 6 – WEEE Plastics – UK Recycling Company (Confidential)

This best practice example is based on the company website and can be summarised as follows:

Input Material:	Mixed plastics from WEEE
Key Processes:	Metal removal, washing, cleaning and separation
Output Material:	Granulated and pelletised material (segregated plastics)
Applications:	Numerous mouldings for various applications
Viability:	Facility has 70,000 tonnes per annum capacity

Opportunity 5, as described below is partly based on this facility.

Case Study 7 – WEEE Plastics – UK Recycling Company (Confidential)

This best practice example is based on the company website and further input from the company:

Input Material:	Mixed plastics from WEEE
Key Processes:	Metal removal, washing, cleaning, separation and melt filtration
Output Material:	Pelletised material (segregated plastics)
Applications:	Numerous mouldings for various applications
Viability:	Optimat projections indicate viability at 12,000 tonnes of output material

Opportunity 5, as described below is partly based on this facility.

In the majority of these examples the key factors that affect viability are access to sufficient waste plastics of a suitable quality, achieving high plant utilisation (as these processes are typically low margin operations) and the market price for output materials.

The exception is polystyrene processing, which, as shown below, is not considered a viable stand alone business proposition.

2.2 Opportunity 1 – Recycling of Mixed Contaminated Film Waste

This opportunity focuses on the processing of mixed plastic film waste to manufacture secondary raw materials.

Business Model:

1 Sources and Volumes of Waste Arisings

There are significant arisings of this mixed contaminated film waste in household, commercial and industrial (C&I) and construction and demolition (C&D) waste streams. It is estimated that there is already at least 110,000 tonnes per annum arisings in household, C&I and C&D waste streams with predictions that this is going to increase (lower estimate). There is significant uncertainty over the mixed contaminated film waste arisings in the C&I waste stream with the upper estimate being over 170,000 tonnes per annum more than the lower estimate.

A number of companies in Scotland that are collecting and segregating waste plastics (and other materials) have access to significant volumes of this material but these companies generally find it very difficult to identify an attractive market. UK reprocessors are not interested in the material and exporting is also very difficult. Thus there is little encouragement for waste collectors and traders to pursue collection of the material or develop processing technologies.

Furthermore, it has been estimated that over 20,000 tonnes of additional recycling of mixed film arising in household, C&I and C&D waste is required, by 2025, to meet the targets set by the Scottish Government Zero Waste Plan[13].

Note: Agricultural plastic film is excluded as potential input material for this business opportunity for a number of reasons, namely

- The high level of contamination (typically 60% of weight supplied to the reprocessors is made up of sand and soil) which requires a custom designed plant
- There are existing reprocessing facilities in Scotland that could accommodate higher volumes of materials collected in Scotland.
- The key challenge for agricultural waste plastic is to increase collection activities in Scotland rather than reprocessing capacity.

It has been highlighted during stakeholder consultation activities that one of the main barriers to recycling agricultural plastic film is the opportunity that farmers have to burn waste plastics, under a SEPA "Paragraph 29 exemption". It is recommended that this is investigated further with a view to assessing the impact on recycling that the removal of this exemption might have.

2 Processing Technology

The typical composition of this type of plastic waste, based on four different sources of material, is shown opposite[14]. It is considered that the most practical option for processing this material is to do so in a mixed form.

For example, the Nextek report for WRAP describes technology that has been proven in prototype form for the size reduction, dry cleaning, extrusion and pelletising of clean film shred. Components moulded from this materials have been assessed and were considered accpetable for selected applications.

It is also expected that similar technologies can be developed and applied by others.

	C&I Source 1	C&I Source 2	MRF Source Film Residue	MRF Dry Recyclable Residue
HDPE	23	31	16	
HDPE 3D				23
LDPE	42	36	48	
PET 3D				33
PP	15	11	15	
Film				15
Mixed 3D				16
Multi	5	3	8	
Moisture	10	12	8	5
Contam.	5	8	5	3
Metal				5
TOTAL	**100**	**100**	**100**	**100**

Figure 4 Example Compositions of Mixed Plastic Film

[13] *Priority Waste Streams, Optimat report for Zero Waste Scotland, March 2012*

[14] *Cleaning and Recycling of Residual Mixed Plastic Film, Nextek Ltd for WRAP, September 2011*

Alternatively, there may be opportunities to invest in plastic to oil product conversion processes. Several technologies are under development that can be used to manufacture fuels, refinery feeds, functional specialities or other bulk petrochemicals. It is understood, however, that these processes cannot typically cope with a mixed plastics stream and that segregation (of PET and PVC) is required. Zero Waste Scotland is currently investigating the potential of plastic to oil technologies and this work is expected to be completed in September 2012.

Our analysis here focuses on the Nextek technology as it has been proven in prototype form and is, therefore, available for exploitation (subject to overcoming any scaling issues).

3 Market Opportunities

Testing of materials produced by the Nextek process indicates that it can be effectively used for injection moulding and manufacture of thick gauge films. There are, therefore, a number of potential market applications for the material in a range of industry sectors.

4 Constraints

The key constraint here is the challenge to obtain a reliable supply of sufficient quantities of mixed plastic film to secure the operation of the plant. This material is not being collected at the moment and is considered a zero value material by the industry. Initiatives need to be established to highlight the potential to recycle this material and to collect sufficient tonnages to ensure that facilities can achieve viability. This is reflected in the modest capacity proposed for this opportunity in Section 3, below. Of course The Waste (Scotland) Regulations 2012 will require collection from January 2014 which is expected to catalyse the need for additional capacity.

Financial Model:

The Nextek report includes a financial model that shows a profitable operation based on a 7,000 tonne output capacity, as shown below:

Input Tonnes	11781
Output Tonnes	7069
Yield	60%
Waste to Landfill	1532
Landfill Costs	318,087

	£	£ (per tonne)
Investment for 7,000 tonnes	2,270,000	
Sales	3,180,870	450
Materials	294,535	42
Labour	297,203	42
Energy	359,438	51
Other Direct Costs	578,910	82
Gross Margin	1,650,784	234
Fixed and Indirect Costs	993,630	141
Annual Gross Profit	657,154	93
EBIT on Sales	21%	
Simple ROI	29%	

Figure 5 Financial Model Prepared by Nextek

The model shows a margin of £93 per tonne and is based on achieving a sales price of £450 per tonne for output material.

There is potential to increase the scale and profitability of the plant by increasing capacity. Similarly there is some flexibility in the sales price of material. Breakeven is achieved at just under £360 per tonne but, of course, that does not include any opportunity for repayment of the initial investment in equipment.

Based on the evidence available there are opportunities to establish three of these facilities in Scotland to deliver the additional recycling required to meet the Scottish Government Zero Waste Plan targets.

2.3 Opportunity 2 – Recycling of Mixed Rigid Plastic Waste

Business Model:

1. Sources and Volumes of Waste Arisings
   This type of plastic waste arises in the household, C&I, C&D, ELV and WEEE waste streams, although for the purposes of this study u-PVC and WEEE arisings are treated separately (see Opportunities 4 and 5). Drinks bottles are also excluded from the analysis as there are already established collection and reprocessing routes for these.
   Estimates[15] indicate that arisings are in excess of 150,000 tonnes per annum as shown in Figure 3. This material is available throughout Scotland, with higher volumes available in the populated and industrialised areas.

   The material will be available in two main formats:
   a. Pots, trays and tubs in local authority collections of dry recyclables.
      Research indicates[16] that 15 Scottish local authorities are already collecting a combination of pots, trays and tubs in either source segregated or comingled format. All materials collected are currently reprocessed elsewhere in the UK or overseas.
      WasteDataFlow[17] data shows that 26,230 tonnes of plastics were collected by local authorities in 2010/11 while Recoup[18] reports that 22,450 tonnes of plastic bottles and 4,514 tonnes of "non-bottle rigids" were collected in Scotland in 2010. Data from these sources are reasonably consistent and indicate that around 4,500 tonnes of "non-bottle rigids" are available for recycling in Scotland, essentially by diverting from sale to elsewhere in the UK or to export markets. This material will be available from the contractors operating collection activities in the areas with established collection schemes[19]. It consists of a mixture of polypropylene, polyethylene, PET, PVC and polystyrene in variable quantities.
      Of course there is expected to be significant increases in collected tonnages when the other 17 local authorities begin collecting these waste products, as required by The Waste (Scotland) Regulations 2012.
      Recoup also estimates that between 500,000 and 600,000 tonnes of "non-bottle rigids" entered the UK household waste stream in 2010, suggesting tonnage arisings in Scotland of between 44,000 and 53,000 tonnes, indicating significant potential for increased collection.
   b. Mixed rigid plastics from household, C&I, C&D and ELV sources, that will typically be collected and segregated by the waste management industry at MRFs and waste transfer stations. This material stream includes all rigid plastics and is inconsistent in composition, quality and cleanliness (depending on the source of material and how it was handled during collection and segregation processes).
      It is estimated that arisings of this waste stream are over 100,000 tonnes per annum, in addition to the tonnages of pots, tubs and trays defined above.
      This material will be available from organisations delivering waste management services in the populated and industrialised areas in Scotland.

2. Processing Technology

   Three processing approaches can be considered here:

   a. Recycling of pots, tubs and trays only
      The UK facility identified is an integrated washing and sorting facility in the UK designed for recycling of these specific "non-bottle rigids". It is expected to achieve its full processing capacity of 20,000 tonnes in 2012 and employ around 30 people. It is estimated that the initial investment to add this capability to an existing recycling facility would be around £4 million.
      The key stages in the processing are

      - Removal of dirt, grit, glass and other small contaminants in a rotating cylinder

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15 *Developing an Evidence Base for Plastic Recycling in Scotland, Optimat report for Zero Waste Scotland, April 2012*

16 *Developing an Evidence Base for Plastic Recycling in Scotland, Optimat report for Zero Waste Scotland, April 2012*

17 *Waste Data Flow (http://www.wastedataflow.org/)*

18 *UK Household Plastics Packaging Collection Survey 2011, Recoup, 2012*

19 *Developing an Evidence Base for Plastic Recycling in Scotland, Optimat report for Zero Waste Scotland, April 2012*

- Extraction of plastic bags and other films
- Removal of paper and metals by optical means
- Granulation of the plastics stream
- Cold wash
- Centrifugal segregation into "light" and "heavy" streams
- Segregation into polymer types and colour by optical sorting

This process delivers several different high quality polymers for sale to a range of markets. It can be considered as a current "UK best practice approach" to recycling this waste stream.

b. Mixed rigids to produce several segregated polymers
The equipment required for this processing approach will be very similar to the process detailed above for pots, tubs and trays. Alternatively, a more sophisticated approach that processes most of the different plastics streams to produce pellet has been technically and financially reviewed by WRAP[20]. This report estimates an investment of almost £30 million to establish a plant that can process a wider range of contaminated mixed plastics.

c. Mixed rigids to produce a mixed polymer output
This is a lower cost approach than (b), above. It focuses on partial segregation of rigid plastic waste and moulding of a mixed material into lower grade products. A similar approach is proposed for mixed plastic film in Opportunity 2.

3. Market Opportunity
The market opportunity here is dependent on the quality of the output materials and thus on the processing technology used.
The output material from (a) and (b) above is segregated polymer streams that can be sold as a commodity polymer for manufacture of a range of products, such as bottles, extruded sheet, trays, plant pots, storage boxes pallets, automotive parts and office furniture.
The mixed polymer output produced from mixed rigids is typically processed in house by those companies that segregate it. It can be used to manufacture a range of low specification products such as boards and walkways for a range of markets, including agriculture, construction, land management and sports and leisure.

4. Constraints

Achieving sufficient input material to support the operation of such a plant in the short term is a major concern. Of course, as highlighted above, it is expected that The Waste (Scotland) Regulations 2012 will catalyse a major step change in activity from 2014.

As indicated above, it is estimated that less than 5,000 tonnes of non bottle rigids (specifically pots, tubs and trays) were collected from household sources in Scotland in 2010. If the focus, therefore, is on this limited waste stream, major increases in collection tonnages are required to support the viability of such a plant. This is a major issue for each of the local authorities to address because, as detailed in the evidence base report, many councils do not collect this type of material. The Waste (Scotland) Regulations 2012 will require Local Authorities to offer recycling collections for 'plastic' and there is no stipulation that this will only include bottles. Competition with the existing plant in England should also be considered a constraint here. As a result of these factors, one plant of 20,000 tonne capacity is proposed, although estimates above suggest between 44,000 and 53,000 tonnes of arisings in Scotland.

If the focus, however, is on a plant that can accommodate a wider range of mixed rigids then a larger capacity can be considered. A facility of 30,000 tonnes is practical, based on the arisings detailed in Figure 3, as long as the collection infrastructure is effectively developed and the plant itself has the capability to deal with a complex mix of

[20] *Commercial Scale Mixed Plastics Recycling , Nextek Ltd for WRAP, June 2009 and A Financial Assessment of Recycling Mixed Plastic in the UK, Axion Consulting for WRAP, June 2009*

plastics. This has already been demonstrated to be possible in the UK (see WRAP report – reference 20) and overseas.

Further, it is recommended that only one of these options is pursued in the short term.

Financial Analysis

A financial model for the existing recycling plant is commercially sensitive and is not available. However, the operating company asserts that the process is commercially viable.

A detailed model for process (b) above has already been prepared by WRAP[21] and demonstrates a viable business operation can be achieved. This is for a wide ranging process capability and would need to be customised to address specific needs (e.g. tonnage capacities, materials included, end product quality).

The financial model for processing of mixed waste rigid plastics to manufacture a mixed polymer output will be similar to that for processing mixed film waste as detailed in section 2.1.

2.4 Opportunity 3 – Recycling of Expanded Polystyrene

This opportunity focuses on adding value to expanded polystyrene through collection and compaction services.

Business Model

1. Sources and Volumes of Waste Arisings

   It is estimated that the total arising of expanded polystyrene (EPS) for household and C&I sources of arisings is just over 15,000 tonnes per annum in Scotland[22]. No data could be sourced for C&D arisings. However, as the construction sector hold over 42% share of the UK market for expanded polystyrene[23], it would be expected that there are significant arisings from this source.

   It is further estimated that over 7,000 tonnes per annum of EPS needs to be recycled to meet the targets set by the Scottish Government's Zero Waste Plan[24].

   Current arisings of EPS tends to consist of either significant volumes from industrial facilities or relatively small volumes from other industrial or household sources. The low weight to volume ratio of EPS seriously affects the viability of collection and recycling activities. For those facilities that do generate high tonnages of waste (e.g. fish processing facilities or certain types of retail outlet) it is practical to invest in compaction equipment that is used to reduce the volume of EPS prior to sale to materials merchants. Such activities are established and will continue. The challenge is to achieve an effective collection and compaction services for distributed low level arisings. This opportunity is considered here.

2. Processing Technologies

   The key step in processing EPS is to compact the material. Two approaches are typically used for compaction:

   - Cold compaction, that involves crushing and extrusion at room temperature and achieves a ~40:1 size reduction
   - Thermal densification, where the EPS is melted without burning. A ~90:1 size reduction can be achieved with this process

   These processes operate best with consistent input material but are difficult to operate if various grades of EPS are processed.

3. Market Opportunities

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21 *A Financial Assessment of Recycling Mixed Plastic in the UK, Axion Consulting for WRAP, June 2009*

22 *Priority Resource Streams, Optimat report for Zero Waste Scotland, March 2012*

23 *Expanded Polystyrene Industry Outlook in the UK to 2015, GlobalData, 26/07/2011*

24 *Priority Resource Streams, Optimat report for Zero Waste Scotland, March 2012*

The main market opportunity for compacted EPS is export. It is estimated by the industry that 95% of compacted EPS is exported to China where it is processed into a range of household and other products.

4 Constraints

The key constraints here are the cost of collection (based on the high volume/low weight of the materials) and the variable specifications for expanded polystyrene (based on its application) that makes it very difficult to effectively operate compaction equipment. As discussed below, these fundamentally affect the viability of potential business models.

Financial Model:

A financial model for the compaction of EPS has been developed based on information from a facility in England. This can be shown as follows:

	Case study (England)	
Capacity (per annum)	30	tonnes
Operator costs	£10,000	
Transport costs	£1,200	£200 per load
Overhead		
Income	£4,800	
Balance	-£6,400	
Reduced landfill fees	£2,400	assume £80 per tonne
Revised balance	-£4,000	

Figure 6 Financial Model for EPS Compaction

This model assumes no cost of capital to purchase equipment and no costs for collection. It also excludes energy / overhead costs. Furthermore, increasing capacity does not improve the cost model as the cost of collection and compaction are always higher than the income generated. It is, therefore, difficult to identify commercially viable intervention options for the material.

This observation is consistent with evidence from the industry where attempts to achieve a viable EPS collection and compaction operation have been unsuccessful.

We, therefore, conclude that EPS recycling is not a viable business proposition under current market conditions.

2.5 Opportunity 4 – Recycling of u-PVC

The opportunity analysed here is the collection and processing of waste window and door profiles to provide raw material for manufacture of window and door profiles, thus achieving closed loop recycling.

Business Model

1. Sources and Volumes of Waste Arisings
   It is estimated that there are over 45,000 tonnes of PVC waste arisings in Scotland with almost 36,000 tonnes arising from C&D sources[25]. The current recycling rate is estimated at 21.5%.
   Waste management companies and organisations that collect and segregate waste plastics are the major sources of waste u-PVC. These companies are increasingly recognising the value of the waste material, are actively seeking to segregate material and are selling to recycling companies (both independent recyclers and window and door profile extruders) that are processing the material for use as a raw material in the manufacture of window and door profiles. Already several Scottish companies have demonstrated the ability to collect and segregate good quality waste u-PVC and are supplying to recycling companies based in England.

[25] *Priority Resource Streams, Optimat report for Zero Waste Scotland, March 2012*

Projections of the future tonnages required for recycling, to meet the requirements of the Scottish Government's Zero Waste Plan, indicate that almost 25,000 tonnes of additional PVC recycling is required by 2025.

2. Processing Technologies

The process converts waste u-PVC door and window profiles into secondary raw material. It consists of typical plastic reprocessing activities, namely fragmentation, metal removal, washing, inspection, granulation and colour sorting.

This type of process technology has already been established by at least four companies in England and they have demonstrated the quality of the secondary raw material for manufacture of window and door profiles.

3. Market Opportunities

The market opportunity is to sell secondary raw material to window and door extrusion companies. The European demand for PVC was estimated[26] at 6.1 million tonnes in 2009 with profiles having a 21% market share[27] as shown below:

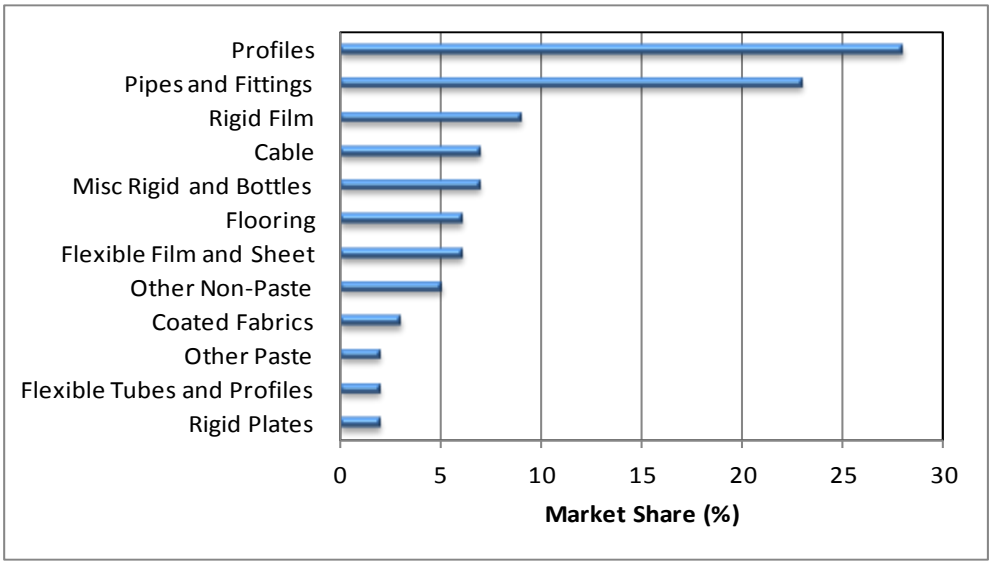

Figure 7 PVC Market Segmentation

This indicates a 1.3 million tonne European market for PVC for door and window profiles.

4 Constraints

This market is currently under development as initiatives to collect waste PVC grow. It is estimated that around 50,000 tonnes of waste PVC are collected in the UK[28]. Evidence from reprocessors indicate that there is insufficient waste windows and doors collected at the moment for all to achieve target processing capacities, which, of course, affects plant viability. Collection activities need to be further developed to ensure viability of reprocessing activities.

Existing reprocessing plants in England will offer strong competition to a new facility based in Scotland.

Financial Model

A financial model has been developed for an independent operation that processes waste u-PVC and produces a pelletised material that can be used for extrusion of new u-PVC window and door profiles. This model is shown overleaf and it assumes full utilisation of capacity.

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[26] *Polyvinyl Chloride (PVC) Global Market Dynamics to 2020, GBI Research, January 2011*

[27] *Vinyl 2010, see http://www.vinyl2010.org/about us/what-is-pvc.html*

[28] *Jane Gardner, Recovinyl at BPF Recycling Seminar, October 2011*

Income is generated from the sales of material to u-PVC extrusion companies and obviously the profitability of the operation is very dependent on the prices of both input and output materials. The financial model is based on an input material price of £120 per tonne and a sales price of £425 per tonne. A sales price of £355 is required to achieve breakeven, based on the cost assumptions in the model.

PVC Reprocessing Facility

Output tonnes	8,000
Sales price (per tonne)	425

	£	£ per tonne
Investment for 8,000 tpa	1,500,000	
Sales	3,400,000	425
Materials	960,000	120
Labour	300,000	37.5
Other costs	260,000	32.5
Overhead	660,000	82.5
Total cost	2,180,000	273
Annual gross profit	1,220,000	153
EBIT on sales	0.36	
Simple RoI	81%	

Figure 8: U-PVC Recycling Financial Model

2.6 Opportunity 5 – Recycling of WEEE Plastics

This opportunity focuses on the manufacture of secondary raw materials from plastics extracted from WEEE.

Business Model

1. Sources and Volumes of Waste Arisings

   Typically, around 22% of the composition of WEEE is plastics[29]. There are 35 authorised treatment facilities registered in Scotland and it is estimated that there are over 30,000 tonnes per annum arisings of dense plastics from WEEE in Scotland[30]. It is understood, however, that there are no facilities in Scotland for processing plastics from WEEE and that these materials are currently being sent elsewhere in the UK, exported or sent to landfill.

   A wide range of polymers are typically used in the manufacture of electrical and electronic equipment. For example, an analysis by WRAP[31] showed the following frequency of use of different polymers in small electrical and electronic equipment:

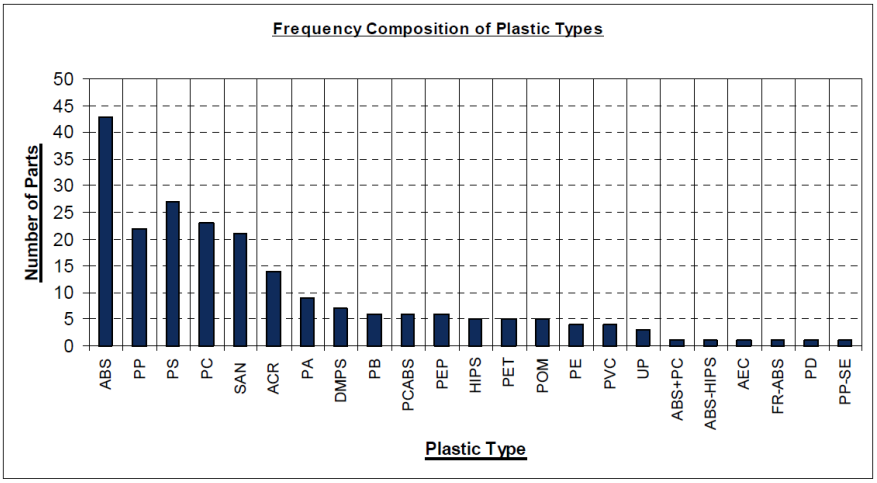

Figure 9 Typical Plastics Found in Small WEEE

29 *Partial financial impact assessment of a Quality Protocol for the manufacture of secondary raw materials from waste non-packaging plastics, WRAP/Environment Agency, 2008, Table 3, p.4*

30 *Developing an Evidence Base for Plastic Recycling in Scotland, Optimat report for Zero Waste Scotland, April 2012*

31 *Compositional Analysis of Kerbside Collected Small WEEE, WRAP, February 2009*

The plastic fraction of WEEE, comprising a mixture of these polymers is typically segregated during the primary shredding of WEEE and can be obtained at that stage for further processing.

2. Processing Technologies

   The recycling of plastics from WEEE has been established by several UK companies.

   The recycling processes required are similar to other waste streams and typically include:

   - Removal of remaining metals and other contaminants
   - Washing and cleaning
   - Separation into different plastics using different (e.g. density, optical, etc) techniques
   - Melt filtration

   This process delivers pellet material that can be used in plastic moulding processes.

3. Market Opportunities

   The output material from WEEE plastics reprocessing, assuming plastics containing brominated fire retardants have been removed (as defined by the WEEE Directive) can be sold as commodity materials to the plastic processing industry, .

4. Constraints

   Similar to other proposed opportunities the key issue and potential constraint is access to sufficient waste plastic to ensure the process plant can operate at, or near, capacity. As there is currently no recycling of WEEE plastics in Scotland, significant effort will be required to develop the activity to achieve reasonable tonnages.

Financial Analysis

Information was not readily available to prepare a financial model due to the limited number of established facilities processing WEEE plastics and the commercial sensitivity of information that is available. Further, industry sources indicate that the processes for adding value to these plastics are still under development. Industry estimates do, however, suggest:

- An initial capital investment of £2–3 million for ~12,000 tonne per annum capacity
- Income dependent on the relative amounts and quality of different plastics produced
- Return in investment in 5 to 7 years

3. Attractiveness and Impact of Opportunities

3.1 Ranking Business Opportunities

Evidence of potentially viable business opportunities has been presented for four of the five opportunities assessed. The relative attractiveness of these opportunities (including different approaches for processing mixed rigid plastics) has been analysed further by considering several key business factors for each. The environment for establishing a new business in Scotland can be assessed by ranking each of the business factors. These factors, categorised under three themes, and the ranking system used, are as follows:

Supply Chain

1. Tonnages of plastics in the waste stream (arisings)

Scoring:	High:	Material to support several recycling plants of specified size
	Medium:	Material to supply at least two plants
	Low:	Sufficient material for one plant

2. Tonnages available in the waste plastics supply chain

Scoring:	High:	Sufficient to support new recycling operation
	Medium:	Partially supports new recycling operation
	Low:	Collection systems need to be developed

3. Lack of competition for waste materials – are other businesses already accessing the materials?

Scoring:	High:	No current UK recycling options
	Medium:	Developing UK demand for recovered material
	Low:	Established, strong UK demand for recovered material

Market Pull

4. Opportunity clearly identified

Scoring:	High:	Market demand in specific applications
	Medium:	Market demand as commodity material
	Low:	Market demand needs to be established

5. Market characteristics support recyclate use

Scoring:	High:	Strong market pull for recyclate use
	Medium:	Use of recyclate offers limited market pull
	Low:	Recyclate treated as "just another material"

Strategic Fit

6. Provides additional or added value recycling capacity

Scoring:	High:	Diverting material from landfill
	Medium:	Partially displacing existing recycling activity elsewhere
	Low:	Displacing existing recycling activity in Scotland

7. Offers closed loop recycling

Scoring:	High:	Closed loop recycling demonstrated elsewhere
	Medium:	Potential for closed loop recycling
	Low:	No potential for closed loop recycling

The opportunities can be compared using these factors, based on the evidence in the preceding section, as follows:

		Supply Chain			Market Pull		Strategic Fit		Relative Attractiveness
		Tonnage in Waste Stream	Tonnage in Supply Chain	Lack of Competition	Identified Opportunity	Supportive Market	Additional Recycling Capacity	Closed Loop Recycling	
Mixed Rigid Plastics	Tubs, Pots and Trays	Medium	Medium	Medium	Medium	Medium	Medium	Medium	0.67
	Mixed Rigids	High	High	High	Medium	Medium	High	Low	0.81
Mixed Contaminated Film		High	High	High	Medium	Medium	High	Low	0.81
u-PVC Profiles		High	Medium	Medium	High	High	Medium	High	0.86
WEEE Plastics		Medium	High	Medium	Medium	Medium	High	Medium	0.76

Figure 10 Ranking Business Opportunities

Here the relative attractiveness is calculated by scoring each high ranking as 3, medium as 2 and low as 1, adding the score and dividing by 21 (the maximum potential score).

This ranking shows that

- All opportunities score highly, suggesting that they are all attractive opportunities
- u-PVC profile recycling is considered the most attractive opportunity
- Recycling of mixed rigids and mixed film are highly ranked, despite the lack of closed loop recycling potential

3.2 Potential Impact

As highlighted in Figure 2, an increase in plastics recycling of at least 157,000 tonnes by 2014 and 181,000 tonnes by 2025 is required to meet the requirements of the Scottish Government's Zero Waste Plan.

Based on the opportunities and processing technologies identified in this study and the case studies summarised, the potential to partially address the gap in recycling tonnages, through an increased recycling capacity of 71,000 tonnes, is detailed below:

		2009 Arisings (Tonnes)	Plant Capacity (tonnes)	Estimated Capital Investment per plant	Potential Number of Plants	Potential Scottish Capacity (tonnes)
1	**Mixed, rigid materials**	154,693	30,000	£18.0M	1	30,000
2	**Mixed contaminated films**	80,860	7,000	£2.7M	3	21,000
3	**uPVC**	16,672	8,000	£1.5M	1	8,000
4	**WEEE plastics**	30,653	12,000	£2M	1	12,000
	TOTAL	**282,878**			**TOTAL**	**71,000**

Figure 11 Potential Contribution to Recycling Capacity

These are also the four opportunities that score best in Figure 10.

It is estimated that these facilities will achieve a combined turnover of over £24 million per annum and provide over 100 jobs if working at capacity.

The potential to encourage higher investment and predict higher levels of recycling capacity is realistic in the future but is currently restricted by concerns regarding the collection infrastructure for waste materials. This is discussed further in the following section.

4. Enabling Successful Business Opportunities

Success in the new business opportunities described in the preceding section can be facilitated by:

1. Enhancing the supply of materials for recycling
2. Developing attractive end user opportunities for recycled materials

These are discussed below.

4.1 Supply Chain Development

As indicated earlier in this report, investing in new recycling capacity alone is not sufficient. The "market pull" that these new facilities will generate will not overcome some of the fundamental issues in the waste plastics supply chain.

These supply chain issues include:

- Lack of awareness of the potential for plastics recycling.
  This is an issue with those generating waste plastic and also within the waste plastic supply chain.
- Lack of coherent collection approaches and systems.
  For example, the potential for recycling rigid plastics from the household waste stream was highlighted in the previous section, but there is no consistent approach to collection or processing of dry recyclables within the 32 local authorities in Scotland[32]. Standardised approaches and collection strategies would enable more effective amalgamation of materials collected and thus higher volumes of material for recycling.
- The need to optimise segregation at MRFs and waste transfer stations.
  The financial benefits of recycling rather than landfilling plastics is increasingly recognised by these operators but the quality of plastics that they are making available needs to be improved. Companies specialising in waste plastics state that they have endeavoured to educate their suppliers to optimise materials quality (cleanliness of materials and segregation of different plastics) but have achieved little success with this.
  Even though some of the proposed business opportunities focus on mixed plastics processing, optimising the cleanliness and quality of material will still have a tangible impact on the success of these processes.
- Financially attractive alternatives to recycling
  This is consistently highlighted by the industry as an issue for, e.g. WEEE (inappropriate exporting) and agricultural plastics (inappropriate exporting[33] and burning rather than recycling[34]).

It is important that these issues are addressed in parallel with the development of new recycling capacity to optimise the future success of these new facilities. Awareness, best practice and advice programmes will address the first three of these issues while the tightening and implementation of regulations will address the fourth.

4.2 Developing Attractive End User Opportunities

As indicated in the introduction to this report, the focus of the business opportunities highlighted has been the manufacture of secondary raw materials as the critical first stage in diverting material from landfill. It is then important that this recycled material is effectively used – either as a partial replacement for virgin materials or for the manufacture of products from 100% recyclate. In both cases establishing quality standards is important, especially when a number of the potential materials available will be a composite of a several polymers (e.g. Opportunity 2 as described in Section 2.3, above).

To partially replace virgin material, it is important that recycled plastics manufactured in Scotland are of good quality and can be effectively supplied to the market. The development of a "Recycled in Scotland" brand with established quality standards and agents working on behalf of Scottish companies producing material of the appropriate quality under this brand would facilitate both these requirements. It would also provide market knowledge and access that the companies themselves are unlikely to have.

Manufacture of products from 100% recycled material is arguably the ideal long term goal. A number of potential products have already been identified and manufactured, but these are typically low value products that are difficult to

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32 *Developing an Evidence Base for Plastic Recycling in Scotland, Optimat report for Zero Waste Scotland, April 2012*

33 *BPI Chairman Attacks Illegal Waste Exporter, PRW, 28th March 2012*

34 *Stakeholder interview programme carried out as part of this study*

manufacture in a profitable manner. It is, therefore, important to identify products that are suited to manufacture from recycled materials, address markets that are sustainable and can be made in a profitable way (possibly using novel process technology). We consider that there is a strong rationale for a market development and testing initiative to address this need. This initiative would identify potential second life products, prepare prototypes using appropriate process technology, test these in real applications and develop business plans / models for larger scale manufacture. This type of programme would be suited to a pre-commercial procurement programme where applications (for products manufactured from recyclates) in the public sector are targeted.

5. Conclusions and Recommendations

Based on the work carried out in this study we can conclude that:

1. There are significant tonnages of waste plastic arisings in Scotland that, if collected in an appropriate way, can form the basis of new business opportunities
2. There are a number of potentially viable business opportunities for plastic recycling in Scotland. These include, but are not limited to:
   - Processing of mixed contaminated plastic film waste
   - Processing of mixed, contaminated rigid plastic waste
   - Processing of waste U- PVC window and door profiles
   - Processing of waste plastics from WEEE
3. These opportunities are commercially attractive, assuming sufficient quantities of plastic waste are available, will make a significant contribution to the tonnages of waste plastic arisings in Scotland that are recycled and will, therefore, make an important contribution to delivery of the Scottlsh Government's Zero Waste Plan. It is estimated that these business opportunities can support, at a minimum, an additional recycling capacity of 71,000 tonnes per annum.
4. Concerns over the limitations of the current collection infrastructure may inhibit the development of these, and other, recycling business opportunities in the short term.
5. It is expected that The Waste (Scotland) Regulations 2012 will catalyse a major change in the volumes of material collected that will support such recycling activities

We, therefore, recommend that Zero Waste Scotland:

6. Raises awareness of these opportunities and encourages investment in new recycling capacity in Scotland. Obviously the key next steps for any potential investor are to identify waste streams, processing technologies and markets that they believe will support investment and to develop a detailed business plan for this investment.
7. Catalyses development in the collection infrastructure and activities in Scotland. Engagement with public and private sector organisations to extend and optimise collection activities and to enhance the management and segregation of waste collected will be required to achieve this.
8. Assesses opportunities to support the development of markets for recycled materials. This may include market access mechanisms for Scottish recycling companies and the development of novel applications of recovered plastics.

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