Packaging Recycling Supply Chain Assessment

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Valpak Limited

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Packaging Recycling Supply Chain Assessment

1 Introduction

1.1 Background

This report presents the findings of research commissioned by Valpak Limited to investigate the potential for process losses along the packaging recycling supply chain and the impact these have on recycling rates. Packaging supply chains included in the scope of this work are: paper/card, glass, aluminium, steel, plastic and wood.

This work focussed on Scotland and used placed on the market (POM) and recycling figures from the 2015 report 'Scottish Packaging Market Assessment'. However, the process losses identified during this work are not specific to Scotland.

1.2 Methodology

The project methodology involved four key phases:

- Phase 1: Secondary Research
- Phase 2: Model Development
- Phase 3: Peer Review
- Phase 4: Report Writing

Each of these are discussed in further detail.

Phase 1: Secondary Research

The secondary research involved an extensive literature review of publically available information relating to:

- Packaging recycling processes (by packaging material)
- Process losses (by packaging material)
- Variability of EU recycling reporting

Once this was complete, information relating to process losses, contamination rates and reprocessor specifications was extracted and compiled within a database. Following an internal review of research, data relating to contamination rates and reprocessor specifications was removed from the database as it predominantly only documented the composition of the material rather than identifying packaging process losses.

Phase 2: Model Development

Once the secondary research was complete, the data was entered into an MS Excel model. This was set up so that the recycling supply chain for each packaging material could be viewed individually as well as collectively.

Phase 3: Peer Review

Once the model had been developed, the findings were presented to key industry stakeholders to allow for a peer review. Stakeholders included:

- Confederation of Paper Industries (Paper)
- British Glass (Glass)
- AluPro (Aluminium)
- Tata Steel (Steel)
- Recoup (Plastics)
- Wood Panel Industries Federation (Wood)
- Scottish Environment Protection Agency (All Materials)

Based on the peer review, the model was updated to incorporate the feedback received.

Phase 4: Report Writing

This document presents the findings from the project and aims to provide the background to the work, methodology used and key findings. Its key purpose is to support the model.

2 Research

2.1 Introduction

This section of the report provides an overview of the packaging process losses experienced at the key stages of the packaging recycling supply chain:

- Materials Recovery Facility (MRF)

- Recycler/Reprocessor

For the purpose of this project, process losses are considered to be the target packaging material that is lost during the recycling process[1]. They do not include materials that would be considered non-target / contamination by the facility operator (such as a plastic toy in a PET plastic bottle feedstock).

It should be noted that this is a high level overview of the supply chain and so it will not cover all scenarios and complexities. Nevertheless, the aim of this report is to provide a basic understanding of where in the supply chain the majority of losses occur and the extent to which this affects the packaging recycling rate. Other reasons this review was kept to a high level include: the vast number of variables that can affect process losses, the considerable variance in supply chains (even for the same material) and the lack of publically available data specifically relating to packaging process losses.

In order to calculate packaging recycling rates, POM and recycling figures from the 2015 report 'Scottish Packaging Market Assessment' were used. To estimate the quantity of packaging (and recycling rates) back up the supply chain, the calculations worked backwards from the recycling figures identified in the 2015 report. Using process losses from each part of the supply chain, the quantity of packaging that would have to be fed into the recycling supply chain to achieve the quantity of packaging recycled was calculated.

The recycling rates are calculated using the quantity of packaging collected/recycled at each stage of the supply chain divided by the POM.

It should be noted that, within the report, some figures may not add up correctly due to rounding.

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[1] It is acknowledged that the process losses may include minimal non-target materials, which are attached to target materials such as paper labels on a glass bottle.

2.2 Paper/Card

2.2.1 MRF

Figure 1 shows paper/card packaging process losses encountered at the MRF stage of the recycling supply chain.

FIGURE 1 – PAPER/CARD PACKAGING MRF PROCESS LOSSES

Description	Notes	Paper/Card Packaging Process Loss	Source
Rejected recyclable waste	Not material specific	9%	Rejected recyclable waste up 84% in England since 2011 (BBC)
Not recovered by MRF	A large high quality output MRF operator estimate for a MRF that is set-up to focus on the recovery of paper. This type of setup ensures process losses are minimal	5.8%	A large high quality output MRF operator
Not recovered by MRF	A large high quality output MRF operator estimate for a poor performing MRF	13%	A large high quality output MRF operator
	AVERAGE	**9.3%**	

Figure 1 shows the results of a review of data at the MRF stage of the paper/card packaging recycling supply chain and the results from a review of process losses by a large high quality output MRF operator. They estimated that their MRF has a process loss of 5.8% and believe that theirs will be one of the top performing MRFs for recovering paper (as it is designed specifically to recover paper/card). However, they also stated that the believed that poorer performing MRFs could have losses of up to 13%.

2.2.2 Reprocessor

Figure 2 shows paper/card packaging process losses encountered at the reprocessor stage of the recycling supply chain.

FIGURE 2 – PAPER/CARD PACKAGING REPROCESSOR PROCESS LOSSES

Description	Notes	Paper/Card Packaging Process Loss	Source
Process losses		3%	Confederation of Paper Industries (CPI)
Process losses		3%	Correspondence with commercial shredding company. This figure was also supported by a large high quality output MRF operator
	AVERAGE	**3%**	

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CPI stated that the yield loss for paper/card is approximately 12-14%; however, it should be noted that ~10% of this will be from fibres that have already been recycled several times, meaning that the fibre length is too short to recycle. CPI believes that if this material is excluded then 2-4% would be paper/card packaging process loss would occur due to laminate materials, such as coffee cups. CPI believes that 3% rather than 10% process loss should be used for this work as it represents the material that is lost to recycling rather than the material that simply cannot be recycled.

2.2.3 Paper/Card Packaging Recycling Rates along the Supply Chain

Figure 3 shows the recycling rate at each stage of the supply chain.

FIGURE 3 – PAPER/CARD PACKAGING RECYCLING RATES ALONG THE SUPPLY CHAIN

	MRF				**Reprocessor**			
	COLLECTED		**SORTED**				**REPROCESSED**	
Process Losses	9.3%				Process Losses	3.0%		
POM	**Input**	**Losses**	**Output**		**Input**	**Losses**	**Output**	**Recycled**
357,184	**306,504**	28,398	**278,107**		**278,107**	8,343	**269,764**	**269,764**
Recycling Rate	85.8%		77.9%				75.5%	
Difference	←	**8.0%**	→ ←	**2.3%**	→			
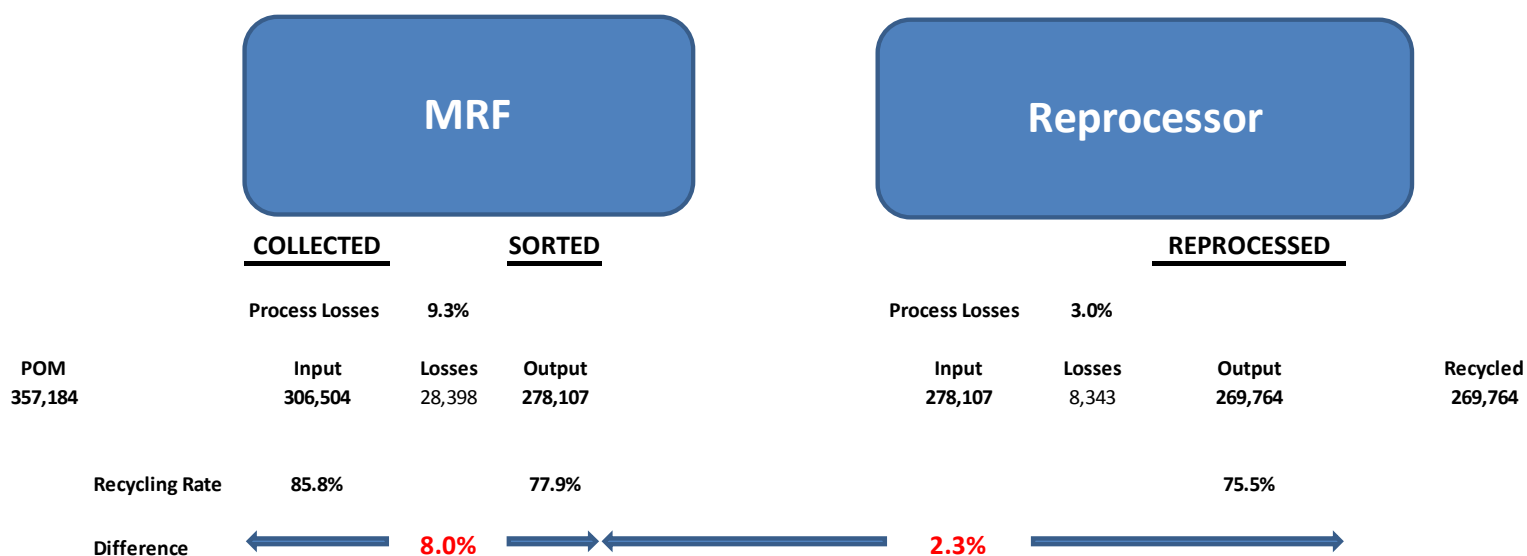
The greatest loss of paper/card packaging occurs at the MRF stage of the supply chain, with 9.3% process losses experienced. This reduces the potential packaging recycling rate by 8%.

The reprocessor stage of the supply chain experiences a 3% process loss and accounts for a further 2.3% drop in the recycling rate. However, as stated in Section 2.2.2., there can be a further 10% yield loss if the non-recyclable fibres are included, which would decrease the recycling rate by 11.3% rather than 2.3% at the reprocessor stage.

In total, 306,504 tonnes (85.8%) of paper/card packaging placed on the market is required to be put through the recycling system in order to achieve a 75.5% recycling rate. This means that 10.3% of paper/card packaging is lost within the paper/card recycling supply chain.

2.3 Glass

2.3.1 MRF

Figure 4 shows glass packaging process loss encountered at the MRF stage of the recycling supply chain.

FIGURE 4 – GLASS PACKAGING MRF PROCESS LOSSES

Description	Notes	Glass Packaging Process Loss	Source
Not recovered by MRF		5%	British Glass
	AVERAGE	5%	

British Glass estimates that, on average, 5% of glass packaging is lost at this stage2. This figure takes into account the fact that most glass packaging is not sorted in an MRF, but rather the glass is often only stockpiled at this type of facility prior to delivery to a glass recycler/reprocessor or would be collected and delivered direct to a recycler/reprocessor.

2.3.2 Reprocessor

Figure 5 shows glass packaging process losses encountered at the recycler/reprocessor stage of the recycling supply chain.

FIGURE 5 – GLASS PACKAGING REPROCESSOR PROCESS LOSSES

Description	Notes	Glass Packaging Process Loss[3]	Source
Process losses		21%	British Glass
	AVERAGE	21%	

Process loss data was provided by British Glass for a full colour separation and furnace ready cullet preparation process (closed-loop recycling). It should be noted that although 21% of the glass packaging is lost at this stage a high proportion of this is glass fines which can potentially be used as an aggregate.

2.3.3 Glass Packaging Recycling Rates along the Supply Chain

Figure 6 shows the recycling rate at each stage of the supply chain.

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[2] Although an average 5% loss has been used at the MRF stage, this figure can vary significantly depending on whether the MRF sorts glass or not.

[3] The term 'Glass Packaging Process Loss' at the reprocessor stage of the glass packaging recycling supply chain refers to glass packaging which is lost in producing furnace ready cullet. A high proportion of this can still be recycled in other applications.

Figure 6 – Glass Packaging Recycling rates Along the Supply Chain

	MRF				Reprocessor			
	COLLECTED		**SORTED**				**REPROCESSED**	
Process Losses	5.0%				Process Losses	21.0%		
POM	**Input**	**Losses**	**Output**		**Input**	**Losses**	**Output**	**Recycled**
195,710	**158,087**	7,904	**150,183**		**150,183**	31,538	**118,644**	**118,644**
Recycling Rate	80.8%		76.7%				60.6%	
Difference		**4.0%**			**16.1%**			
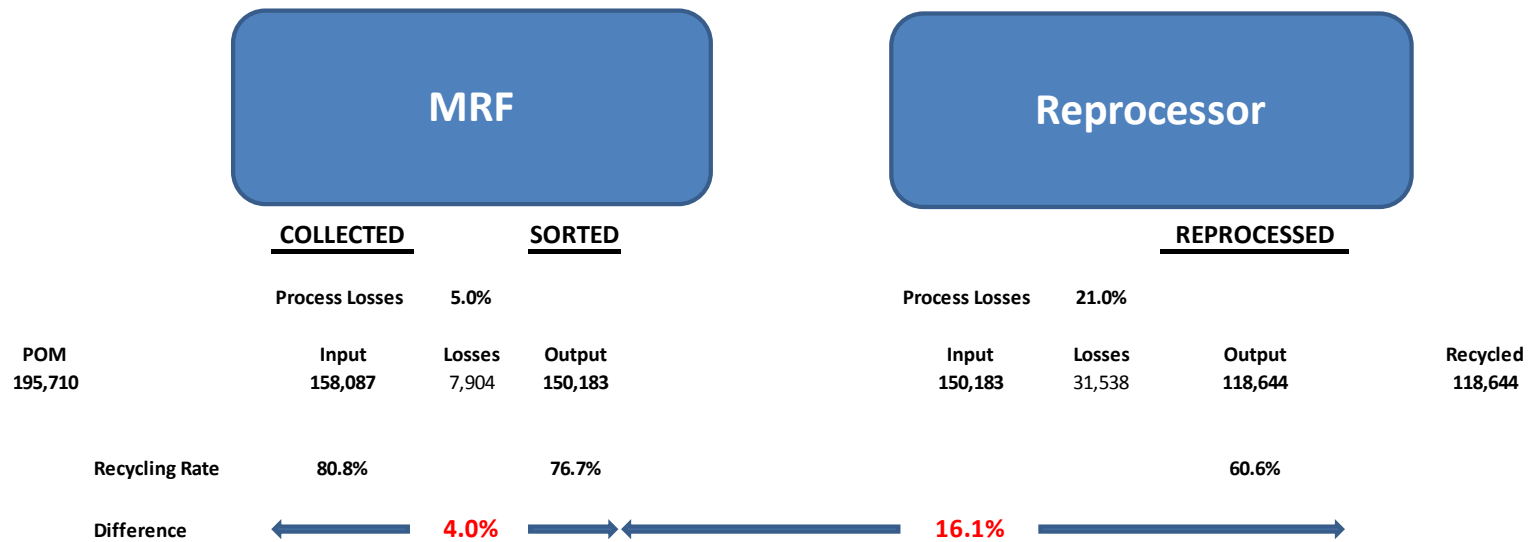
The greatest loss of glass packaging occurs at the reprocessor stage of the supply chain, with 21% process losses experienced in the preparation of furnace ready cullet. However, it should be noted that this also includes the recycler and colour separation stage (preparation of furnace ready cullet) of the supply chain as well as the actual reprocessing of the glass into a new product. The 21% recycler/reprocessor process loss reduces the overall potential recycling rate by 16.1%.

In order to achieve a 60.6% recycling rate 158,087 tonnes (81%) of glass is required to be collected. This means that approximately 20% of glass packaging is lost within the glass recycling supply chain. However, it should be noted that a high proportion of these losses will be glass fines, which can potentially be recycled as an aggregate, or metals that are extracted for recycling.

2.4 Aluminium

2.4.1 MRF

Figure 7 shows aluminium packaging process losses encountered at the MRF stage of the recycling supply chain.

FIGURE 7 – ALUMINIUM PACKAGING MRF PROCESS LOSSES

Description	Notes	Aluminium Packaging Process Loss	Source
Rejected recyclable waste	Not material specific	9%	Rejected recyclable waste up 84% in England since 2011 (BBC)
Not recovered by MRF	Depends on the type of MRF	6.5%	Analysis of material recovery facilities for use in life-cycle assessment (Research article, 2014)
	AVERAGE	**7.7%**	

Following a review of data at the MRF stage of the aluminium packaging recycling supply chain, two average process losses were used in the model. Based on this, an average process loss of 7.7% was identified. AluPro peer reviewed this data and indicated that the figure was reasonable.

2.4.2 Reprocessor

Figure 8 shows aluminium packaging process losses encountered at the reprocessor stage of the recycling supply chain.

FIGURE 8 – ALUMINIUM PACKAGING REPROCESSOR PROCESS LOSSES

Description	Notes	Aluminium Packaging Process Loss	Source
Process losses		1%	Delft University of Technology
Process losses		0.8%	The Minerals, Metals & Materials Society (TMS)
	AVERAGE	**0.9%**	

Following a review of data at the reprocessor stage of the aluminium packaging recycling supply chain, two average process losses were included within the model. Based on this, an average process loss of 0.9% was identified. AluPro peer reviewed this data and indicated that the figure was also reasonable.

2.4.3 Aluminium Packaging Recycling Rates along the Supply Chain

Figure 9 shows the aluminium packaging recycling rate at each stage of the supply chain.

FIGURE 9 – ALUMINIUM PACKAGING RECYCLING RATES ALONG THE SUPPLY CHAIN

	MRF				**Reprocessor**			
	COLLECTED		**SORTED**				**REPROCESSED**	
	Process Losses	7.7%			Process Losses	0.9%		
POM	**Input**	**Losses**	**Output**		**Input**	**Losses**	**Output**	**Recycled**
14,993	**5,408**	419	**4,989**		**4,989**	44	**4,945**	**4,945**
Recycling Rate	36.1%		33.3%				33.0%	
Difference		**2.8%**			**0.3%**			
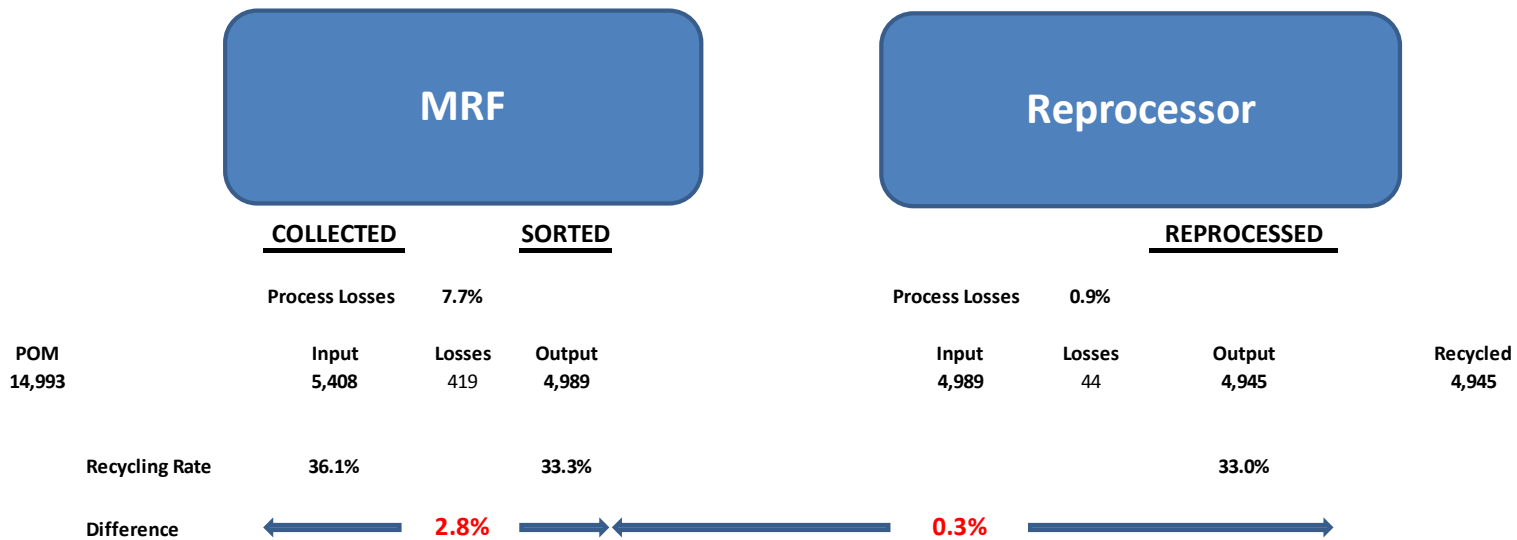
The greatest loss of aluminium packaging occurs at the MRF stage of the supply chain, with 7.7% process losses experienced. This reduces the potential packaging recycling rate by 2.8%. It also shows that there is very little packaging lost at the reprocessor stage of the supply chain. Although there is a loss of 0.9%, this has minimal impact on the recycling rate, equating to a reduction of 0.3%.

In order to achieve a 33% recycling rate in aluminium 5,408 tonnes of aluminium packaging is required to be collected. This means that 3.1% of aluminium packaging is lost within the aluminium recycling supply chain.

2.5 Steel

2.5.1 MRF

Figure 10 shows steel packaging process losses encountered at the MRF stage of the recycling supply chain.

FIGURE 10 – STEEL PACKAGING MRF PROCESS LOSSES

Description	Notes	Steel Packaging Process Loss	Source
Rejected recyclable waste	Not material specific	9%	Rejected recyclable waste up 84% in England since 2011 (BBC)
Not recovered by MRF	Depends on the type of MRF	6%	Analysis of material recovery facilities for use in life-cycle assessment (Research article, 2014)
	AVERAGE	**7.5%**	

Following a review of data at the MRF stage of the steel packaging recycling supply chain, two average process losses were used in the model. Based on this, an average process loss of 7.5% was identified. Tata Steel peer reviewed this data and indicated that the figure was reasonable.

2.5.2 Reprocessor

Figure 11 shows steel packaging process losses encountered at the reprocessor stage of the recycling supply chain.

FIGURE 11 – STEEL PACKAGING REPROCESSOR PROCESS LOSSES

Description	Notes	Steel Packaging Process Loss	Source
Processing steel mills and foundries	Steel scrap, not specific to packaging	0.5%	Iron and Steel Recycling in the United States in 1998
TATA Steel	Process losses	0.3%	TATA Steel
	AVERAGE	**0.4%**	

Following a review of data at the reprocessor stage of the steel packaging recycling supply chain, one average process loss was included within the model. However, when this was peer reviewed by Tata Steel, they believed the figure of 0.5% was a high estimate for two reasons:

- Most waste materials/spillages would be put back into the process
- Most losses from the steel production process are in the production of high carbon steel; however, with packaging steel being low carbon, any yield losses would be minimal

Tata Steel believed that the 0.5% was their high estimate and their average rate would be 0.25% (rounded up to 0.3%). Adding the 0.3% from Tata Steel to the original estimate gives an average process loss of 0.4% for this material.

2.5.3 Steel Packaging Recycling Rates along the Supply Chain

Figure 12 shows the recycling rate at each stage of the supply chain.

FIGURE 12 – STEEL PACKAGING RECYCLING RATES ALONG THE SUPPLY CHAIN

	COLLECTED		SORTED		REPROCESSED			
	Process Losses	7.5%			Process Losses	0.4%		
POM	**Input**	Losses	**Output**		**Input**	Losses	**Output**	Recycled
52,656	**30,658**	2,299	**28,360**		**28,360**	106	**28,253**	28,253
Recycling Rate	58.2%		53.9%				53.7%	
Difference	⟵ 4.4% ⟶		⟵ 0.2% ⟶					
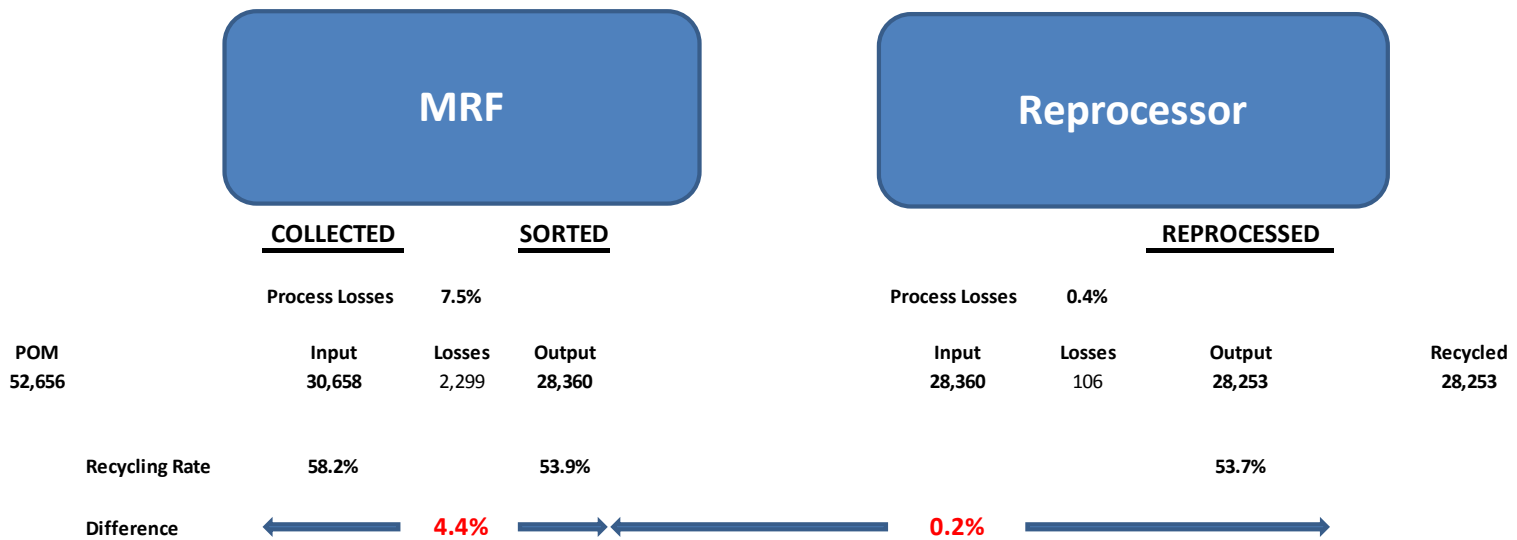
The greatest loss of steel packaging occurs at the MRF stage of the supply chain, with a 7.5% process loss experienced. This reduces the potential steel packaging recycling rate by 4.4%. It also shows that there is very little packaging lost at the reprocessor stage of the supply chain. Although there is a loss of 0.4%, it has minimal impact on the recycling rate, equating to a reduction of 0.2%.

In total, 30,658 tonnes (58.2%) of steel packaging placed on the market is required to be put through the system in order to achieve a 53.7% recycling rate. This means that 4.6% of steel packaging is lost within the steel recycling supply chain.

2.6 Plastics

2.6.1 MRF

Figure 13 shows plastic packaging process losses encountered at the MRF stage of the recycling supply chain.

FIGURE 13 – PLASTIC PACKAGING MRF PROCESS LOSSES

Description	Notes	Plastic Packaging Process Loss	Source
Rejected recyclable waste	Not material specific	9%	Rejected recyclable waste up 84% in England since 2011 (BBC)
Not recovered by MRF	Depends on the type of MRF	11.5%	Analysis of material recovery facilities for use in life-cycle assessment (Research article, 2014)
Not recovered by MRF		12%	Recoup
	AVERAGE	10.8%	

Following an initial review of data at the MRF stage of the plastic packaging recycling supply chain, two average process losses were used in the model. Recoup peer reviewed this data and indicated that an average process loss of 12% seemed reasonable. This was then added to the model to produce an average figure of 10.8% process losses at this stage of the supply chain.

Recoup stated that the losses have increased recently due to an increase in collections of pots, tubs and trays without there being end markets available for the material in all cases.

Recoup believed that, due to the significant number of variables which could affect the level of losses and the lack of available data relating to plastic packaging process losses along the supply chain, there would be no further value gained in trying to break down these process losses further by format of plastic packaging.

2.6.2 Reprocessor

Figure 14 shows plastic packaging process losses encountered at the reprocessor stage of the recycling supply chain.

FIGURE 14 – PLASTIC PACKAGING REPROCESSOR PROCESS LOSSES

Description	Notes	Plastic Packaging Process Loss	Source
Process losses		15%	Recoup
Process losses		15%	Axion - Radical rethink needed to maximise UK recycling rates
	AVERAGE	15%	

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Following an initial review of data at the reprocessor stage of the plastic packaging recycling supply chain and a sense check by Recoup, several process losses were removed from the model due to:

- Figures only representing parts of the reprocessor stage, rather than the whole process

- Figures being derived from trials that are not representative of any real commercial process within the UK
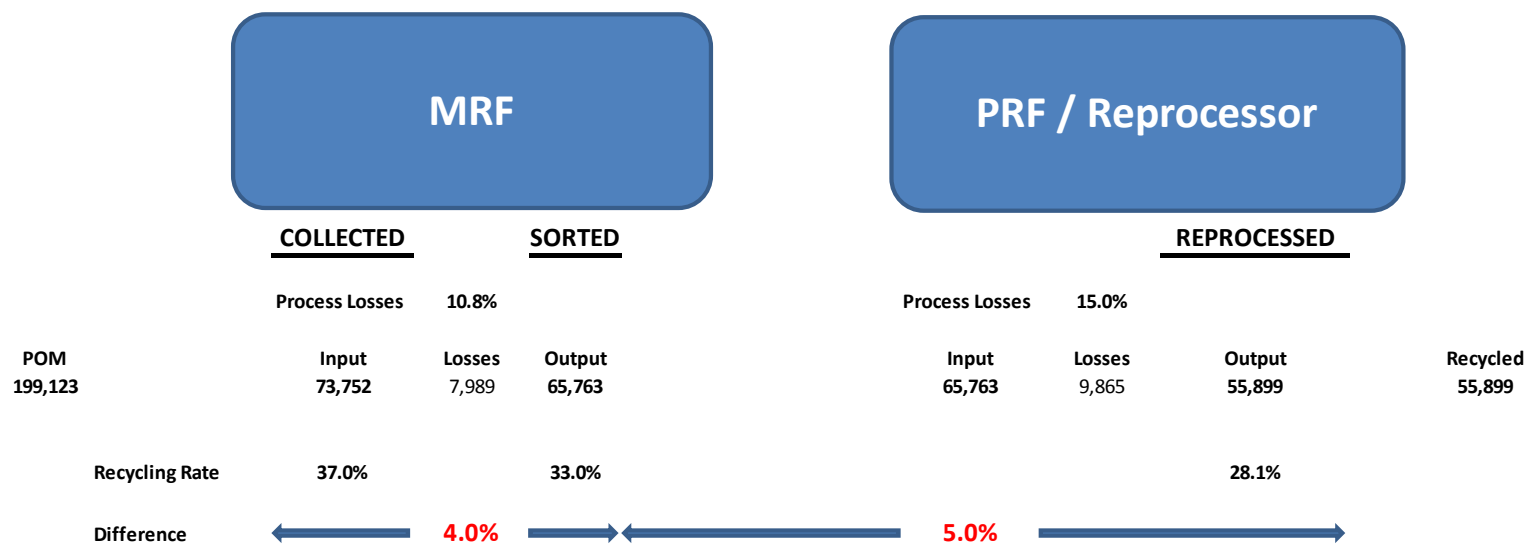
Recoup believes that a process loss of between 10-20% would be realistic (including moisture loss). They also stated that this would cover both the Plastics Recovery Facility (PRF) and reprocessing stages. In addition, Recoup provided research published by Axion that supported this estimate.

In terms of where the PRN is raised in the supply chain, Recoup stated that it should be when the plastic is melted into a product, such as a pellet. Nevertheless, they also stated they are supportive of the PRN being raised at the clean flake stage as this can sometimes be a cleaner product than a pellet.

2.6.3 Plastic Packaging Recycling Rates along the Supply Chain

Figure 15 shows the recycling rate at each stage of the supply chain.

FIGURE 15 – PLASTIC PACKAGING RECYCLING RATES ALONG THE SUPPLY CHAIN

	MRF				PRF / Reprocessor			
	COLLECTED		SORTED				REPROCESSED	
	Process Losses	10.8%			Process Losses	15.0%		
POM	Input	Losses	Output		Input	Losses	Output	Recycled
199,123	73,752	7,989	65,763		65,763	9,865	55,899	55,899
Recycling Rate	37.0%		33.0%				28.1%	
Difference		4.0%				5.0%		

The greatest loss of plastic packaging occurs at the PRF/Reprocessor stage of the supply chain, with 15% process losses experienced. However, it should be noted that this covers the PRF stage of the supply chain as well as the actual reprocessing of the plastic. It also includes a significant reduction in the moisture contained within the input material through these processing stages. The 15% PRF/Reprocessor process loss reduces the overall potential recycling rate by 5%.

The research also shows that there is a significant process loss (10.8%) at the MRF stage of the supply chain. This has an overall impact of 4% on the recycling rate.

In total, 73,752 tonnes (37%) of plastic placed on the market is required to be put through the system in order to achieve a 28.1% recycling rate. This means that 9% of plastic packaging is lost within the recycling supply chain.

2.7 Wood

2.7.1 MRF

Figure 16 shows wood packaging process losses encountered at the MRF stage of the recycling supply chain.

FIGURE 16 – WOOD PACKAGING MRF PROCESS LOSSES

Description	Notes	Wood Packaging Process Loss	Source
Not recovered by MRF	The Wood Panel Industries Federation (WPIF) states that no wood will be sorted at the MRF stage of the recycling supply chain. These will be used as bulking points only.	0%	Wood Panel Industries Federation
	AVERAGE	**0%**	

This project identified that any process losses at the MRF stage of the wood packaging supply chain would be negligible as MRFs are typically only used as bulking points for wood.

2.7.2 Reprocessor

Figure 17 shows wood packaging process losses encountered at the reprocessor stage of the recycling supply chain.

FIGURE 17 – WOOD PACKAGING REPROCESSOR PROCESS LOSSES

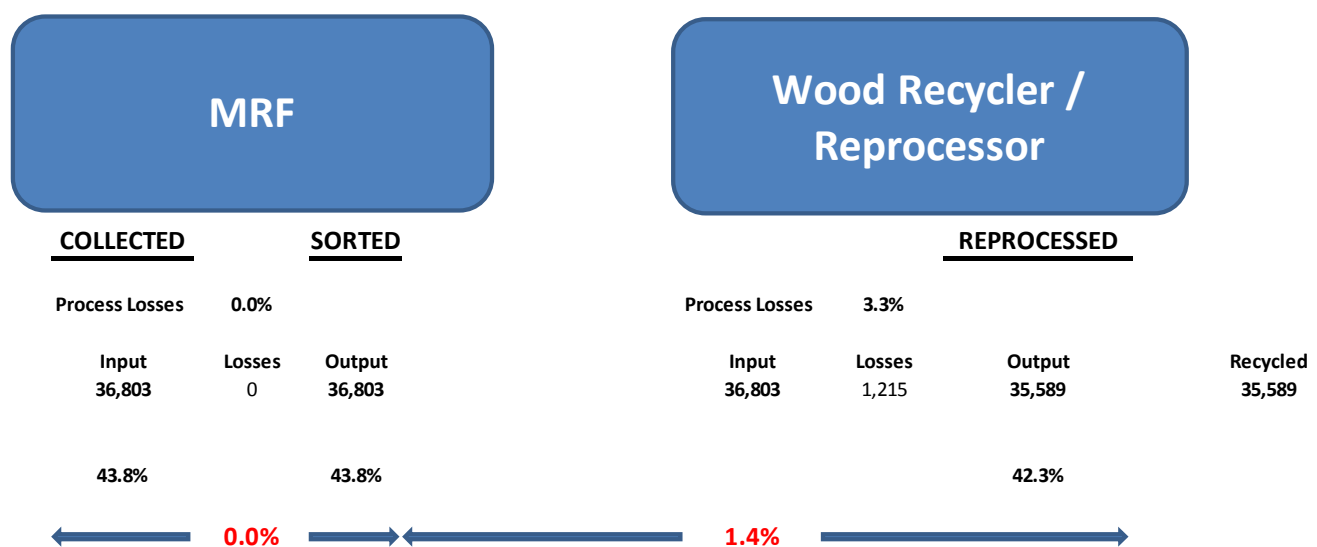| Description	Notes	Wood Packaging Process Loss	Source
Process losses	The WPIF states that this stage covers both the wood recycler and end reprocessor stages. The WPIF states that losses at this stage will be from fines (1%) and non-wood packaging. The WoodFlow 2020 project indicated that ~2.3% of wood packaging is non-wood, i.e. nails and strapping. Therefore, the total is 3.3% (Excl. moisture), which was agreed by WPIF.	3.3%	Wood Panel Industries Federation
	AVERAGE	**3.3%**	

The WPIF stated that the yield loss is for wood at this stage is approximately 3.3%. However, it should be noted that 2.3% of this will be from non-wood packaging, such as nails, which will be removed and recycled. The WPIF also stated that, on average, wood can have ~12% moisture content which will be removed during the recycling/reprocessing stages; however after incorporation into a product such as panel board it will acclimatise and start to pick up moisture so that in service all the wood that makes up the panel will have a moisture content of 8% ±2%.

2.7.3 Wood Packaging Recycling Rates along the Supply Chain

Figure 18 shows the recycling rate at each stage of the supply chain.

FIGURE 18 – WOOD PACKAGING RECYCLING RATES ALONG THE SUPPLY CHAIN

	MRF				Wood Recycler / Reprocessor			
	COLLECTED		**SORTED**				**REPROCESSED**	
	Process Losses	0.0%			Process Losses	3.3%		
POM	Input	Losses	Output		Input	Losses	Output	Recycled
84,074	36,803	0	36,803		36,803	1,215	35,589	35,589
Recycling Rate	43.8%		43.8%				42.3%	
Difference		**0.0%**				**1.4%**		

This shows that the greatest loss of wood packaging occurs at the recycling/reprocessor stage of the supply chain, with a 3.3% process loss experienced. This reduces the potential recycling rate by 1.4%. However if moisture is included in the losses, then this increases to 15.3%, which results in a 7.5% drop in the recycling rate.

In total, 36,803 tonnes (43.8%) of wood packaging is required to be put through the system in order to achieve a 42.3% recycling rate.

3 Key Findings

3.1 Summary of Recycling Rates and Process Losses

A summary of the key findings of the audit are provided in Figure 19.

FIGURE 19 – RECYCLING AND RECOVERY RATES

	MRF In		MRF Out	Reprocessor In		Reprocessor Out
Paper/card	85.8%	8.0%	77.9%	77.9%	2.3%	75.5%
Glass	80.8%	4.0%	76.7%	76.7%	16.1%	60.6%
Aluminium	36.1%	2.8%	33.3%	33.3%	0.3%	33.0%
Steel	58.2%	4.4%	53.9%	53.9%	0.2%	53.7%
Plastics	37.0%	4.0%	33.0%	33.0%	5.0%	28.1%
Wood	43.8%	0.0%	43.8%	43.8%	1.4%	42.3%

This shows that the potential recycling rate for paper/card is reduced by 8% due to process losses experienced at the MRF stage. This can be through paper/card being lost in other material streams, or can be due to contamination. In terms of the reprocessor stage, glass experiences the highest drop in recycling rate due to process losses; however, it should be noted that some of the process losses can be recycled as aggregates. This means that the process losses for glass may be lesser in other scenarios than that which is included in this work.

Figure 20 shows the quantities of packaging lost within the system compared to the POM and recycled figures.

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FIGURE 20 – PACKAGING LOST WITHIN THE SCOTTISH RECYCLING SYSTEM 2013 (T)

Packaging Material	POM	MRF In	MRF Out	Reprocessor Out (Recycled)	Recycling Process Losses	Recycling Process Losses (%)
Paper/card	357,184	306,505	278,107	269,764	36,741	10.3%
Glass	195,710	158,087	150,183	118,644	39,443	20.2%
Aluminium	14,993	5,408	4,989	4,945	463	3.1%
Steel	52,656	30,658	28,360	28,253	2,405	4.6%
Plastics	199,123	73,752	65,763	55,899	17,853	9.0%
Wood	84,074	36,803	36,803	35,589	1,215	1.4%
TOTAL	**903,740**	**611,213**	**564,205**	**513,094**	**98,119**	**16.1%**
RECYCLING RATE		**67.6%**	**62.4%**	**56.8%**		

The figure shows that glass experiences the highest process losses, followed by paper/card and plastics.

Figure 20 also shows that 98,119 tonnes (16.1%) of packaging that is input to the recycling system is lost in the recycling supply chain. Further, 67.6% of packaging material is required to be input to the recycling system to achieve a 56.8% packaging recycling rate in Scotland. These findings highlight the impact on the recycling rate depending on where in the packaging recycling supply chain it is measured.