NALED Extended Producer Responsibility

EPR System Upgrade and Preferred Option for Serbia

November 2021

Report for NALED

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Executive Summary

E.1.0 Approach

This report provides results of the EPR modelling work which seeks to estimate:

- current performance and cost of the existing waste management system;
- projected cost for system upgrade scenarios in order to meet future targets;
- projected impact on performance; and
- cost impact on the proposed EPR system of the introduction of a deposit return scheme (DRS).

This work provides a full impact analysis of what the new system would achieve for Serbia, exploring both the operational effects and EPR system design options. Revising Serbia's EPR scheme has challenges, including designing a system that:

- meets the targets;
- ensures producers meet the costs of packaging recycling; and
- ensures that the costs of the system to producers are efficient.

The report makes recommendations regarding:

- Collection system changes: where current collection systems are not adequate to achieve the targets, we have highlighted in broad terms the types of changes that are likely to be necessary.
- Infrastructure changes: where transfer, sorting or reprocessing facilities are likely to be required to make the waste system function to the required standard, we have identified the critical gaps.
- Fiscal changes: it may be helpful in some cases to put in place fiscal instruments that will encourage recycling and help make EPR effective. This is likely to be applicable where the cost of disposing of waste is low.
- Engagement changes: we have highlighted the need for communication and engagement and the likely costs of this, both to accompany changes and on an ongoing basis in order to maintain performance.

E.2.0 Recommendations

Definition of Overall Preferred Solution

Based on the analysis carried out, the following recommendations are made regarding the preferred solution.

EPR Operational Design

Regarding the options for the collection systems to be implemented under a refreshed EPR scheme, it is recommended that:

- **Coverage.** A comprehensive packaging recycling system should be made available to **all households** within Serbia. Door-to-door collection services **should be provided in rural areas** to all households suitable to receive one[1], as this would deliver a meaningfully greater recycling performance that will contribute to meeting the targets (especially the plastic target) and thus justifies the additional cost.
- **Collection system.** Alongside a DRS[2], a **dual stream** collection system should be implemented, collecting one stream of plastics, metals, cartons, and glass, and another stream of paper and cardboard.
    - This provides a cost-effective system that delivers the large majority of the available environmental benefit, and preserves material quality for plastic films and papers.
    - With a high proportion of glass captured into the DRS, a separate glass collection is costly and the additional environmental benefits are low.
    - If no DRS, or a DRS with limited scope, were to be implemented, there would be greater benefits (particularly for recycling targets) from a separate glass collection, and a three stream system might then be preferable.
    - The inclusion of non-packaging papers, due to the revenues obtained from the material for minor additional collection costs, is a net benefit to system costs for cardboard and paper packaging. There is the additional potential that a contribution to the scheme for the collection and recycling of non-packaging paper could be sought in future, reducing packaging EPR costs further.
- **Mixed waste sorting.** EPR subsidies should be made available for the recovery of material from mixed waste as mixed waste sorting (processing mixed waste through a sorting facility to extract metals, plastics, cardboards) may be necessary to meet the plastic packaging recycling target in particular. Recovery of organic waste ideally through separate organic waste collections, and taxes on disposal, are likely to be needed to contribute to the viability of mixed waste sorting facilities. Improved residual waste composition information would support further development of the business case for modern mixed waste sorting plants.

[1] All households should be provided with a door-to-door collection but some exceptions may apply if access is very limited

[2] Materials included in the DRS modelling are plastic, cans, glass and cartons, including wines and spirits

- **Wider waste policies.** Alongside the roll-out of recycling collections, the Government should consider enacting an accompanying set of waste policies. One priority would be to deter the use of residual containers for recyclable packaging waste. This might be via direct measures (e.g. requiring certain levels of charges be applied to residual waste collections, prescribing a low effective weekly volume of residual waste a household may have collected) or indirect ones (e.g. giving municipalities powers to fine people who put recyclable items in the residual waste, setting a level of landfill tax and/or incineration tax that disincentivise disposal of packaging materials).
- **Communications and Enforcement.** To ensure the high participation and capture rates modelled for the different recycling systems, there will need to be additional communication and enforcement. It is reasonable that these costs, insofar as they are necessary to meet the targets, should be borne by producers.

EPR System Design

It is recommended that the design of an EPR system for the Serbian context should have the following features:

- **Cost recovery.** Producers should cover 100% of the net necessary costs of the disposal/recovery of packaging waste fractions.
    - This approach is the only one that will ensure that there is funding for an adequate collection and sorting system of packaging waste from residual waste, which will be necessary to meet future targets;
- **Cost coverage.** In order to properly incentivise the switch to more recyclable packaging and ensure brands are not harmed by being associated by litter, costs that are met by producers should extend beyond the minimum requirements of the Waste Framework Directive to include:
    - The costs of managing the remaining packaging within residual waste; and
    - The costs of clean-up of all littered packaging, rather than this requirement being limited to certain single-use plastic (SUP) items specified in the SUP Directive.
- **Collection.** Municipalities should maintain responsibility for collection of household waste but the design of collection services should be aligned to a national service standard.
    - Changing the current responsibility would risk creating inefficiency and potential problems of coordination in delivering the collection service;
    - Municipalities that demonstrate that their services are being operated efficiently should have their collection services fully funded; and
    - Producers should encourage efficiency by paying municipalities only the “necessary costs” of collecting packaging, which may be established through benchmarking or modelling.
- **Sorting.** The responsibility for sorting separately collected packaging should generally sit with the municipalities that collect the material, with some conditions to allow for a Producer Responsibility Organisation (PRO) to meet their reasonable requirements.

    - Municipalities should have the option to opt-out of sorting responsibilities. Sorting responsibilities would then revert to the PRO (with an appropriate notice period);
    - Collectors should be expected to deliver a minimum quality of material that meets the requirements sorting facilities and be subject to pay deductions where the quality is substandard; and
    - Sorting facilities should be required to deliver, as outputs, materials of a grade suitable for onward reprocessing. The approach to procurement should be designed to deliver, over time, a high-quality sorting infrastructure of appropriate scale and geographic distribution. Producers should pay municipalities (and private sector sorters, where applicable) the necessary costs for sorting.
- **Material sales.** The responsibility for arranging material sales should sit with producers. Within an EPR scheme, the producers, or those acting on their behalf, have the greatest incentive to realise the maximum value from material sales, can build expertise in sales and can minimise the cost of sales by selling frequently and in volume. Where one or more PROs are in control of the terms upon which recyclables are sold, they ought to be able to create a better investment framework for sorting and reprocessing infrastructure.
- **Governance.** There appear to be few advantages to a system with multiple competing PROs that cannot be achieved through a well-functioning single PRO. A single PRO also reduces the administrative costs of the system overall. The PRO must be transparent about its costs and the results it achieves and must be responsive to the needs of stakeholders. The legislative framework must put regulation in place to minimise the risk of collusion and monopolistic behaviour.
- **Legislation.** The Government of Serbia should take the lead on preparing and consulting upon the necessary legislation to implement the EPR system and to set the responsibilities and roles of all actors within the waste system. It should also put effective enforcement systems in place to help ensure compliance.
- **Transition.** The transition from the existing system to the new one will take time for adjustments, and there are contractual relationships that will be affected. The earlier decisions are taken, the longer the period for adjustment and the less problematic and costly the transition is likely to be.
- **Waste Compositional Analysis:** Better resolution on the composition of the plastic packaging waste stream within Serbia would be needed to assess the appropriate scale at which to introduce specific materials, and the potential case for regional or national sorting facilities to sort, for instance, an HPDE/PP mix, or PP films from mixed film bales.

Presentation of Refined Preferred Option

The preferred option of dual stream with DRS including glass[3] was compared with three stream with DRS excluding glass to test the robustness of the collection system recommendation. Key findings are;

- when comparing **Dual stream with DRS including glass and three stream with DRS excluding glass,** the full system cost and benefit comparison shows that, collecting beverage glass through the DRS and non-beverage glass in two-stream collections results in lower net system costs, higher glass recycling and higher GHG benefit, compared to collecting all glass in a separate collection; and
- when modelling the impact of **separate glass collection in cities** the recycling and environmental benefits for urban glass collections do not provide a clear justification for the additional system cost.

The robustness of the preferred option was then tested to explore how key sensitivities could affect the order of results. A comparison of the whole system performance is shown in Table 6-1.

Table 0-1: Whole System Performance Comparison

	Dual Stream; DRS with glass	Three Stream; DRS without glass	Difference
Glass Packaging Sorted for Recycling Rate	78%	62%	-16%
EPR Recycling Net Collection Cost per Household	€ 7.4	€ 9.2	€ 1.8
DRS Recycling Net Collection Cost per Household	€ 10.1	€ 8.5	-€ 1.7
Residual Disposal Cost Saving per Household	-€ 2.4	-€ 2.3	€ 0.1
System Net Cost per Household	€ 15.1	€ 15.4	€ 0.3
Net GHG Emissions Savings from Recycling per Household	-51.5 kgCO2e	-51.2 kgCO2e	0.3 kgCO2e

Glass sensitivities

[3] Glass packaging such as glass beverage containers and jars

In summary the glass market sensitivities show;

- if **no end markets are developed** for MRF glass, the glass recycling rate would drop to from 53% (from 78%), there would be no change to GHG benefits and the system costs would increase by €0.5M;
- if a **price in the same region of the disposal costs is received for MRF glass,** there is no change to the glass recycling rate or GHG benefit and the system costs would increase by the same as the no end markets sensitivity (€0.5M);
- if **additional glass cleaning steps were put in place**, there would be no change to the glass recycling rate but a significant increase in GHG benefits and also a significant increase in systems costs.

Mixed waste sorting

The results show that **MWS would deliver a significant increase in recycling rates**, and is likely to be necessary to meet plastic packaging recycling targets. However, if MWS were to be implemented, rolling out a comprehensive household organics collection would reduce arisings of non-recoverable waste in residual, which would also improve quality and recovery potential of recoverable materials and increasing taxes on disposal would further improve the financial business case.

Other variations

Other sensitivities that were investigated that do not change the conclusion that duel stream with DRS including glass is the recommended collection system are;

- if material income fluctuated dramatically;
- if productivity of the system increased or reduced by 10%;
- if material capture rates reduced by 20%;
- if packaging waste being produced is at the rate it is currently being reported (as opposed to the assumption that its 40% higher than is currently being reported);

Contents

Glossary

The following are some of the key abbreviations and terms used throughout this report.

Avoidance cost	Cost borne to reduce an undesirable environmental impact
Comingled collection	Collection of one mixed stream of recyclables separately from residual waste
Door to door collection	Collection of recyclables from every household which has its own private access to street level (a house) or communal or bring bank collection from flats and apartments
DRS	Deposit Return Scheme
End Market	Brokerage or reprocessor that buys collected or sorted material
EPR	Extended Producer Responsibility
Freeriding	Free-riding refers to situations where some producers do not adequately comply with their obligations under EPR
GHG	Greenhouse Gas
HSO	Household of multiple occupancy
MBT	Mechanical and Biological Treatment
MWS	Mixed Waste Sorting – The processing of collected mixed residual waste through a dedicated sorting facility to extract materials including at least metals, plastics, and cardboard.
MRF	Material Recovery Facility – A facility that sorts dry mixed recycling into streams suitable for end markets
Orphan products	Orphan products are those which were put on the market before the introduction of EPR systems by producers who are no longer in business or illegal importers, thereby leaving the responsibility to finance their treatment to current producers.
PPWD	Packaging and Packaging Waste Directive
PRO	Producer Responsibility Organisation
Producer	Manufacturer, filler or importer of the packaging
PRN	Packaging Recovery Note - A document providing evidence that a particular tonnage of recyclables has been recycled and therefore contributes to satisfying producers' recycling obligations
Recyclables	Materials that can be recycled

Reprocessor	An organisation or facility that converts a waste into a new raw material
Residual waste	Waste that cannot be reused or recycled
RVM	Reverse Vending Machine
Separate collection	Collection of one type of recyclable, separately from all other materials
Sorted fractions	Materials for recycling, recyclables and/or secondary raw material after sorting
SUP	Single Use Plastics
WFD	Waste Framework Directive

1.0 Introduction

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2.0 EPR Operational Design

2.1 Collection System Options

This section outlines the options for the EPR scheme that are under consideration for this study and compares the options based on costs, recycling performance, GHG emissions and supply chain impacts.

The aim of this analysis is to set out a system for the collection of household packaging waste that will meet EU packaging waste targets. Household packaging waste is not well recovered currently,

and progress towards higher packaging targets will depend on reform of the household packaging waste collection.

This entails both making choices regarding what should be provided – how materials should best be collected for recycling – and also how the EPR scheme itself should be designed to ensure the collection system is funded effectively and performs well which is discussed in Section 4.0.

Key features of collection systems that deliver high recycling performance are:

- Full-service coverage: The provision of recycling services is currently sparse. An estimated 28% of residents have access to recycling services[4]. All residents should have access to containers for the separate collection and recycling of the full range of packaging materials.
- High resident convenience: Door to door recycling services (where households are provided with individual containers) make it as convenient for residents to place packaging waste in recycling containers as it is to place them in with residual waste, leading to higher recycling rates, so long as the system is effectively communicated. Individual containers should be provided to all households suitable to receive them (with the space to store containers in the grounds of their property or on the street). Households would receive a regular, scheduled collection of these containers on a set day and know when to set out containers for collection. Communal bins would be provided to other households (for instance those in larger apartment blocks).
- Standardisation of materials and collection streams: The provision of recycling services is varied across the country, with some areas collecting a small number of specific materials (PET, paper) and some collecting a broader range of packaging materials. A common collection approach and standard set of targeted materials and collection streams across the country helps to avoid confusion[5], and benefit from economies of scale and flexibility for sorting and material sales.

Within these parameters, there are strategic choices regarding the choice of collection system, notably the extent to which different packaging materials are collected within the same containers. Collecting packaging materials together reduces the number of different types of containers required and the number of collection rounds for different packaging materials, saving on collection resource and fuel usage. Packaging materials that are collected mixed together must then be sorted into distinct material fractions at sorting centres, incurring additional sorting cost for the system overall. Collecting materials together can have an impact on the quantity and quality of materials once sorted. This analysis weighs up these considerations to recommend a collection system for implementation across Serbia.

[4] SEPA Annual report (2019)

[5] Existing legislation obligating producers to source separate packaging for recycling is contained within Law on Waste Management ("Official Gazette of the RS" No. 36/2009, 88/2010, 14/2016 and 95/2018 – other law) http://demo.paragraf.rs/demo/combined/Old/t/t2018_12/t12_0277.htm

Table 2-1: Collection Options Considered

Providing individual recycling containers and collecting these 'Door to door' tends to be more effective at raising recycling rates compared to providing containers on the street to serve a number of households together. This door to door collection is more efficient in urban environments. This study also assesses the relative cost-effectiveness of providing door-to-door collection to suitable households rather than communal containers in rural areas, taking into account additional collection costs against impact on recycling rates.

The impact assessment of a DRS shows the benefits of a deposit return scheme in raising collection and recycling rates for high value beverage container streams. This study focuses on the costs of EPR systems alongside DRS, but also considers the choice and performance of collection schemes if a DRS is not implemented.

3.0 Impact of Upgrading EPR

- Upgrading the existing EPR scheme to meet EU targets will require producers' costs to rise significantly. This increase is not only because of the need to ensure full net cost recovery by producers, but also because the current recycling performance for packaging is somewhat below what is required to be achieved in future. In line with Article 8a of the Waste Framework Directive, producers should meet the costs of waste management "necessary to meet the Union waste management targets". Thus producers will need to meet a bigger share of waste management costs than they do today, and the amount spent on waste management will need to increase in order to put systems in place that are capable of meeting the targets.

3.1 Benefits of Upgrading the EPR System

Upgrading the current EPR scheme will have several benefits, which include:

- **Increased recycling performance:** Increased funding for household recycling collection and sorting infrastructure will yield a stronger contribution from household packaging to overall packaging recycling rates. Household collections are expected to:
  - Enable future cardboard/paper targets to be met.
  - Alongside a DRS, enable glass packaging recycling targets to be met; and
  - Make progress towards plastic packaging recycling targets.

If no DRS were to be implemented, additional material recycled from improved household collections would be expected to increase the amount of packaging waste overall collected and sorted for recycling by 12 percentage points for plastics, 16 percentage points for metals, 28-30 percentage points for glass and 10-13 percentage points for card and paper. In the context of a DRS, material would be diverted away from the household collection system; but the improvement in EPR-funded collections would still contribute 13 percentage points overall to the plastic packaging recycling rate, 30 percentage points to the metal packaging recycling rate and 27-29 percentage points to the glass recycling rates.

- **Job creation:** The additional recycling activity will lead to the creation of at between 500 and potentially up to 1,000 jobs, depending on the choice of collection system and the labour intensity of sorting operations, with further supply chain jobs available in reprocessing.
- **Reducing GHG emissions:** Increased diversion of waste from the residual stream will yield a net GHG emissions reduction of 230-330 ktCO_2e, equivalent to 94 to 130 kgCO_2e per household.
- **Reduction in municipal residual waste management costs:** Increased diversion of an additional 180-230kt[6] of waste into EPR collections (excluding impacts from DRS) will save municipalities €4.0-€5.7 M per annum, largely through reduced landfill and disposal costs, which is equivalent to €1.6-€2.3 per household (in addition to ensuring full funding of recycling collection services). This is based on current landfill gate fees[7]. This will create the opportunity to redirect funds to activities that have a greater social and environmental value, or can be used to reduce local taxation. This is without considering the additional impact of future taxes on disposal, which would increase the savings to municipalities by avoiding these future taxes.
- **Greater availability of secondary raw materials:** Many producers are eager to incorporate more recycled material in their packaging. Improving the recycling rate will give access to greater quantities of such material.

The figures presented here relate to the expected costs and impacts of an EPR scheme based on the current quantities and types of packaging waste materials on the marketplace, and without significant legislative and policy changes outside the remit of EPR schemes. The projected recycling performance for plastic is currently low. Reasons include the high levels of 'difficult to recycle' plastic being placed on the market and a lack of recycling markets for a considerable portion of plastic packaging.

Additional interventions that could significantly further raise performance (and which may be needed to meet some packaging recycling targets), but which require actions outside the direct power of EPR schemes to bring about, are listed below:

[6] This additional diversion would represent between 40% - 47% of total packaging placed on the market.
[7] Landfill costs in EU member states can be found on the European Environment Agencies Website https://www.eea.europa.eu/data-and-maps/figures/typical-charge-gate-fee-and

- **Improvements in the recyclability of packaging.** The design of the EPR fees and packaging regulations can, through 'eco-modulation' of fees and banning the least recyclable packaging formats, increase the recyclability of plastic packaging. This would increase the amount of plastic packaging that could be effectively recycled once collected, by reducing losses in sorting plants and reprocessors, and enabling more material to be sorted into grades with viable recycling markets.
- **Introducing policies to control or limit residual waste disposal, to encourage residents to maximise their use of recycling containers[8].** Limitations on waste disposal are one significant driver of household recycling performance. These policies are effective in the context of strong controls on illegal waste disposal (fly-tipping, burning of wastes, use of unregulated local dumps or landfills), and the effective use of education and enforcement to keep contamination in dry recycling collections within acceptable limits.
- **Introducing mixed waste sorting to recover remaining plastics and metals.** Mixed waste sorting can play a major role in recovering additional materials, especially plastic and metal, from the residual waste stream. The business case for mixed waste sorting in other European countries depends on avoided disposal costs in addition to revenues and subsidy for materials extracted. The relatively low cost of landfilling waste in Serbia will hinder the development of these plants. These plants are also more effective where the majority of food and other organic waste is collected separately and not present in mixed waste. Therefore, taxes on waste disposal, and the introduction of widespread food waste collections, are likely to be needed alongside EPR subsidies, to provide the business case needed for effective mixed waste sorting facilities. An improved and more detailed understanding of the composition of residual waste would assist in developing this business case.

However, the additional benefits of improving recyclability and improved residual waste policies cannot be realised without effective, universal recycling collections. Once universal household recycling collections are in place, further improvements in performance can be realised at quite low incremental collection cost, improving the effectiveness and performance of EPR over time. For example, a collection system will allow producers to benefit by shifting away from harder to recycle plastics, with little need for reconfiguration of waste services or infrastructure; and municipalities can introduce changes that drive up recycling, such as reducing residual waste capacity, with little need for additional vehicles.

3.2 Producer Fee

The costs borne by producers for material placed on the market will need to increase to fund universal collections. The estimation of current cost contribution is derived from average subsidy levels per tonne of material collected for recycling calculated by the baseline quantity of

[8] Examples of policies that maximise the use of the recycling system is to restrict residual container size or reduce the frequency of collection for the residual collection.

household packaging collected.[9] Based on a full net cost recovery, the fee per tonne paid by producers would need to increase from current levels. Modelled fee changes, by material, are set out below in Table . Costs are shown on two bases:

- per tonne of household packaging modelled to be on the market, estimated at 40% higher than reported volumes[10]; and
- per tonne based on overall reported packaging placed on the market.

Table 3-1 Modelled EPR Fees, Current and Upgraded EPR[11]

Packaging Types	Current Subsidy per Tonne placed on the Market (€/tonne) [12]	Current Net Subsidy (€M)	Modelled Updated EPR Net Cost (€M)	Fee Range Modelled, €/tonne		
				All household packaging placed on the market	All packaging placed on the market	All packaging reported placed on the market
Plastic Packaging	6.1 - 12.2	0.8 - 1.6	11.4 - 13.5	126 - 149	88 - 104	123 - 146
Metal Packaging	4.0 - 8.0	0.1 - 0.2	0.3 - 0.5	19 - 30	13 - 21	18 - 30
Glass Packaging	14.8 - 26.0	1.3 - 2.3	6.6 - 9.5	96 - 136	77 - 109	107 - 153
Paper/Card Packaging	3.4 - 5.9	0.6 - 1.0	7.5 - 8.4	125 - 140	47 - 53	68 - 76
Beverage Cartons			1.0 - 1.1	101 - 113	91 - 102	91 - 102

[9] The level of current subsidy depends on the source of collection, availability of materials, types of materials, quantities, treatments and types of collection equipment. The middle value within the range provided is used to estimate total baseline subsidy levels.

[10] Deloitte (2018) Review of the current state of the packaging management system in Serbia and recommendations for its improvement

[11] These modelled EPR fees are based on the net cost of the waste management system including the collection, sorting, transportation and material income from the sale of materials.

3.3 Preferred Option

Eunomia has modelled three household collection options, involving different levels of source separation of different material streams. Our recommendation is that the dual stream option, in which paper and card are collected separately from a mixed glass, plastic and metal packaging stream, should be the preferred option to accompany a DRS. This is based on modelling results that indicate that:

- The additional net costs of separating out cardboard and paper into a separate collection appear to be justified by the recycling and environmental benefits (see Table 3-3). Collection costs are higher, although these are partly mitigated by reduced sorting costs and higher revenues (see Table 3-4). However, collecting cardboard and paper separately from other materials gives greater confidence that the high cardboard and paper packaging recycling targets can be met. Further, the cost per additional tonne of GHG emissions savings is in the region of €110/tCO_2e, close to the avoidance cost of carbon (€100), and may be lower if paper losses are higher than modelled, or if revenues for sorted cardboard are lower.
- The additional net costs of a separate glass collection are relatively high, whereas especially alongside a DRS, the recycling and environmental benefits are lower. Although glass recycling rates would be lower in the dual stream scenario when compared to the three-stream scenario where glass is collected separately, in the context of a DRS, this lower performance would not substantially undermine efforts to meet glass packaging recycling targets. The marginal cost of the additional GHG emissions benefit from implementing separate glass collections (due to improved glass outcomes) is estimated at above €1,400/tCO_2e.

If, however, a DRS is not introduced, additional supporting interventions are likely to be necessary to meet the glass recycling targets, and the separate glass collection is more important for future glass recycling targets. However, there is still a relatively high marginal cost per tonne of additional GHG emissions, reduced to somewhere in the region of €800/tCO_2e.

The modelling results depend on the development of recycling markets for aggregate glass sorted from sorting plants. If there are limited opportunities to recycle lower quality glass streams, additional investment in MRF glass recovery technology can clean and upgrade the quality of glass from sorting plants so that a portion of it can be sold into remelt markets. This additional cost is likely to still be lower than the costs of implementing a separate glass collection.

Table 3-2 shows the net cost of the preferred solution. Table 3-3 shows the recycling rate impact and system costs by packaging material. Table 3-4 shows a further breakdown of EPR separate collection costs by packaging material and cost component (collection, sorting, etc.)

Table 3-2: Net Impact of Preferred Solution

	DRS	EPR	Combined
Hhld Packaging Recycled, tonnes	60,875	87,994	148,869
Commercial Packaging Recycled, tonnes	17,585		17,585
Hhld Packaging Recycled, %	25%	36%	62%
System Costs, €M			
Management, Communications, Enforcement	1.6	6.7	8.3
Collection (incl DRS handling fee)	33.1	19.8	52.9
Sorting	6.2	5.4	11.6
Material Revenues	-8.4	-13.4	-21.8
Unredeemed Deposits	-6.8		-6.8
Avoided Disposal Costs	-1.5	-4.6	-6.1
Net System Cost, €M	25.7	18.5	44.2
Net Cost/Tonne Recycled, €	327.8	210.1	265.6

Table 3-3: EPR Cost per Tonne of Preferred Solution, by Packaging Type

	Plastic Packaging	Metal Packaging	Glass Packaging	Cardboard and Paper Packaging	Beverage Carton Packaging	All Materials
Household Packaging Recycling Rate	33%	63%	79%	75%	95%	-
Overall Packaging Recycling Rate	40%	72%	78%	88%	95%	-
DRS Net Cost Per Tonne Placed on the Market	50	114	44	0	532	740
EPR Net Cost Per Tonne Placed on the Market	77	98	17	53	96	341
Total Cost per Tonne Placed on the Market	126	212	60	53	628	1,081
Total Cost, €M	11.0	27.5	1.4	8.4	6.6	54.9

The breakdown of EPR system costs are shown for our preferred EPR option in Table 3-4, per tonne of material managed and for each component of the collection system.

Table 3-4: EPR Cost per Tonne (Euro) of Preferred Solution, by Packaging Type

	Plastic Packaging	Metal Packaging	Glass Packaging	Cardboard and Paper Packaging	Beverage Carton Packaging
Management, Comms & Enforcement	35.7	34.9	39.9	16.7	44.9
Collections	76.3	54.7	32.6	46.8	47.6
Transfer/Haulage	1.1	0.8	0.3	1.5	0.6
Sorting	15.9	16.0	4.6	6.8	3.6
Material Revenues	-33.5	-90.1	-2.0	-19.0	-1.0
Sorting Residues Treatment/Disposal Costs	2.1	0.3	1.0	0.0	0.1
Total	**97.7**	**16.7**	**76.6**	**52.8**	**95.8**

In the following sections of this part of our report, we present the analysis that has led us to the preferred EPR collection system.

3.4 Options Analysis

This section shows the key results of the EPR modelling. The key metrics described are:

- **The household packaging sorted for recycling rate**. We anticipate, based on international experience, that the quantity of target material captured under each collection system would be similar. The key differences in recycling performance are due to the increased potential for losses of paper and glass to sorting residues when these materials are collected co-mingled.
- **The net recycling collection cost**. The key differences in cost relate to a higher cost of collecting material in multiple streams, offset by lower costs of sorting material for recycling. In both cases, there are also haulage costs and income from the sale of material for reprocessing.
- **GHG emissions savings compared to the baseline**. Sources of emissions include fuel and electricity use in the course of collection, haulage and sorting, which are offset by the benefit from recycling materials and the avoided residual disposal emissions. The key difference here is the amount of material recycled within each option, as this tends to outweigh the emissions from collection and sorting.

- **Job numbers**. This includes frontline staff for collection, haulage and sorting. Collection tends to be more labour intensive than sorting, and therefore job numbers are greater when recycling is collected in multiple streams.
- **Capital investment**.
    - For collections and haulage vehicles
    - For collection containers
    - Sorting equipment
- Capital investment for containers and vehicles is greater when material is source separated, but this is offset by lower sorting costs.
- **Impact on supply chains due to the quality of the separated material**. Source separation generally results in higher quality material that is more amenable to being used in local supply chains.

Table 3-5 shows the key results of the options modelling, assuming that improved collections accompany a DRS. The results show that:

- Increasing the amount of separation of collected material leads to:
    - higher recycling rates, as less material is lost during sorting;
    - better quality of material, which will be of benefit to producers that wish to make use of recycled material in their products; and
    - the highest GHG savings since more material ends up being recycled and displacing virgin materials and less energy is required to separate the material.
- The increase in separation comes with an increase in collection costs, as more staff and vehicles are required to collect the material, although this is offset slightly by lower sorting costs. The collection resources are significantly higher for the three-stream option compared to the other two, as the separate glass round adds considerable additional cost, as does the increase in frequency for collecting plastic and cans due to these being collected from sacks.
- As many more resources are required for the three-stream option, this option provides the most employment. Employment numbers between the two stream and mixed dry are similar, as the increase in collection staff is offset by the decrease in sorting staff.
- Dual stream requires the most capital investment, due to it having the highest container costs. (The three-stream option collects glass from a box and plastic and cans from a single-use sack, which is cheaper than the wheeled bin used in the dual stream option.)
- Overall capital requirements are similar for the mixed dry and three stream options. Although three stream requires the most vehicles, due to the additional glass round, it also requires the least capital investment in sorting equipment.

Table 3-5: Results Overview – With a DRS

	Mixed Dry	Dual Stream	Three Stream
Household Packaging Sorted for Recycling Rate	61%	62%	62%
Net Recycling Collection Cost per Household[1]	€ 6.5	€ 7.4	€ 9.0
Residual Disposal Cost Saving per Household	-€ 1.9	-€ 1.9	-€ 1.8
GHG Emissions Savings Compared to Baseline	-260k tCO_2	-281k tCO_2	-284k tCO_2
Cost of GHG Emissions Savings	-€62/tonne	-€66/tonne	-€79/tonne
Jobs	614	671	898
Capital Investment	€90M	€104M	€89M
Supply Chain Impacts: Material Quality	Lowest quality material, most difficult to find market for	Some separation of materials, so higher quality than fully mixed	Highest quality material, easiest to find market for

1 Net recycling collection cost inclusive of management and communications, collection, transfer and haulage, sorting, and material revenues. The breakdown of these net collection costs are shown in section 3.7

The costs of door-to-door collections are greater in rural areas than in urban and suburban ones, due to the greater distance that must be travelled between collections. Eunomia therefore modelled a communal rural provision sensitivity, where households in rural areas receive collections from communal containers instead of door-to-door collections. Table 3-6Table shows the key results of this analysis, and shows a very similar overall pattern of results to the main option, but with lower costs and performance. Offering only communal collection services to rural areas would mean:

- Lower recycling rates. Due to the lower performance associated with communal containers, which are less convenient for users, it would be expected to lead to a 12% reduction in collected recycling compared with the full door-to-door service.
- Lower collection costs, due to a smaller number of containers needing to be emptied.
- Lower emissions savings, as less material is recycled to offset virgin material and more material is disposed of as residual. This is offset slightly by lower vehicle emissions in collections.
- Less employment.

Container costs are much lower for the dual stream option with communal rural provision compared to the door-to-door scenario for all households, as instead of each household being given two wheeled bins they instead make use of a share of larger communal containers.

Table 3-6: Results Overview – Communal Rural Provision (with a DRS)

	Mixed Dry	Dual Stream	Three Stream
Household Packaging Sorted for Recycling Rate	57%	58%	58%
Net Recycling Collection Cost per Household[1]	€ 5.8	€ 6.5	€ 7.6
Residual Disposal Cost Saving per Household	-€ 1.7	-€ 1.7	-€ 1.6
GHG Emissions Savings Compared to Baseline	-233k tCO_2	-252k tCO_2	-254 tCO_2
Cost of GHG Emissions Savings	-€62/tonne	-€64/tonne	-€74/tonne
Jobs	482	550	709
Total Capital Investment	€84M	€91M	€86M
Supply Chain Impacts: Material Quality	Lowest quality material, most difficult to find market for	Some separation of materials, so higher quality than fully mixed	Highest quality material, easiest to find market for

1 Net recycling collection cost inclusive of management and communications, collection, transfer and haulage, sorting, and material revenues. The breakdown of these net collection costs are shown in section 3.7

If no DRS were to be introduced, greater volumes of plastic bottles, cans and glass bottles would need collecting through EPR-funded collections. Though no difference in individual household containers or collection frequencies are modelled, glass is modelled with a denser communal collection network, with a glass container for every site with a plastics/metals and papers

container. There are some additional collection resource costs, as the higher volume of material means vehicles can collect from fewer households before tipping.[13]

Table 3-7Table 3-7 shows the key impacts of dry recycling collections without a DRS. Again, the outcome follows the same pattern as the main results. Compared to the main results:

- Overall recycling rates are lower, without the high capture rates of materials targeted by the DRS.
- Without a substantial portion of glass captured into high quality recycling streams within the DRS, there is a greater difference in recycling performance and environmental performance between the dual and three stream collections.
- The recycling collection cost is about the similar for the 'mixed dry' option with and without a DRS, as there is a large increase in material incomes due to high-value materials staying within EPR collections. This is, however, offset by an increase in collection, sorting and haulage costs. For the other options, recycling collection costs are lower, as the further separation of collections derives more benefit from higher material incomes, due to a greater amount of material collected. This particularly affects the three stream option, with its separate glass round.
- GHG emissions savings from EPR-collected material are higher, as more recycling is collected through the EPR collections. There is a greater additional GHG emissions benefit from further source separation, due to better quality material (particularly glass).
- A greater level of employment is required within the EPR.
- Higher capital investment is required, as there are more vehicles and sorting equipment required due to the higher quantity of material collected. The same capital investment is required for containers, as these are assumed unchanged. The mixed dry and dual stream options see the largest reduction in capital investment compared to the main options, as these require the most sorting equipment.

[13] Within the modelling, we have conservatively assumed no difference in the frequency of most collections or change in numbers of containers for the containers or plastics/metals streams. The cost may be able to be reduced from what is modelled accompanying a DRS, as, in some areas, the small volume of recyclable material may allow the collection frequency (especially for glass) - and therefore the resources required - to be lower than what is modelled. Reducing collection frequencies is easier to manage on communal collections, whereas regular, set frequency collections are needed where residents set out containers for collection.

Table 3-7: Results Overview – Without a DRS

	Mixed Dry	Dual Stream	Three Stream
Household Packaging Sorted for Recycling Rate (including DRS material)	50%	51%	53%
Recycling Net Collection Cost per Household[1]	€ 5.9	€ 6.7	€ 8.5
Residual Disposal Cost Saving per Household	-€ 2.3	-€ 2.3	-€ 2.2
GHG Emissions Savings Compared to Baseline	-300k tCO_2	-321k tCO_2	-328k tCO_2
Cost of GHG Emissions Savings	-€49/tonne	-€52/tonne	-€64/tonne
Jobs	695	715	975
Total Capital Investment	€97M	€111M	€98M
Supply Chain Impacts: Material Quality	Lowest quality material, most difficult to find market for	Some separation of materials, so higher quality than fully mixed	Highest quality material, easiest to find market for

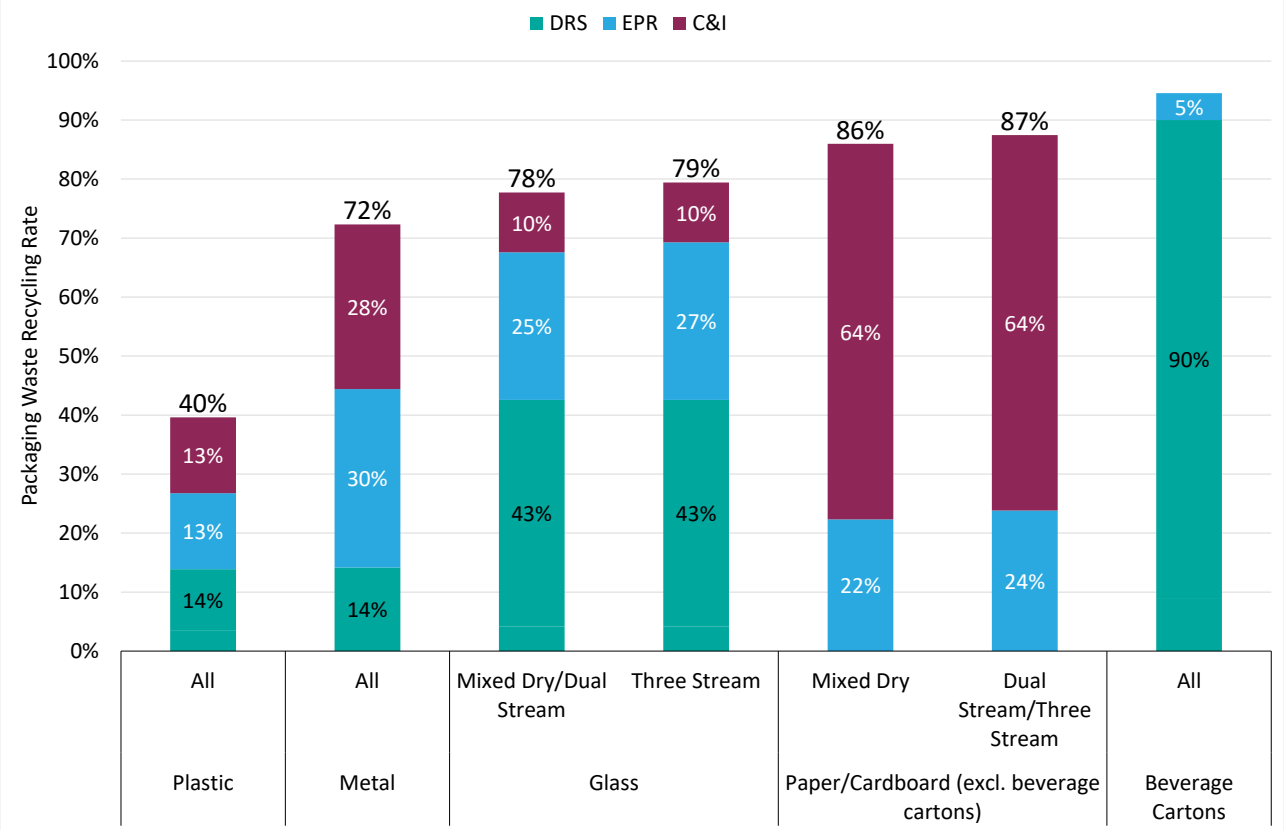
1 Net recycling collection cost inclusive of management and communications, collection, transfer and haulage, sorting, and material revenues. The breakdown of these net collection costs are shown in section 3.7

3.5 Impact on Packaging Recycling Rates

A universal, accessible, convenient, well-designed and communicated EPR scheme should increase the recycling of household packaging waste to make a much greater contribution to packaging waste targets, particularly when implemented alongside a DRS.

All options are expected to increase the amount of household waste sorted for recycling from the current position of approximately 31% to around 60% (including the impact from DRS). The expected impact on overall (household and non-household) material-specific packaging recycling rates overall is shown in Figure 1, illustrating the contribution made by the DRS and EPR systems.

Figure 1: Packaging Recycling Rates, Contribution by System



Recycling rates shown are based on the revised EU calculation method. DRS modelled with the full scope including wines and spirits. The contribution from EPR is shown in blue.

The amount of material captured into recycling collections in each option is assumed to be the same, since there is no clear evidence for the extent of source separation as a factor in participation or collection yields of individual materials. The key differences in recycling performance are due to potential losses of paper and glass to sorting residues.

The recycling rate achieved for plastic, metal and cartons remains the same for all three options, since collecting paper/card and glass separately doesn't affect the quantities of plastics, metal or cartons sorted for recycling. However, it does improve the quantity and quality of the glass and paper/card sent for recycling,

These differences are estimated initially to result in a 2 percentage point difference in the paper recycling rate and a 2-4 percentage point difference in the glass recycling rate depending on whether or not the DRS covers wines and spirits. The more glass that is targeted through a DRS, the less difference the EPR scheme makes to glass recycling performance overall.

There are, however, greater risks associated with achieving recycling performance in the dual stream and fully mixed options, due to the potential lack of markets for lower quality sorted outputs of mixed papers and glass. A lack of recycling options could lead to a further quantity of material not being recycled and a greater difference between the options.

Table 3-8: Overall Packaging Recycling, EU Measurement Method[14]

	Baseline	Mixed Dry Recycling	Dual Stream: Containers, Papers	Three Stream: Plastics/Metals; Papers; Glass	Three Stream without DRS	EU Packaging Targets (2025/2030)
Plastic	24%	40%	40%	40%	32%	50%/55%
Metal	51%	72%	72%	72%	67%	50%/60%
Glass	32%	78%	78%	79%	62%	70%/75%
Card/Paper	69%	86%	88%	88%	85%	75%/85%
Card/Paper (excl. beverage cartons)	74%	86%	87%	87%	87%	As card/paper
Beverage Cartons	0%	95%	95%	95%	46%	As card/paper

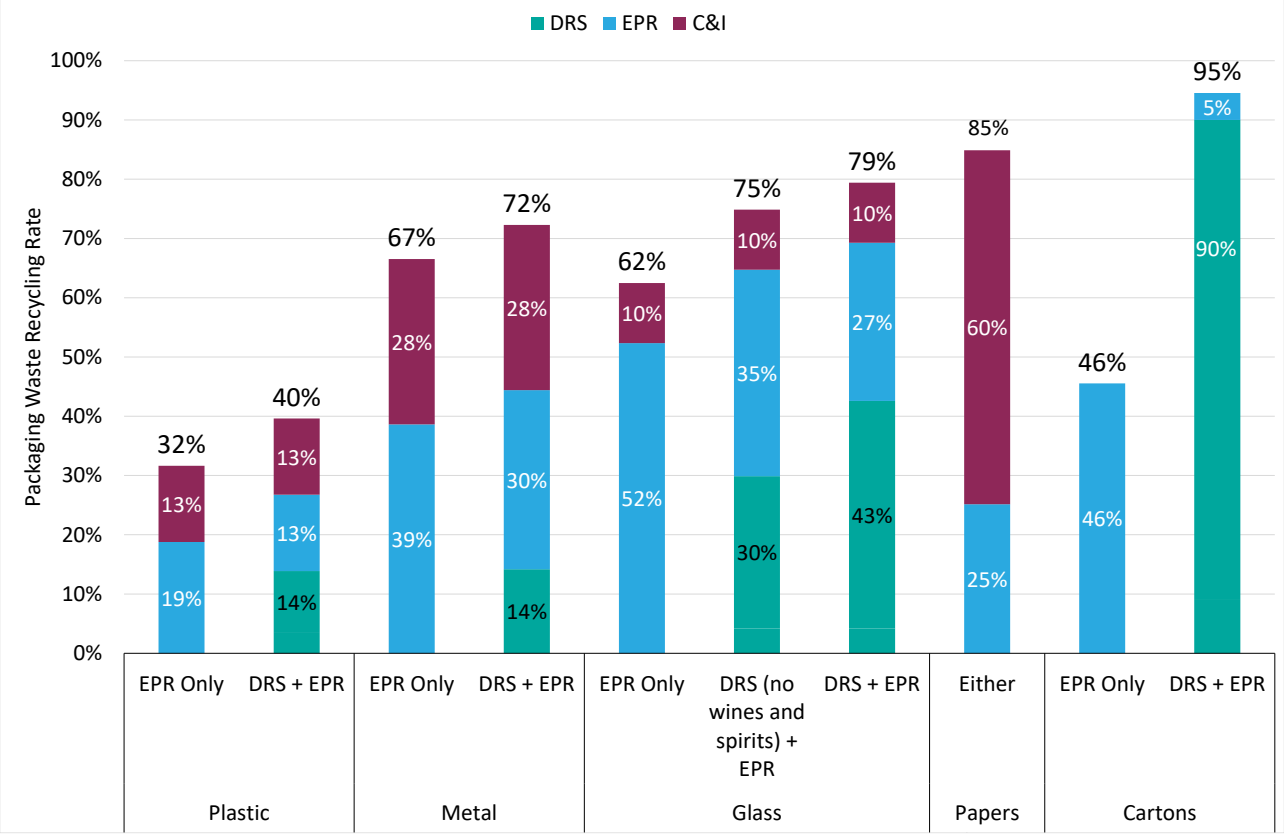
The combination of DRS and EPR is expected to comfortably exceed packaging waste targets for metals, meet the targets for metal and glass, but fall short against the plastic packaging targets. In order to meet the plastic target, improvements would also need to be made to commercial and industrial packaging recycling, which are outside the scope of this study.

EPR collections without DRS are modelled to meet the metal and paper/cardboard packaging waste targets, but remain some way below the targets for glass and plastics.

Without a DRS, recycling rates of all materials would be lower. A DRS results in the majority of PET beverage bottles and aluminium cans being removed from the EPR collection system, and achieves a high level of recycling. The largest impact of a DRS in tonnage terms is for glass packaging, where in the region of half the material would no longer be collected in EPR collections. Figure 3-1 shows (for the three stream collection) the difference in packaging recycling rates between EPR collections only and a DRS, assuming the collection of commercial and industrial packaging waste stays constant.

[14] *Recycling rates measured based on EU measurement method, counting only packaging material entering the final recycling operation.*

Figure 3-1: Overall Packaging Recycling, Contribution by System



As shown in Table Figure 3-1 the contribution that the additional household packaging recycled makes to overall packaging recycling performance varies by material:

- Plastic packaging: comprehensive household packaging collections are expected to add 7 percentage points to the current plastics packaging recycling rate, though even with a DRS collection, and good capture rates of packaging materials, performance is expected to fall short of the future EU targets, necessitating action on commercial and industrial waste. Capture and recycling of PET and HDPE bottles are expected to increase. However, typically lower capture and sorting efficiencies of household film plastics, alongside quantities of harder to recyclable plastics with packaging waste, mean that other measures are likely to be needed to enable targets to be met. Such measures could include reducing unrecyclable plastic packaging, extracting additional plastics for recycling from mixed waste, and incentivising the use of recycling collections through residual waste policies. However, accessible and comprehensive plastic recycling collections will form the basis for improving recycling rates further into the future.
- Metal packaging: Due to the high material value and extensive commercial and informal sector collection, metal packaging recycling rates are already high. Comprehensive and accessible coverage for household packaging recycling should lead to performance exceeding 2025 and 2030 EU recycling targets.
- Glass packaging: household packaging collections can be expected to result in a near doubling of glass packaging recycling. However, without a deposit system in place, this still falls short of the EU targets for glass recycling for 2025 and 2030. As with plastics, other

residual waste policies can support higher capture rates into glass, and higher performance may be obtainable through communications. However, low revenues, lack of nearby glass reprocessing facilities - and therefore high transport costs - are impeding the economics of commercial glass collection. With a deposit system and three stream EPR collections, however, glass packaging recycling is expected to exceed targets by 4 to 9 percentage points. Higher losses of glass from EPR (through dual stream collection system, for instance) can therefore be sustained without affecting the systems' ability to meet targets.

- Paper/cardboard packaging: household packaging recycling collection is expected to enable Serbia to meet European paper and cardboard packaging targets. However, the anticipated performance is near the level of the 2030 target, and so reduction in EPR performance (through higher losses in a full mixed dry collection scheme, or through reduced rural provision) may affect the system's ability to meet targets.

Table 3-9 shows the projected 'sent for recycling' rates of household packaging, based on the weight of separately collected/sorted material input to packaging reprocessing operations. Table 3-10 then shows the impact of that change in household packaging recycling on the overall packaging waste recycling rates (assuming there is no change in the recycling of commercial packaging waste).

This 'sent for recycling' rate is higher than the actual weight of packaging materials recycled, due to the presence of non-target material and impurities/moisture included within collected/sorted waste streams.

The European targets are measured against a revised measurement method for calculating packaging recycled for the purposes of the targets. This calculation method considers losses of material in further cleaning and sorting steps during reprocessing operations prior to the 'final recycling process'. Final measured recycling performance against the EU packaging waste targets is shown in Table . The largest additional losses are in plastic waste streams, where losses for household packaging waste streams between exiting a sorting plant and the calculation point (the production of clean, dry, flaked recyclate) are typically in the region of between 20-30% of the sorted weight. Losses of cartons may also be high (in the region of 27%) depending on the fate of the plastic and aluminium layers. Losses of target material for other materials are lower, making the loss rate more comparable to the quantity of non-target materials within bales.

Table 3-9: Household Packaging Sorted for Recycling Rates

	Baseline	Mixed Dry Recycling	Dual Stream: Containers, Papers	Three Stream: Plastics/Metals; Papers; Glass
Plastic	20%	42%	42%	42%
Metal	34%	68%	68%	68%
Glass	27%	81%	81%	83%
Card/Paper	27%	79%	83%	83%

	Baseline	Mixed Dry Recycling	Dual Stream: Containers, Papers	Three Stream: Plastics/Metals; Papers; Glass
Beverage Cartons	0%	96%	96%	96%
Card/Paper (excl. beverage cartons)	31%	76%	81%	81%

Sorted for recycling rates shown include recycling rate contribution from DRS-collected material.

Table 3-10: Overall Packaging Sorted for Recycling Rates

	Baseline	Mixed Dry Recycling	Dual Stream: Containers, Papers	Three Stream: Plastics/Metals; Papers; Glass
Plastic	27%	46%	46%	46%
Metal	51%	75%	75%	75%
Glass	32%	79%	79%	81%
Card/Paper	70%	89%	90%	90%
Beverage Cartons	0%	95%	95%	95%
Card/Paper (excl. beverage cartons)	74%	89%	91%	91%

Sorted for recycling rates shown include recycling rate contribution from DRS-collected material.

3.5.1 Communal Rural Provision

The costs of door-to-door collections are greater in rural areas than in urban and suburban ones, due to the greater distance that must be travelled between collections. Eunomia therefore modelled a communal rural provision sensitivity, where households in rural areas receive collections from communal containers instead of door-to-door collections.

If communal, rather than individual, containment was provided to households outside of urban areas (including in smaller towns), modelling suggests that there would be a decrease in the region of 12% in collected recycling. Table Table 3-11 shows the impact on household packaging recycling rates of the rural communal collections sensitivity, and Table shows the material-specific packaging recycling rates. The percentage impact is similar for all material-specific packaging recycling rates and between the different collection options. It leads to a larger shortfall in the plastics recycling rate, and a potential shortfall in glass recycling depending on the option and whether wines and spirits are in the DRS scope.

Table 3-11: Household Recycling Performance with and without Rural Collections Sensitivity

	Mixed Dry Recycling	Dual Stream: Containers, Papers	Three Stream: Plastics/Metals; Papers; Glass
With Door-to-Door Rural Service	64%	65%	66%
With Communal Rural Service	60%	61%	61%

Table 3-12: Packaging Recycling Rates, Communal Rural Provision, EU Measurement Method

	Baseline	Mixed Dry Recycling	Dual Stream: Containers, Papers	Three Stream: Plastics/Metals; Papers; Glass	EU Packaging Targets
Plastic	24%	38%	38%	38%	50%/55%
Metal	51%	69%	69%	69%	50%/60%
Glass	32%	75%	75%	75%	70%/75% Glass
Glass (DRS w/o wines and spirits)	32%	69%	69%	69%	
Card/Paper	69%	84%	86%	86%	75%/85%
Beverage Cartons	0%	94%	94%	94%	As card/paper
Card/Paper (excl. beverage cartons)	74%	84%	85%	85%	As card/paper

3.6 Greenhouse Gas Emissions Impact

Increasing recycling of packaging materials reduces the need for virgin materials and so reduces the emissions associated with their production. The collection, sorting and transport of packaging

involves activities which create emissions, offsetting a proportion of the emissions savings from recycling.[15]

Since all options involve a large increase in packaging recycling, the emissions savings of each option are of a similar order of magnitude. However, there is a difference in emissions performance between the options, shown in Table , reflecting both small differences in the amount of collected recycling lost to sorting residues, and the difference in end destinations for recycling of glass.

Where glass is collected with and sorted from other materials, it is likely that a high proportion of the sorted output would remain suitable for aggregate use rather than remelt.

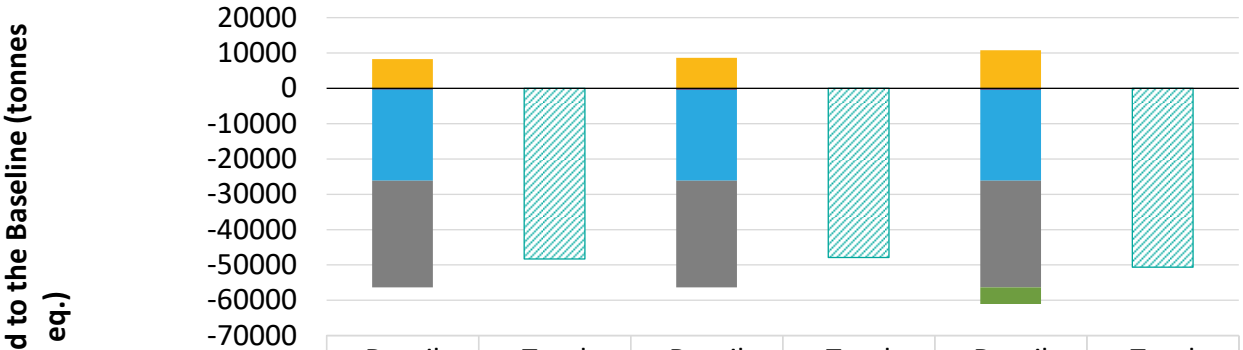
Table 3-13: Greenhouse Gas Emissions Savings Associated with EPR Collection Systems, excluding the impact of DRS (tonnes CO_2 e.)

	Mixed Dry Recycling	Dual Stream: Containers, Papers	Three Stream: Plastics/Metals; Papers; Glass
Benefit from Recycling	-71k	-73k	-78k
Reduced Residual Disposal	-197k	-217k	-217k
Collection and Sorting Emissions	8k	9k	11k
Total	-260k	-281k	-284k

As shown in Table , the majority of emissions savings are obtained from additional recycling of metals, but glass and plastic also contribute significant amounts.

[15] The GHG emissions impact of electricity use in sorting operations in Serbia is relatively high due to the high proportion of coal in the electricity mix. This is expected to reduce as electricity production switches to lower carbon sources.

Table 3-14: GHG Emissions Savings by Packaging Material



	Mixed Dry Recycling		Dual Stream: Paper/Cardboard; Containers		Three Stream: Paper/Cardboard; Plastics/Metals; Glass	
	Detail	Total	Detail	Total	Detail	Total
Glass	0k		0k		-5k	
Metal	-30k		-30k		-30k	
Plastic	-26k		-26k		-26k	
Paper	0k		0k		0k	
Collection and Sorting	8k		9k		11k	
Total GHG Emissions		-48k		-48k		-51k

If wine and spirits are not included in the deposit system, the additional GHG emissions saved from a separate household glass collection (compared to collection in a two-stream system) increase by around 1,000 tCO_2e, whilst GHG emissions from collections vehicles change very little.

Table 3-13Table details the GHG emissions savings for the communal rural and introduction of DRS sensitivities.

If communal, rather than individual, containment was provided to households outside of urban areas (including in smaller towns), there would be a 11% reduction in GHG emissions savings, reflecting the reduction in recycling.

Without the introduction of deposit system that targets glass bottles, the difference in the environmental performance between the two- and three-stream collection systems would be greater. With a DRS, a large portion of the glass would be captured into the deposit system and be suitable for re-melt. Without a DRS, the environmental benefit is reliant on the EPR collection producing high quality glass.

Table 3-15: Greenhouse Gas Emissions for Sensitivities (excluding impact of deposit schemes, tonnes CO_2 e)

	Mixed Dry Recycling	Dual Stream: Containers, Papers	Three Stream: Plastics/Metals; Papers; Glass
With door-to-door Rural Service	-233k	-252k	-254k
Without Deposit	-300k	-321k	-328k

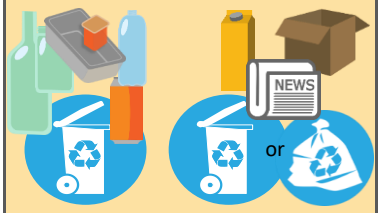
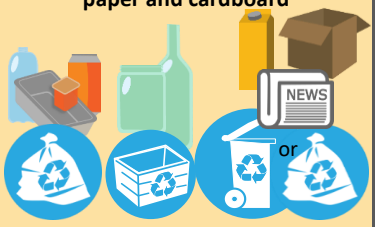
3.7 Collecting and Sorting Costs

Eunomia's modelling compares and assesses three collection systems, which are outlined in Table 3-16. The cost of the collection system depends on collection design choices such as the type of containment provided and frequency of collections. These choices have been made to reflect the volumes expected to be collected and appropriate containment for the different material streams, and also to provide a fair comparison of collection costs across the different systems.

Following collection, material is transferred to sorting plants (either direct delivered by collection vehicles or hauled from transfer stations) to be sorted into saleable grades and sold to reprocessors for recycling.

In the main comparison all households suitable for door-to-door collections, whether urban or rural, are provided with individual containers for recycling. Those not suitable, primarily apartment blocks with multiple households, are provided with communal containers. Urban and rural areas are provided with the same collection system with the same door-to-door collection frequency.

Table 3-16: Collection Options Modelled

	Mixed Dry Recycling	Dual Stream: Paper/Cardboard; Containers	Three Stream: Paper/Cardboard; Plastics/Metals; Glass
Households Provided with Individual Containers	Wheeled bin for mixed dry recycling (including non-packaging papers) 	Wheeled bin for glass, plastic and metal packaging Wheeled bin or single-use sack for paper and carboard 	Single-use sack for plastic and metal packaging Box for glass Wheeled bin or single-use sack for paper and cardboard 
Door to Door Collection Frequency	Fortnightly	Alternating fortnightly (Fortnightly for sacks)	Fortnightly for sacks Monthly for wheeled bins/boxes
Households Provided with Communal Containers	1100 litre bin 	1100 litre bin for glass, plastic and metal packaging 1100 litre bin for paper and cardboard 	1100 litre bin for plastic and metal packaging 1100 litre bin for paper and cardboard Wheeled bin for glass 
Households per Communal Container	9	18	18 50 for glass alongside DRS

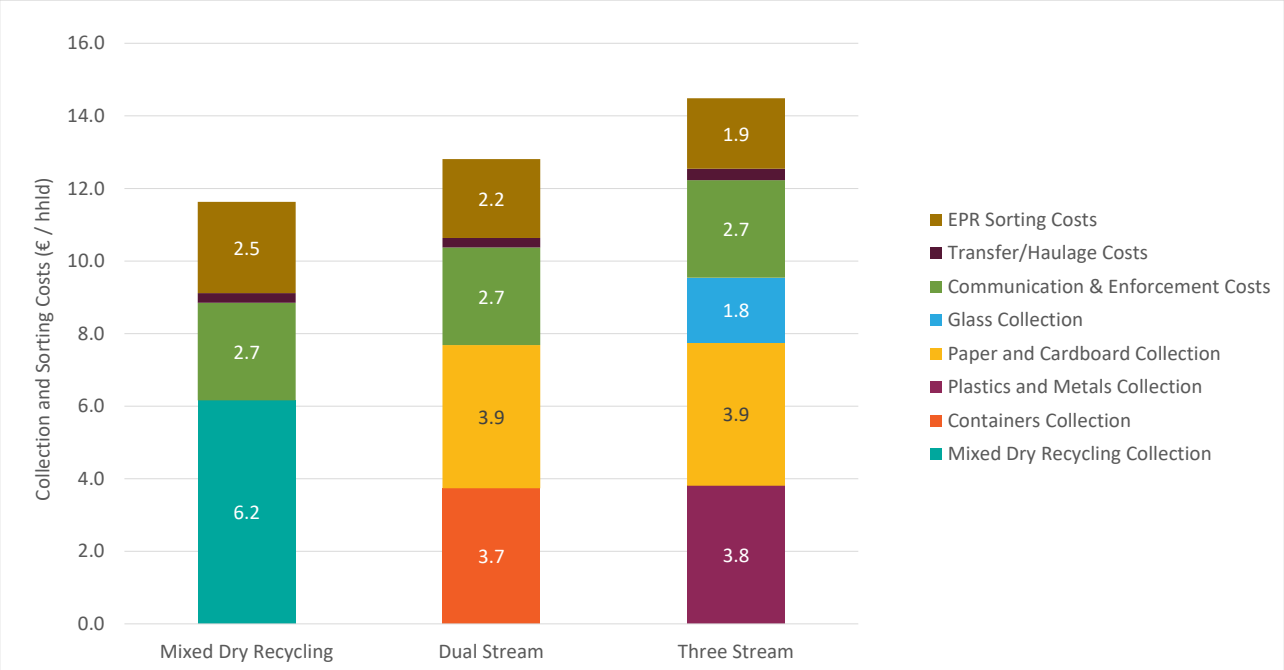
The results of the cost modelling are shown in Table 3-17 and Table 3-18.

- The dual stream option shows greater costs compared to the fully mixed dry recycling. Collection resources are similar in each of these options, but more containers are required in the dual stream option, particularly due to some households being on a sack-based fortnightly papers collection. As the material is already partially separated, sorting costs in the dual stream option are lower. The cost per tonne of additional GHG benefit from

collecting paper glass separately (compared to within a mixed dry recycling collection) is in the region of €110/tCO_2e, close to the current avoidance cost of GHG emissions (€100/tCO_2e).[16] With the mixed dry option, there is the risk that material revenues for paper and cardboard are lower due to the quality of sorted material and/or that losses are higher than modelled, which would reduce the cost difference.

- Three stream has the highest cost due to the additional resources required to implement a third collection round, in which glass is collected separately. Collecting the glass separately results in lower losses and higher quality material and so leads to some improvement in material revenues, but the DRS is expected to account for more than half of glass collected. The sack-based collection of plastic and cans is marginally more expensive that the containers collection in the dual stream system, since it is provided at a greater frequency than containers in the dual stream option, but with greater collection efficiency and lower container costs. Sorting costs are lowest in this option. However, taking into account the improved environmental outcome for glass, the cost per tonne of additional GHG benefit from collection glass separately (compared to dual stream collections) is very high at over €1,400/tCO_2e.
- Communication and enforcement costs are assumed unchanged across the options.

Table 3-17: Cost Breakdown of Recycling Services



[16] The avoidance cost of carbon emissions is the estimated cost per tonne required to reduce sufficient emissions to meet the Paris Agreement climate goals. The avoidance cost increases into the future above €100/tonne. Value taken from DG Move (2019) *Handbook on the External Costs of Transport*, https://op.europa.eu/en/publication-detail/-/publication/9781f65f-8448-11ea-bf12-01aa75ed71a1

Table 3-18: Net Cost of Each Collection System

The difference in material revenues from the different collection systems are small in comparison to the difference in collection and sorting costs.[17]

Sorting costs are impacted by the additional space, equipment and labour required to conduct additional sorting steps and operations, as shown in Table 3-19.

Table 3-19: Sorting Cost Impacts

Sorting Cost Impacts	Mixed Dry Recycling	Dual Stream: Papers (Packaging and non-packaging) and Containers	Three Stream: Papers, Light Packaging and Glass
Glass	Higher glass sorting costs		Optimal

[17] Conservatively, no difference is centrally modelled in paper and cardboard sorted from separate collections compared those sorted from mixed dry recycling. A €10 cost differential between separately collected and MRF-sorted glass is applied.

Paper	Higher costs of equipment to sort and clean papers and plastic films	Additional equipment maintenance costs	
Plastic Film	Higher cross-contamination with papers Higher sorting costs for separating papers and plastic films		

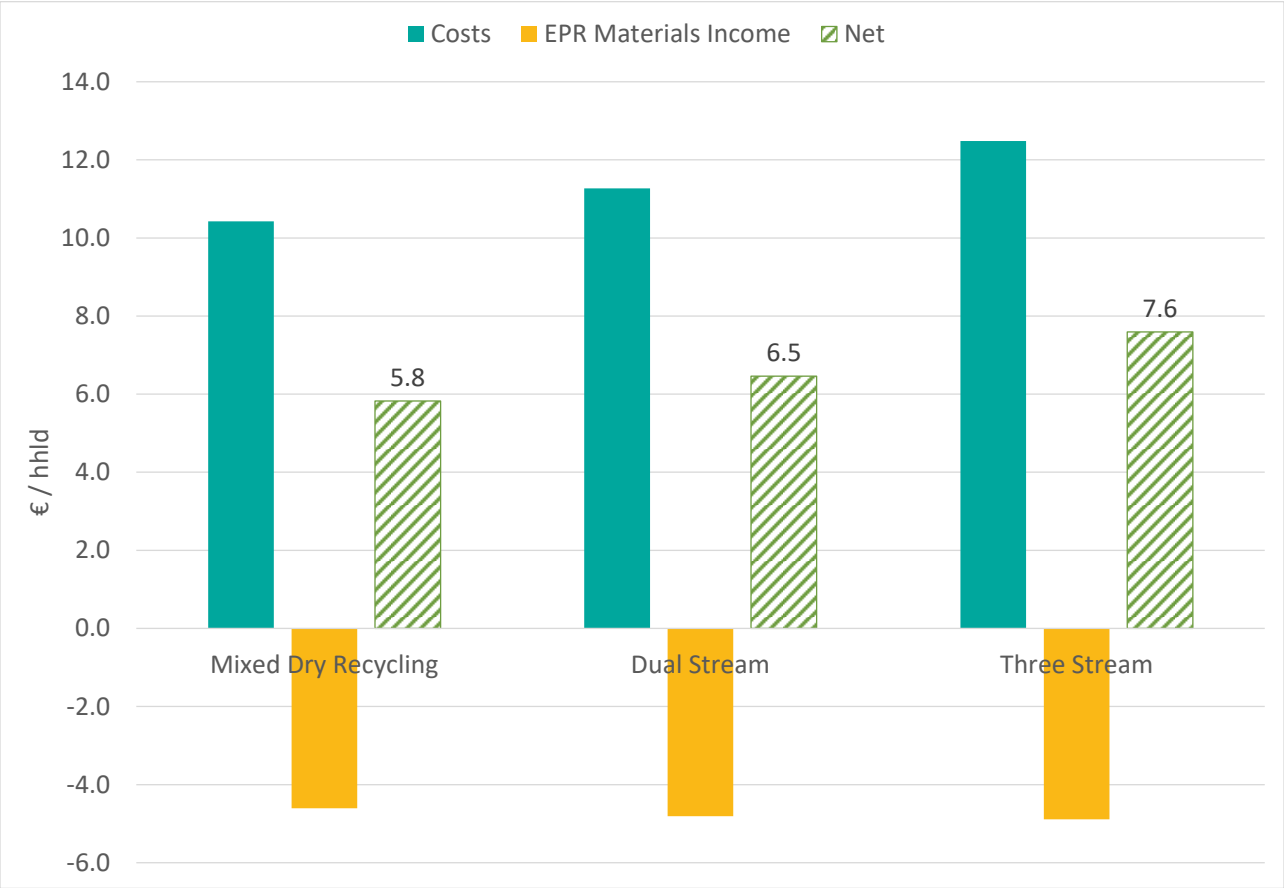
3.7.1 Rural sensitivity

As discussed above, Eunomia considered a sensitivity in which communal collections are provided instead of door-to-door services in rural areas and small towns. The results of the rural coverage sensitivity are shown in Table 3-20. It shows the same pattern of results as the main options modelling, but with the following differences:

- Collection costs are reduced, due to less resources being required in rural areas.
- The reduced coverage in rural areas is modelled with a reduction in collected recycling, and so a lower recycling rate. The reduction in collected material leads to:
  - Lower sorting costs; and
  - Lower material revenues.
- Communication and enforcement costs are assumed unchanged.

Though collection costs are lower, the net cost per tonne of material doesn't change, since a smaller amount of material is collected. However, the cost of this is lower recycling and environmental performance, as detailed in Sections 3.5 and 3.6. Glass and paper targets may become harder to reach if door-to-door collections are not provided in rural areas. Although slightly more expensive per tonne of GHG emissions avoided, the marginal GHG benefit from implementing door-to-door rural collections compared to communal collections is €72/tCO_2e, under the estimated avoidance cost of GHG emissions (€100/tCO_2e).

Table 3-20: Net Cost - Rural Sensitivity



3.7.2 Implications of Upgrading EPR Without Implementing a DRS

The implementation of a DRS alongside EPR will lead to greater costs. In order to allow NALED to understand the costs and benefits, Eunomia modelled the results of upgrading the EPR both with and without the implementation of a DRS. The results of the options modelling without the implementation of a DRS are shown in Table and Table 3-22.

- As in the main options modelling, the three-stream option has the highest modelled cost and the mixed dry option has the lowest modelled cost.
- The net cost of household collections across all options reduces, due to the increase in material revenues available.
- The volumes needing collecting in both the plastics/metals and glass collection increase, leading to more efficient collections. Therefore, although the total collection cost increases slightly compared to the equivalent options alongside a DRS, the cost per tonne sorted for recycling is a third lower for each option.
- Since the amount of glass available to EPR is higher without a DRS, there is greater material revenue benefit from collecting glass separately. Though there is also a greater vehicle requirement compared with the glass collection with DRS, the cost per tonne of the separate glass collection is 36% lower without a DRS. However, the marginal GHG benefit from separate collection of glass (three stream compared to dual stream collections) is still high at over €500.

- Communication and enforcement costs are assumed to be unchanged.

Table 3-21: Cost Breakdown of Recycling Services: without DRS

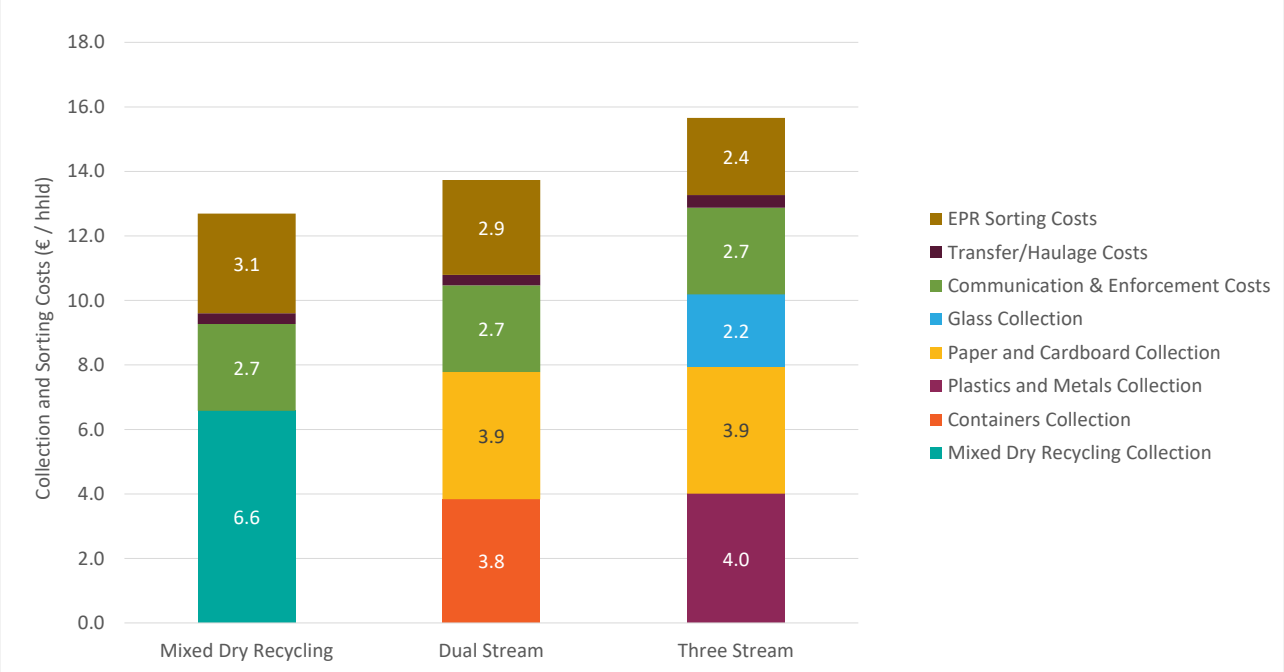
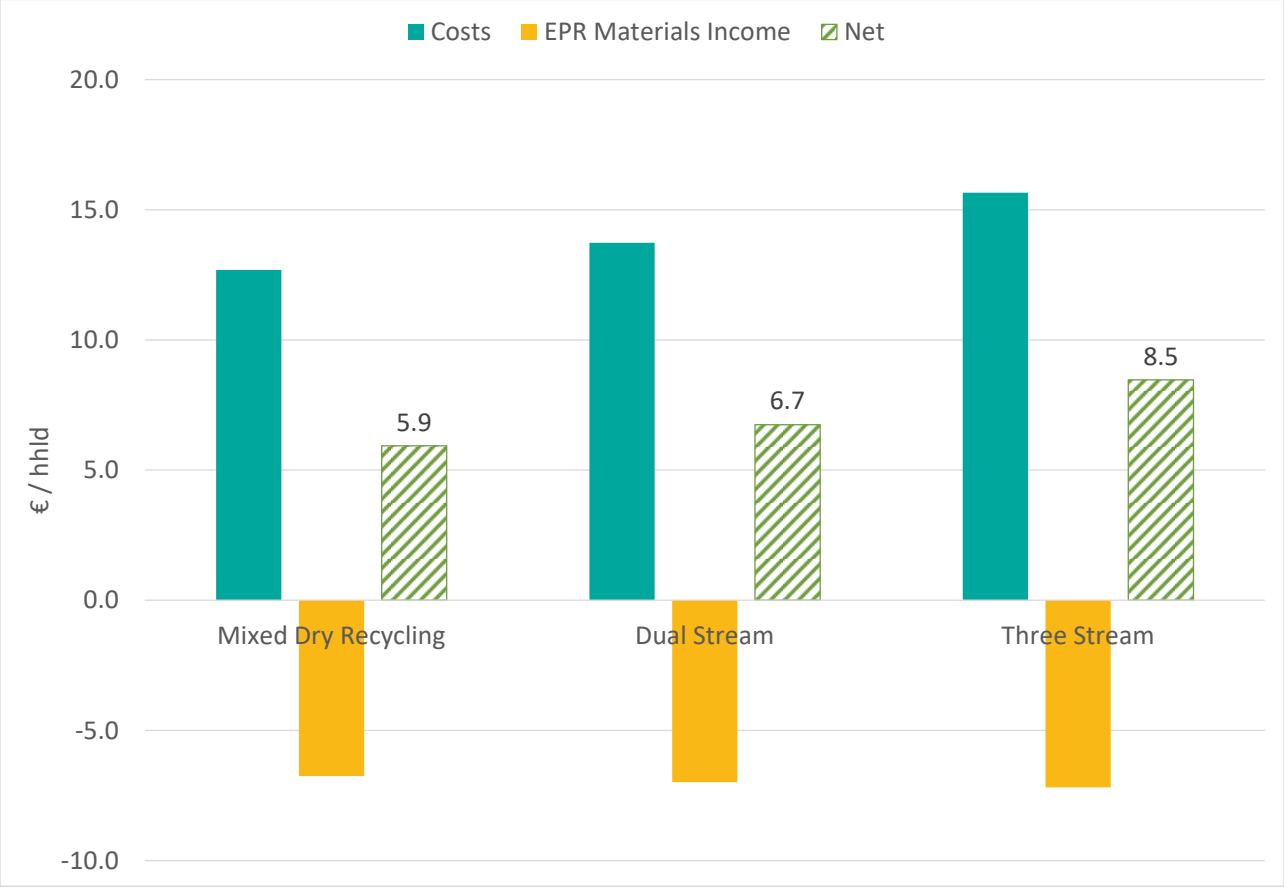


Table 3-22: Net Cost without DRS



3.8 Supply Chain Analysis

3.8.1 Differing Labour Requirements Between Options

All options give rise to an increase in employment opportunities. The largest numbers of jobs required across the options are for driving and for crewing collection vehicles. The number of jobs in the system overall are therefore greater where packaging materials are collected through a higher number of streams. However, when materials are combined, this creates the need for additional jobs in sorting. Table Table 3-23 below shows the difference in FTE job requirements in Serbia across the options compared, and Table compares this job requirement with the slight reduction in jobs required if rural properties were served by communal containers, and if a DRS scheme were not introduced.

Table 3-23: Full Time Employee (FTE) Equivalent Jobs Required Across Options

	Mixed Dry Recycling	Dual Stream: Containers, Papers	Three Stream: Plastics/Metals; Papers; Glass
Collection	477	537	767
Haulage	19	19	23
Sorting	117	115	108
All	**614**	**671**	**898**

Table 3-24: Full Time Employee (FTE) Equivalent Jobs Required Across Options

	Mixed Dry Recycling	Dual Stream: Containers, Papers	Three Stream: Plastics/Metals; Papers; Glass
Main Options	614	671	898
Communal Rural Service	482	550	709
Without Deposit System Introduction	695	715	975

3.8.2 Sorting and Reprocessing Capacity Requirements

Each collection option involves some mixed materials being collected. This necessitates sorting operations to separate out saleable grades of sorted material. The different collection system options require sorting plants configured to sort the different streams:

- In the three-stream option, the plastics/metals stream and the paper/cardboard stream would both need dedicated sorting plants (paper mills may own and run, or contract with, paper sorting facilities to extract grades of paper to their own specifications).
- In the dual stream option, the facility sorting plastics and metals would need additional equipment and processing line to extract and clean or grade the glass.
- In the single stream option, all the sorting would be located within the same facility, with additional equipment to separate larger quantities of papers to clean film from paper and vice versa; and to separate glass, plastics and metals.

There could be regional differentiation, with smaller MRFs separating fractions of materials for further sorting in larger scale facilities (which can better justify the capital investment in additional sorting and cleaning steps). An infrastructure review of existing sorting plants may identify existing sites able to expand to sort and process larger volumes of waste streams.

The sorting plants themselves can be configured with higher capital investment in automated sorting (for instance, Near Infrared (NIR) machines for sorting and/or quality control) or can rely more heavily on manual sorting. Low labour costs in Serbia compared to some other European countries suggest that, initially, it is likely to be more cost effective to utilise a higher degree of manual picking, which can also be more flexibly targeted as required to produce different sorted outputs.

Table 3-25: Sorting Capacity Required Across Options[18]

	Mixed Dry Recycling			Dual Stream: Cardboard/Paper; Containers			Three Stream: Cardboard/Paper; Plastics/Metals; Glass		
	With DRS	With DRS, communal rural	Without DRS	With DRS	With DRS, communal rural	Without DRS	With DRS	With DRS, communal rural	Without DRS
Mixed Dry	192 kt	172 kt	236 kt	-			-		
Container Sorting (Plastics, metals, glass)	-			68 kt	60 kt	114 kt	-		

[18] Glass sorting is assumed to be undertaken by offtakers of glass, and no additional sorting costs for separately collected glass are modelled. (The sale price of glass collected separately is assumed to cover the cost of glass sorting.)

	Mixed Dry Recycling			Dual Stream: Cardboard/Paper; Containers			Three Stream: Cardboard/Paper; Plastics/Metals; Glass		
	With DRS	With DRS, communal rural	Without DRS	With DRS	With DRS, communal rural	Without DRS	With DRS	With DRS, communal rural	Without DRS
Plastics and Metals	-						41 kt	36 kt	61 kt
Paper Sorting	-			123 kt	110 kt	123 kt	123 kt	110 kt	123 kt
Glass				49kt			25kt	21kt	49kt

The haulage modelling assumes a total of 5 regional sorting plants of each type, located near Belgrade, Grad Novi Sad, Cacak, Jagodina and Grad Nis. The selection of locations reflects the geographic population distribution, minimising transport distances needed.

Each system will make a similar quantity of additional household material available to reprocessors, which Serbian reprocessors may be able to benefit from, therefore delivering additional jobs and economic benefits within Serbia. Cardboard and steel are likely to be recycled within Serbia, and there may be opportunities to expand Serbian plastics reprocessing industries. Serbia has a single glass recycling facility, and the costs of transport to recyclers in Croatia and Bulgaria is considerable at €25-€30 per tonne. The largest recycling infrastructure gap is glass recyclers to utilise re-melt quality glass.

Table 3-26: Reprocessing Capacity Required Across Options (tonnes) (Excluding DRS Material)

	Mixed Dry Recycling			Dual Stream: Cardboard/Paper; Containers			Three Stream: Cardboard/Paper; Plastics/Metals; Glass		
	With DRS	With DRS, communal rural	Without DRS	With DRS	With DRS, communal rural	Without DRS	With DRS	With DRS, communal rural	Without DRS
PET	2,622	2,319	12,690	2,622	2,319	12,690	2,622	2,319	12,690
HDPE/ PP	12,120	10,719	12,120	12,120	10,719	12,120	12,120	10,719	12,120
PE	7,931	7,014	7,931	7,931	7,014	7,931	7,931	7,014	7,931
Papers	110,557	99,628	110,557	121,050	109,088	121,050	121,050	109,088	121,050

	Mixed Dry Recycling			Dual Stream: Cardboard/Paper; Containers			Three Stream: Cardboard/Paper; Plastics/Metals; Glass		
	With DRS	With DRS, communal rural	Without DRS	With DRS	With DRS, communal rural	Without DRS	With DRS	With DRS, communal rural	Without DRS
Beverage Cartons	517	463	5,175	517	463	5,175	517	463	5,175
Glass	22,601	19,891	43,447	22,601	19,891	43,447	24,133	20,001	47,308
Steel	7,674	6,853	8,257	7,674	6,853	8,257	7,674	6,853	8,257
Aluminium	163	147	1,630	163	147	1,630	163	147	1,630

3.8.3 Informal Sector

Serbia's waste management system at present relies heavily on the activities of the informal sector. It is therefore important to consider how the proposed introduction of an improved EPR system affects the lives and livelihoods of those who rely on obtaining the value from secondary raw materials.

Serbia is not alone in facing these issues as it attempts to improve its waste management. Some of the models for the informal sector that are emerging from countries around the world are:

- Integration – continue to operate as informal. Remain as independent recyclers but with some support/benefits;
- Formalisation – support is given to informal collectors to become co-operatives or SMEs; or
- Employment – informal sector workers are employed in waste and recycling companies.

It is important that, as Serbia develops its plans, the bodies responsible for pushing forward the new EPR system should engage with the informal sector to establish their concerns and interests. For example, do they want formal jobs, which should bring with them better conditions, increased income with access to benefits? Are there ways in which their current practices could be integrated into the new collection system? Establishing the requirements of the informal sector will help to shape the strategy for integration.

There are examples from Brazil and Eastern Europe (e.g., Turkey, Macedonia, Kosovo) where "Price support" on top of market related price for recyclables is paid from PROs to registered Informal Pickers, in exchange for their participation and improvements in data management and

provision, where waste picking is recognised as an occupation.[19] However, risks that exist with respect to implementing "Price support", include:

- Buy-back centres may reduce their "market price" knowing pickers will still get the price support (middleman retains "value");
- It may create incentives to remove material from formal collections, undermining the economics of the collections directly funded by EPR;
- Informal pickers may not want to register with EPR scheme; and
- Increased income for recyclables may encourage more people to enter the informal waste sector.

Impacts on the informal sector and how they can be managed will be explored in more detail when modelling the preferred solution for task B2.3.

3.9 Revenue and Capital Costs

The capital costs for each option are detailed in Table 3-27. Despite higher vehicle capital requirements, capital investment is lowest overall in the three-stream system due to the use of plastic bags and boxes in place of wheeled bins, and the reduced need for sorting facility investment.

Table 3-27: Capital Costs of upgrading the EPR with conventional DRS for all materials

	Mixed Dry Recycling	Dual Stream: Papers (Packaging and non-packaging) and Containers	Three Stream: Papers, Light Packaging and Glass
Capital Resources Required			
Small Collection Vehicles Required	180	202	234
Large Collection Vehicles Required	26	30	30
Glass Collection Vehicle	0	0	69
Haulage Vehicle	11	11	12
Wheeled Bin	1708k	2562k	870k
Communal Container	87k	87k	87k
Glass Box	0	0	1708k

[19] Linda Godfrey (2016) Approaches to EPR and implications for waste picker integration

	Mixed Dry Recycling	Dual Stream: Papers (Packaging and non-packaging) and Containers	Three Stream: Papers, Light Packaging and Glass
Single-use Sack	0	22M	67M
Sorting Capacity Required	199 kt	71 kt containers 131 kt cardboard/paper	43 kt plastics/metals 131 kt papers
Capital Costs			
Vehicle Capital	€25M	€28M	€37M
Container Capital	€42M	€57M	€36M
Sorting Facility Capital	€24M	€19M	€17M
Total Capital Requirement	**€90M**	**€104M**	**€89M**

Capital cost assumptions per unit are detailed in Appendix A.3.4

Reducing rural provision leads to a slight reduction in vehicle requirements and a larger reduction in the numbers of containers required, across each option.

The absence of a DRS increases the volume of material received by sorting plants but does not significantly increase the number of vehicles required, or the capital needed for sorting plants. With a DRS, the EPR-funded collection system contains a smaller fraction of valuable plastics, and it may be more effective to sort the remaining mix of plastics and metals in larger scale facilities.

Depending on how services are procured, the initial capital cost outlay may come either from private sector investment or municipal spend (and the annualised costs covered by ongoing EPR subsidies), or direct funding by the EPR. One sensible approach would be:

- Direct funding from the EPR to municipalities for initial provision and roll-out of containers, to gain economies of scale, lower transition costs for municipalities, and ensure coordination;
- Partial direct funding (on the basis of need) made available for municipalities to invest in required collection vehicles where local private sector capacity is lower;
- Private sector investment in vehicles, financing costs recovered through contracts for collecting recycling;
- Private sector investment in sorting facilities, financing costs recovered through contracts for the sorting of recycling.

3.10 Modelling Limitations

To undertake modelling of this magnitude, a number of simplifications are required. This section summarises some of the key issues and implications of our modelling approach.

3.10.1 Material Markets and Development of Recycling Capacity

The net cost of systems varies depending on the return from material revenues, which tend to fluctuate with the prices of virgin materials. However, material revenues are modelled at single values for the purposes of comparison.

Revenues for some materials depend on the presence and location of recycling operations. This is particularly the case for glass, which, due to its weight and low value per tonne, incurs high transports costs in relation to revenues depending on the proximity of glass reprocessors.

The collection of glass of a quality suitable for glass reprocessors that produce cullet for re-melt is a key differentiating feature between the three-stream collection compared to the other options, where glass is mixed with other packaging. There is a risk that, due to high transport costs, it may be more expensive to transport glass from some regions of the country to a glass processor than to use the glass in aggregate, which would mean that the potentially higher environmental benefit of collecting higher quality glass would not be realised.

The number of recyclers of some types of household plastic packaging waste are limited, due to technical challenges, higher costs and a lack of markets for their outputs at a price that can support recycling operations. There are not many recycling facilities in Europe that accept smaller flexible packaging, PET trays, or PP films. The EPR can specify grades of material to sort, and can seek to identify, contract with, or assist the development of plastic reprocessing operations that would expand the amount of plastic packaging that is actually recycled once collected. It can also seek, through eco-modulation of fees and design for recyclability criteria, to increase the proportion of plastic packaging that is economically recyclable.

Better resolution on the composition of the plastic packaging waste stream within Serbia would be needed to assess the appropriate scale at which to introduce specific, and the potential case for regional or national sorting facilities to sort, for instance, an HPDE/PP mix, or PP films from mixed film bales.

This uncertainty also affects the net costs of the system, as a higher quantity of hard to recycle and unrecyclable plastic packaging within the packaging placed on the market would lower the potential material revenues and the increase the costs of disposing of sorting residues.

3.10.2 Informal Sector Activity

The majority of household recycling collections are carried out by informal collectors. However, the significant number of unregistered individual waste collectors who operate in the informal economy do not report their collection rates or income. As a result, there is a lack of reliable data on quantities collected by the informal sector. However, we understand that the majority of the tonnage collected by the informal sector is brought to sorting centres run by collective schemes and is captured within SEPA's data on collected recycling. Current recycling performance figures may not, therefore, substantially underestimate tonnages actually recycled.

The recycling rates presented as being achieved by EPR collection schemes do not include the impact from any additional material that continues to be collected by the informal sector from mixed waste. As with the development of household recycling collections, the development of mixed waste sorting would formalise the recovery of another part of the material currently at least partially targeted and recovered by the informal sector.

3.10.3 Other Uncertainties within Modelling

No Serbia-specific compositions of household plastic packaging waste were available, so a European composition is used. This uncertainty also affects the net costs of the system, as a higher quantity of hard to recycle and unrecyclable plastic packaging within the packaging placed on the market would lower the potential material revenues and the increase the costs of disposing of sorting residues.

There was a low level of detail on municipal waste compositions on which to base packaging waste generation. If waste generation is more heavily weighted towards urban areas, overall costs would not differ substantially, though rural services would be less cost effective than modelled and urban services would be more cost effective.

There was little existing service data to benchmark efficiency performance of collection resources against. This is therefore based on Eunomia's collections logistics model and our extensive previous collection modelling experience. More efficient rounds with higher pass rates would lead to lower collection costs.

4.0 EPR System Design

4.1 Shared Cost or Full Cost

4.1.1 Background

A key driver for implementing EPR in Serbia is the EU Waste Framework Directive (WFD). While Serbia is not a member of the EU, it became a candidate for accession to the EU in 2012 and is on track for membership from 2025. In order to achieve this, Serbia will need to adopt EU law in full.

Under the Article 8a of the WFD, the default position with regard to EPR is that packaging producers should meet the full net costs of managing packaging waste. However, it is envisaged that in some circumstances it may be possible for the costs of meeting the targets to be met only in part by producers, so long as producers meet no less than 80% of the costs. The relevant text of Article 8a of the WFD is as follows:

> *"Where justified by the need to ensure proper waste management and the economic viability of the extended producer responsibility scheme, Member States may depart from the division of financial responsibility as laid down in point (a), provided that:*
>
> *(i) in the case of extended producer responsibility schemes established to attain waste management targets and objectives established under legislative acts of the Union, the producers of products bear at least 80 % of the necessary costs*

[…]

and provided that the remaining costs are borne by original waste producers or distributors."

While NALED has indicated that full cost recovery should be a guiding principle of this study, we recognise that this assumption needs to be explored, as does the scope of the costs that should be met by producers.

4.1.2 Analysis

From the point of view of achieving compliance with the WFD, the key question is whether the condition described in the quotation above, in which case it would be permissible for packaging producers to meet only 80% of the net costs of meeting the EU's waste management targets and objectives, applies to Serbia. (In addition to point (i) quoted above, there are two other circumstances where less than full net cost recovery is allowed under the WFD, but these apply only to targets set by the individual state, over and above those set out in EU legislation, and so are not applicable in Serbia's case). The remaining 20% would need to be met by distributors or waste producing companies and citizens, not from public funds.

In order for this exception to apply, Serbia would need to argue that deviating from full cost recovery would:

- Be more effective in helping to ensure proper waste management than full net cost recovery; and
- Be necessary in order to ensure the economic viability of Serbia's EPR scheme.

It is difficult to argue that, in a country like Serbia with limited waste management infrastructure, providing partial funding would be as effective as meeting the full costs, let alone more effective. If distributors (e.g. retailers) were made to meet the remaining 20% of costs, this would tend to dilute the financial incentive on producers to reduce the weight and improve the recyclability of the packaging they place on the market. Partial funding that relied on waste producers to meet the remaining costs would create a risk that the necessary services and infrastructure could not be put in place and would create incentives for households and waste producing businesses to seek to evade costs by relying on informal waste management routes. This lost material would make it more difficult to achieve the targets.

The question of whether full net cost recovery is economically viable for the EPR scheme appears to raise the issue of whether producers can afford to make sufficient contributions to meet the costs of the services provided under the scheme. It is difficult for Eunomia to provide a view on what is affordable for producers, but it is relevant to observe that in EU countries where the legislation is being implemented and where waste management costs are higher, full net cost recovery is being selected.

4.1.3 Necessary Costs

It would be unreasonable for producers to be required to bear greater packaging collection costs than are necessary, perhaps due to inefficient operations or poorly managed procurement processes. Where waste operators handle both packaging and non-packaging wastes, there is an opportunity for ambiguity in how costs – both operational costs and overheads – are attributed to

packaging waste. It will be important that the PRO in Serbia has effective systems in place to ensure that producers receive value for money from the services they fund.

The attribution of costs issue has been addressed in numerous ways. At one end of the spectrum, EPR schemes can work closely with municipalities and other waste operators, perhaps on an 'open book' basis, to agree the services to be offered and their cost – and then pay the agreed costs. At the other end, a formula can be used to calculate the necessary costs to be paid to municipalities based on data regarding the performance of efficient collections and typical values achieved through procurement processes.

Where a formula is used to establish the necessary costs, it may use known audited costs from municipalities deemed to be efficient and then use benchmarking techniques to predict costs for other municipalities with similar characteristics. Defining characteristics are often factors such as housing per km of road length, socio-demography, typical regional pay for similar driving/labour roles etc.

The system of payments may include an element that is set on a "per tonne" basis for each packaging type collected, to incentivise higher recycling rates, although it is important that the system recognises that there may be different costs involved in collecting from different areas.

4.1.4 Recommendation for shared cost or full cost

Based on this analysis, our central assumption is that producers will meet the full net necessary costs of recycling; however, NALED could seek to argue that distributors should contribute to the EPR scheme, creating a "shared responsibility" model like that seen in Ireland's producer responsibility system. This would not fundamentally change the operation of the EPR scheme but would mean that some of the resources were contributed from a different source.

It would be unreasonable for any future policy to attribute packaging collection costs to the producer that is unnecessary or associated with inefficient operations or procurement processes. In municipal collections, there is typically some ambiguity in attributing costs correctly between municipal collection services' operations, and overheads and other costs; thus, other EPR schemes have sought to address these issues.

The attribution of costs issue has been addressed in numerous ways. At one end of the spectrum, EPR schemes can help influence a municipality's costs, but then pays those costs. At the other end, a formula is used to calculate the necessary costs to be paid to municipalities based on efficient collections and effective procurement processes.

Where a formula is used to predict the necessary costs, it may use known audited costs from municipalities deemed to be efficient and then use benchmarking techniques to predict costs for other municipalities with similar characteristics. Defining characteristics are often factors such as housing per km of road length, socio-demography, typical regional pay for similar driving/labour roles etc. The resulting cost coverage may often be per tonne of each packaging type collected in order to incentivise higher recycling rates.

4.2 Roles and Responsibilities

In this section, we consider the key components of an EPR scheme and how the responsibilities of actors within the system may be best allocated. We summarise some of these arrangements for a selection of European EPR schemes. These are shown in **Table 4-3**.

In Serbia, municipalities are currently responsible for collecting, sorting and treating packaging waste from households, and are paid a small amount of the cost of these services from producers via the current EPR scheme.

In the following sections, we consider the pros and cons of the responsibility for different service provision aspects to remain with municipalities or be held by the EPR schemes. There are also likely to be responsibilities that fall to government (setting the rules, appointing the PRO(s) and carrying out enforcement where there is non-compliance from producers or waste generators).

4.2.1 Responsibilities for collection, sorting and reprocessing

The future design of EPR in Serbia provides the opportunity to achieve the future recycling targets at the most efficient cost for the nation by attributing responsibilities for the different stages of the recycling process (collection, sorting and reprocessing) to the entity most suited to discharge these responsibilities. This section of the report refers to some existing European EPR Schemes. It provides a rationale for what we believe are the best options for Serbia, given the potential advantages and disadvantages. In instances where producers (via PROs) do not provide a service, then the principle of the costs of recycling being borne by producers should prevail, and producers should pay for the costs of the services being provided by other entities.

4.2.2 Collection Responsibilities

There are two distinct options open to Serbia:

1) Municipalities remain responsible for collecting packaging recyclate;
2) Producers become responsible for directly arranging the collections of packaging recyclate, referred to as a “dual-scheme system”.

Most examples of dual scheme collections in Europe were developed when there were no municipal collections of packaging recyclate in that particular country.

Of the long-term established EPR schemes, Germany and Austria are good examples of the dual scheme approach. The EPR scheme comprises multiple PROs which operate their collection and sorting programmes. This can be contrasted with the schemes in Belgium and France, where municipalities provide the collections (and in some cases arrange the sorting) and a single PRO arranges payments from producer fees to municipalities (and sorters) for these services. Some of the key issues of relevance are highlighted in Table .

Table 4-1: Comparison between "Municipal Collections" and "Dual System".

	Municipal Collections	PRO Collections "Dual System"
Practicalities	Municipalities already have the collection infrastructure and arrangements to collect packaging materials, although improvements would be needed to meet the future targets. This infrastructure and arrangements cover: • Procurement and contracting; • Vehicles and workforce; • Facilities for the collection vehicles to operate from; • Call centres and communications programmes to facilitate service users engagement; • Locations for containers for packaging materials (alongside other municipal materials such as bio waste and residual waste) and cleansing arrangements for these facilities.	It would have to replicate all the infrastructure and arrangements that are already in place in municipal collections. Some of this replication would need to address relatively complex interactions with the remaining municipal services. E.g., space for packaging containment, how do service users engage with the collector with problems with the service, who is responsible for material set out for packaging collections that is contaminated or incorrectly set-out for collection.
Ability to meet Targets	In the future, country-level targets may be cascaded down to municipalities, so enhancing the recycling of all wastes, including packaging, will be important for municipalities to meet their targets. Government and municipalities can employ a wider range of actions than PROs would be able to, such as policies, incentives, regulatory activities information campaigns. Some practical examples are landfill/incineration taxes, pay as you throw systems, communications about how to use the recycling service, etc. There may be a need to sort and extract recyclables from mixed waste. Municipalities are responsible for all forms of collection and treatment, so they will be more able to strike an effective balance between separate collections and MSW.	In a dual scheme in Serbia, PROs may manage targets reasonably well at the currently applicable packaging recycling rates. However, at the higher targets, the simple provision of containment and collection opportunities is unlikely to achieve higher recycling targets without incentives to increase packaging recycling. The use of measures such as landfill/incineration taxes and bans would have no impact on dual systems unless producers also covered the full costs of residual waste collection and treatment/disposal. There may be a need to be sorting and extracting recyclables from mixed waste. PROs would only achieve an efficient outcome with the cooperation of municipalities and/or their contractors.

	Municipal Collections	PRO Collections "Dual System"
Producer Fees	This approach implies the least disruption to the existing situation. Municipalities will likely need to demonstrate that the costs they incur are 'no more than necessary'; i.e., ensure procurements are genuinely competitive, or for in-house provisions, that the service is benchmarked, or 'market-tested', periodically. Risk mitigation examples are available in similar systems (e.g., Belgium), whereby a representative of the PRO is entitled to sit on the tender Board for collection contracts. In practice, this might be more difficult in a situation where there are multiple PROs. The approach to covering "necessary costs" could be through assessing outcomes of procurements or through a formula-based approach. Note that producers would need to be given confidence that the services being put in place by municipalities could deliver the required level of performance. This is likely to require a revisiting of the minimum service standards set by central government.	If non-packaging paper/plastics was included: • municipalities could be charged a small sum for the service; or • contributions could be made from producers of the other products being collected (extending EPR beyond packaging); or • the service could be provided at no additional cost (e.g., non-packaging paper. With more than one PRO, a mechanism for 'apportioning' the overall costs of collection to each PRO would be needed. In some systems (e.g., Germany, Austria), this can lead to short-duration contracts, which could increase costs. Municipalities will still need to provide other (separate) collection services anyway, and indeed, the existing law requires them to do so. Producers may prefer a system where they feel more in control of the costs. However, in practice, the costs might be higher and introduce a layer of administration – in terms of procuring separate contracts.
Efficiencies	Municipalities have responsibility for implementing the requirements for separate collection, which is very unlikely to change. They make decisions regarding containment locations, collection vehicles and the majority of bulking and sorting infrastructure (which can continue to be used). The integration of collection responsibilities for residual waste, bio-waste and packaging streams can allow for more efficient design and operation of collection systems and ensure it delivers high performance. Cascading the national performance targets down to municipalities should make it more likely that packaging targets are met at the same time. By also allocating responsibility for collection municipalities, they could achieve the most efficient balance of separating fractions to separate collection versus separating from MWS techniques. For example, it might be more efficient to cease separate collection of some plastics and metals and remove them from mixed waste in the future.	As noted above, there might be separate providers of collection services for packaging and collection services for other waste streams in many cases. This has the potential to lead to coordination problems. The same contractor would be responsible for service delivery only by chance rather than by design. In general, all the packaging collections are likely to be operated separately from the rest of the municipal waste collection services. Duplication of resources and overheads is more likely. PRO operation of collections would require substantial liaison with municipalities over communications and locating containment where the locations are on municipality-controlled land. If there were to be a strict separation of some materials (such as packaging / non-packaging papers or plastics), this would result in a doubling of containers and collection passes. It seems more likely, though, that an agreement would be reached (see above) regarding financial transfers if producers took responsibility for non-packaging elements.

4.2.2.1 Recommendation for Collection Responsibilities

On balance, it would appear that the arguments in favour of continued municipality collections outweigh the arguments of implementing a dual scheme approach. The existing municipal collection infrastructure and procurement processes are likely to provide an efficient and effective collection system. Combined municipal responsibilities for collecting packaging waste with other municipal waste streams allow for a holistic approach across all municipal wastes, including potential collection system optimisation. Municipalities would need to demonstrate that the collection costs are necessary and then producers via a PRO would pay municipalities for the cost of collection.

The following aspects of the system will need to be addressed in the system design:

- Municipalities shall need to remain obliged by law to provide a packaging collection. Service standards such as coverage of scheme, minimum collection frequencies and so forth will need to be reviewed and refined to ensure that the collection services are likely to deliver the statutory recycling rate targets.
- To ensure producers only pay the "necessary costs" of collection, it will be important that checks and balances are designed into the system. Where municipalities elect to tender for their collection services, the PRO should have the right to advise on the procurement process and assist in developing procurement documentation and evaluation processes. These concepts exist in the Belgian EPR system. Where a municipality elects to provide the services themselves, either directly or through a municipality-owned company, they would need to demonstrate value for money.
- It will be important that municipalities are incentivised to design and operate systems that provide sufficient separation for recycling packaging materials to meet the higher recycling targets. This may occur by amending Serbian law to ensure that the recycling targets, defined by the WFD, are cascaded to municipalities. They would need to be highly effective in separating packaging fractions.

4.2.3 Sorting Responsibilities

4.2.3.1 Current Situation

In Serbia, municipalities are currently responsible for arranging the sorting of separately collected packaging and then their onward sale for reprocessing. Reprocessors and sorting facilities may benefit from revenues derived from agreements to sell PRNs to PROs. However, the magnitude of this revenue stream appears to be small, and in any case, subject to fluctuation in materials prices due to the inherent volatility of the secondary materials market.

4.2.3.2 Sorting Challenges that the EPR Scheme will Need to Address

Depending on the level of source separation implemented in the collection system, there is likely to be a need to invest in and develop the sorting plant infrastructure in Serbia in order to increase overall capacity to manage increased recycling tonnages. These investments may need to be in specific regional facilities, in order to ensure that there is sufficient and convenient capacity to meet the needs of all parts of Serbia, or to improve sorting to allow further separation of specific

packaging items that will need segregating if packaging targets are to be met and producers are to respond to producer fee modulation.

In the future, we also anticipate that further sorting of mixed waste will be required in order to extract further packaging material from the residual waste stream to meet the targets. This infrastructure does not currently exist, and an investment from producers is likely to be necessary to enable it to be introduced; however, such plant will process a good deal of non-packaging waste, and it would be appropriate – if feasible – for other sources of funding to partially support the operation of such facilities. Responsibilities and payments for packaging sorting will need to be designed so that capacity for both sorting streams is safeguarded.

4.2.3.3 Options for Responsibility for Sorting Separated Packaging

There are two primary options for responsibility for sorting:

1) It may be determined that municipalities should remain responsible for arranging sorting infrastructure. Municipalities discharge this responsibility by operating their facilities (those of their local authority companies) or tendering for service provision. The necessary costs incurred by municipalities for sorting packaging would then be paid to them by the PROs; or
2) It may be determined that producers (through the PROs) should be responsible for arranging sorting infrastructure. PROs would issue tenders for these services (and, in some cases, works contracts where necessary). Municipalities and private sector entities would be able to respond to the tender, either with existing facilities or (depending on the nature of the tender), with a proposal to build a new facility.

In both these options, we suggest that the producers (PROs) should own the sorted packaging fractions, which should be produced to specifications designed by the PROs. The specification should be built into the PRO tenders (in option 2) or arrangements with municipalities (in option 1).

Given Serbia's starting place, it is not obvious which of these options is preferable. Examples of both approaches exist in other EPR schemes. In the dual scheme examples of Germany and Austria, the PROs are responsible for arranging sorting facilities. In the municipal collections examples of Belgium and France, it is more typical that municipalities arrange sorting infrastructure.

Sorting plants of sufficient scale that can efficiently sort a wide range of products are needed to meet future packaging targets in Serbia, particularly in plastics. Serbia currently has many municipalities and only the largest urban municipalities produce sufficient quantities of packaging materials to build and operate sufficiently large plants to achieve economies of scale. A significant proportion of the remaining municipalities have to work in partnership through their own municipal companies to build and operate plants. The remainder rely on contracting to either municipal companies or private sector entities that have built plants. This situation has led to some areas that are well served with modern sorting facilities, and some that are not. If Serbia were to rely on municipalities to provide sorting facilities, it may prove more difficult to ensure that there is a good distribution of high quality, low-cost sorting facilities in future.

Table 4-2: Responsibility for sorting of separated packaging from separate collections

Issues	Primarily Municipality	PRO
PRO meeting targets	Risks of not meeting packaging recycling targets due to failures of sorting processes is dealt with in other countries, such as France, through municipalities having to provide sufficient capacity to sort the PRO specified fractions and achieving specified sorting efficiencies given the composition of plant inputs.	Under the Pro option producers may have more control over how much sorting capacity is brought on stream. Given that PROs will need to outsource sorting operations, they will need to secure sufficient capacity to sort the amount of material needed to achieve the future targets. These outsourcing contracts would need to address similar specification issues such as sorting efficiency as required under the municipality sorting option.
PRO only paying efficient "necessary costs"	Existing municipal facilities are likely to be relatively efficient and most sorting facilities are relatively modern. However, it will be important for a PRO only to be charged the "necessary" efficient costs of sorting. Some ways to safeguard this: • Municipalities being paid costs deemed necessary for the circumstances, not actual costs incurred; or • PRO's can ultimately take on responsibility in a municipal area if the costs were proven to be unreasonable.	It may appear that PRO responsibility should automatically lead to most efficient costs for the PRO through competition. However, this might not be the case. A PRO would outsource this service. Efficient results from outsourcing require reasonable competition. It is possible that there would be a lack of competition in some regions from time to time and, therefore, a lack of competitive pricing. This would contrast to costs under the municipality responsibility option, where the PRO would only have to cover necessary costs.
Raising capital for investments	Municipalities can raise capital for infrastructure, particularly where the costs of repaying that investment is covered.	There would be a reliance on private sector investment in response to PRO tenders. Private finance may be more expensive than public finance, increasing the cost of capital.

To meet the future packaging targets, producers will need a strategic network of sorting facilities for separately collected fractions with good geographic coverage and modern, efficient sorting to sort a wide range of fractions and deliver high-quality outputs. If a dual-scheme collection system is selected, it will almost certainly make sense for producers to be responsible for arranging sorting facilities. If municipalities are responsible for collections, then the decision around responsibility for sorting is more complicated.

In Belgium and France, where municipalities are responsible for the collection, they are also responsible for arranging/providing sorting. PROs pay municipalities the necessary costs for sorting, and sorting operations are conducted to PRO specifications with efficiency safeguards designed to protect PRO interests.

Table 4-3Table 4-3Table 4-3 shows that Belgium and France's packaging recycling rates are similar to comparable dual scheme systems. In fact, Belgium's recycling rate exceeds the others, yet

producer fees are no higher than those of the high-performing dual scheme systems. There is insufficient data to attribute cost performance concerning producer fees between collection and sorting costs. Still, it would seem reasonable to assume that municipality responsibility for sorting in these countries is no less financially efficient than in the dual scheme countries. The relatively high packaging recycling rates in these countries demonstrate that these arrangements have provided sufficient sorting infrastructure.

If Serbia adopted the approach of municipality responsibility for sorting separate fractions, PROs would need a framework of specifications for sorting operations to safeguard the reaching of the packaging targets. These specifications would need to be reasonable and achievable, and the PROs would need to cover the "necessary costs" of municipalities (and their contractors) meeting these specifications. These specifications would typically cover:

- The range of materials to be sorted to recycling grades (note that this range may need to expand in the future);
- The minimum sorting efficiencies, given the amount of recycling grade material in the inputs; and
- The quality of sorted recycling grades.

PROs would need to cover the costs of sorting all packaging, whether it is sorted to a recyclable grade or not. A potential advantage to PROs in placing the responsibilities for sorting separate fractions with municipalities is that material collected in separately collected packaging streams that are not packaging would remain the municipalities' financial responsibility. This offers a degree of risk transference – although producers would still be reliant on the municipalities MRFs and would experience difficulties if the costs of managing non-packaging streams affected the financial viability of municipal MRFs.

Many municipalities currently have good arrangements, either through their local authority companies or with contracts with the private sector. The network could likely be adapted to offer cost-efficient solutions in the future. PROs would need safeguards under this approach. The calculation of payments for "necessary costs" would need to be developed to ensure that PROs do not need to pay for inefficient sorting operations. Furthermore, it would seem beneficial to all parties to allow municipalities that cannot provide appropriate sorting facilities to be able to opt out of sorting responsibilities. In this event, arranging sorting for those municipality areas would need to transfer to the PRO, which would allow the PRO to determine where and how to commission the sorting services it requires.

Whoever undertakes the work of sorting packaging fractions from separate collection, would require an operational framework within which to work. The design of this framework (specifications and payment mechanisms) should ensure PROs only pay the "necessary costs" and achieve the recycling performance. It must also produce the necessary data in order to establish the amount of each material that is being collected and the proportion of that which is sorted for recycling. In examples such as Belgium and France, the following contractual features will typically be in place and acting upon a sorting operator:

- The specification would require specified fractions to be separated to agreed quality requirements;

- Material delivered to the sorting facility would be sampled according to a set methodology, and those samples would be hand sorted to give a reasonable composition (characterisation) of the incoming unsorted material to identify the quantity of different types of recyclable packaging, other recyclables and non-recyclable material it contains;
- The specification would require the operator to produce yields of specified fractions according to formulas applied to the composition of incoming unsorted material; and
- Typically, there would be financial deductions for failing to meet yield specifications or quality specifications for separated fractions.

The costs of sampling programmes and meeting the specifications would form part of the necessary costs and, therefore, be payable by PROs. These arrangements are also used in dual scheme examples where private sector organisations deliver sorting operations. It would therefore seem likely that any arrangements suitable for higher recycling rate targets would need to involve these sorts of arrangements, regardless of the allocation of sorting responsibilities.

We recommend that PROs should:

- leverage the existing municipal infrastructure, but recognise that this will need upgrading and expanding;
- have some control over where and to what standards new facilities are built; and
- have some level of cost control, which will necessitate establishing a mechanism by which to create some price pressure on their suppliers.

A model that might achieve this would involve:

- developing a sorting needs analysis and strategy;
- benchmarking sorting costs;
- creating clear standards that they need sorting facilities to meet;
- sourcing integrated collect/sort contracts with municipalities where possible (with clear separation of costs between the two elements), which would allow municipalities to offer as yet unbuilt capacity, not just existing infrastructure;
- look to stimulate/commission additional capacity where there are gaps, either by signalling to the private sector that there is a need (the strategy would do some of this work) or by commissioning facilities directly where the market does not respond; and
- developing a mechanism of cost control, which might be through competition (although this would be likely to necessitate some level of surplus capacity that might lead to inefficiency), or through a system that might involve benchmarking, open book accounting and cost capping.

4.2.3.4 Options for Responsibility of Packaging that is *Not* Separated through Separate Collections

To comply with Article 8a the costs of recycling packaging that is collected through separate collections should be met by obligated producers.

Article 8a does not directly allocate to producers the responsibility to meet the costs of managing packaging that is not separately collected. The aim of Article 8a is that producers meet the costs of collecting, treating and transporting packaging material wastes to enable recycling to the level required to meet the targets. Recitation 26 of the 2018 Directive says that EPR "should cover the costs necessary to meet the waste management targets and other targets and objectives, including waste prevention". The critical question should then be whether separate collections will meet the packaging targets. The packaging targets in the future are based on the new measurement method, and so current performance in any member state does not directly indicate the likelihood that the future targets could be met, since the current figures may not fully account for contamination and process losses[20]. We believe that – while separate collection is important to achieve high quality – for plastics, and possibly some other materials, meeting the targets solely through separate collection will be extremely challenging and potentially not cost-effective. If this is correct, Serbia's mixed waste sorting (MWS) infrastructure could play an important role in meeting future packaging targets.

Recitation 26 of the 2018 Directive states that EPR "should cover the costs necessary to meet the waste management targets and other targets and objectives, including on waste prevention". This is not limited to separate collection; indeed, waste that is prevented can hardly be separately collected. If it becomes clear that mixed waste sorting is necessary to meet the targets, then there is a good case that producers should bear at least a proportion of the costs.

In the event that MWS *is* necessary to meet the targets, Serbia could adopt several policy measures described below to ensure that sufficient capacity of this infrastructure is available in the future. In all cases, it is assumed that municipalities (or any other operator of a MWS plant) would remain responsible for the management of packaging that is not separately collected.

1) First, the EPR scheme could be required to make payments to the facilities according to the quantity of packaging material they extract. In Norway, for example, the PROs pay fees for the tonnage of material derived from MWS. There could be, as necessary, a quality adjustment to these fees, although the fees in Norway are equivalent to those applied for collection and sorting from separate collection systems; and
2) Second, the level of landfill tax and/or incineration tax could be set to disincentivise the landfilling or incineration of plastics once there is sufficient reprocessing capacity. Regarding incineration, a suitable means of applying a tax consistent with climate change objectives would be to set a fossil-derived CO_2 emission tax (as happens in Denmark). This tax would encourage separation of plastics from mixed waste before treatment/disposal;
3) Third, alongside the above, producers could be made responsible for the costs of treating/disposing of packaging found in residual waste. This would provide a financial incentive, in addition to the incentive to achieve the targets, to encourage them to fund the extraction of material from residual waste instead of paying for treatment/disposal;
4) Fourth, the government could mandate MWS (to a minimum standard) at the front end of all existing and new incineration facilities and landfills. As long as the payments referred to

[20] Up to 15% could be lost to contamination and process loss.

in point 1 above were high enough, producers' revenue streams could provide the payback mechanism for such a facility. Alternatively, the government could provide a more 'facilitative' approach whereby it encouraged dialogue between the EPR scheme and the operator of the incinerator or landfill, so as to ease the negotiation process between municipalities, waste contractors and the scheme.

Notwithstanding the case for MWS, the relevant EU Directives essentially mandate 'separate collection' of various packaging fractions, including paper and card, glass, metals and plastics. The SUP Directive is *lex specialis* in this regard (i.e., its provisions take precedence over the WFD and PPWD) and it appears to be almost certain that collections of beverage plastic bottles will only count towards the 90% collection rate target if they are collected separately from mixed wastes (although they may be collected mixed with other types of recyclable material, provided that certain criteria are met). They will not be collected as part of a mixed waste stream and separated subsequently.

The definition of separate collection within the WFD and PPWD does, however, allow for some derogations from the separate collection requirement if:

- it can be demonstrated that materials separated for recycling (from systems that are not separate collections) meet a number of quality tests; and
- the alternative system would not be more expensive.

Further details can be read in the EU guidance. The modelling carried out by Eunomia provides a basis on which Serbian authorities can reach a view on whether the criteria for applying a derogation in respect of separate collections of certain materials may be justifiable.

In summary, it is likely that only plastic beverage bottles collected via separate collections will be able to be counted towards the specific targets, but also that, for other fractions, systems that are not separate collections (e.g., MWS) can – and may need to – be used to supplement the material collected via separate collections in order to meet the targets in the PPWD and Waste Framework Directive.

4.2.3.5 Recommendation Regarding Sorting Responsibilities

The sorting responsibility for separately collected packaging should be allocated to municipalities, with some conditions to allow for a Producer Responsibility Organisation (PRO) to meet their reasonable requirements. Municipalities would have the option to opt-out of sorting responsibilities. Sorting responsibilities would then revert to the PRO (with an appropriate notice period). Collection entities would be expected to deliver minimum quality material to sorting facilities and be subject to pay deductions where the quality is substandard; and sorting facilities would be required to deliver, as outputs, materials of a grade suitable for onward reprocessing.

The approach to procurement would be designed to deliver, over time, a high-quality sorting infrastructure of appropriate scale and geographic distribution. Producers pay municipalities the necessary costs for sorting.

4.2.4 Material Sales Responsibilities

Serbia is in a similar situation to many EU Member States. For certain packaging materials and packaging applications (probably mainly plastics), there is a gap between reprocessor capacities

within the EU and the scale of capacity that needs to be available to achieve the recycling targets. The development of infrastructure to recycle sufficient material to meet the targets is an issue for producers and should be considered in the design of an effective EPR policy.

Serbia's future EPR policy will need to make producers responsible for the net costs of recycling separately collected packaging. The "net" element of this description means that costs are offset by the revenue received for recyclable materials when they are sent to reprocessors – or the costs of reprocessing, where materials do not have a positive value. It has been recommended within this report that the municipalities are given a clear responsibility for collection of household waste – and for sorting this material, where they have the facilities in place to do so – and they would therefore be paid the necessary costs related to this work. However, the question then arises as to whether municipalities should be responsible for arranging for the reprocessing of the separated recyclate and receive the income for this directly (this income being offset against the EPR payments they would receive) or whether the material should be owned and sold by PROs.

In Section 4.2.3.4 we recommend that a new EPR scheme considers payments to municipalities for sorting packaging from mixed waste, as this is likely to be necessary to meet the targets. Should this recommendation be taken forward, the recyclate captured through this method would be subject to the same principles and recommendations as packaging gathered through separate collections.

At present, Serbian municipalities own the separated packaging materials that they collect and are sent for recycling. In some cases, the municipalities pass on this responsibility to those who operate sorting facilities and thereby pass on the responsibility for selling the materials.

There are several issues with the current method of apportioning ownership of materials.

- Municipalities (or their sorting entities) are exposed to the price fluctuation for all separated packaging materials. This makes the business case for investments in collection and sorting infrastructure more difficult to justify.
- Europe and Serbia have a shortage of reprocessors for various plastics packaging to meet future targets, and in particular have:
    - too little capacity to reprocess the readily recyclable packaging such as PET bottles; and
    - no meaningful capacity to recycle more challenging packaging such as PET trays.
- For recyclers to invest in new capacity to meet the targets, they need a good business case showing that they will receive sufficient feedstock of material at sufficient quality, and that there will be a reliable end market. There needs to be a reasonable balance in price between the recyclate they buy and the secondary raw materials they manufacture and sell. For some currently challenging materials such as PET trays, a reprocessor would likely need to secure all the recyclates from the whole of Serbia (and possibly more) to achieve the necessary tonnage to make the business case for a plant economically attractive. It may therefore be necessary for Serbia to source some material from outside its borders if it wishes to be self-sufficient on infrastructure; or to secure capacity outside the country to reprocess these materials.
- Producers are the consumers of the secondary raw materials that are the outputs from reprocessors. Legislation and producer aspirations are driving increases in the recycled content of packaging, which is increasing demand for secondary raw materials, especially

plastics. For most packaging types, producers now want a ready supply of secondary raw materials at sufficient quality for their manufacturing processes. Producers of packaging that is currently difficult to recycle want to see investments in and development of reprocessing options.

While the current system is effective in finding end markets for materials, without the need for producers to be directly involved, it is questionable whether it will in future be effective in meeting producers' needs. If municipalities and waste management organisations continue to be responsible for material sales, they may have no particular incentive to sell material to Serbian producers, especially if there is significant demand from elsewhere. Further, if their net necessary costs are met, they may have little incentive to maximise material income, since higher incomes will lead to a proportional decrease in EPR payments. This would mean producers pay a higher net cost than is strictly necessary. It therefore makes sense for producers to maintain an interest in securing the best value from the materials sorted for recycling. Producers will also be interested in ensuring that high-quality materials are placed on the market to maximise the subsequent value from sorted recyclables, within reason.

Table 4-3**Table 4-3** shows that there are several different models regarding responsibility for sorting and ownership of recyclate in European EPR schemes. In the dual scheme collection examples (Germany/Austria), the ownership of recyclate is effectively with the PROs, but it is discharged in various ways through their contracts with sorters. In some cases, the sorters own the recyclate under their contract with the PROs. In other cases, the sorters sort the materials on behalf of the PROs, who retain ownership of the material. Focusing on municipal collections:

- in Belgium, the PRO responsible for packaging is Fost Plus, which owns the separated fractions.
- in the municipal collection example of France, the ownership and responsibilities for separated materials is complex. Municipalities and their sorters can choose to market material under several different models. Approximately half of the separated tonnage is marketed via Valorplast, a sister organisation to CITEO (the PRO). Offtake is guaranteed, and the value received is assured never to be less than zero value. The majority of the other materials are marketed through several different waste management federations. Although the PRO does not directly own the separated materials, they are influential on aspects such as reprocessor offtake and the development of new reprocessing capacity.
- There are few examples of approaches where producers effectively own the material throughout the process. One of these would be Petcycle in Germany, where DRS PET bottles are kept within a closed loop.

In cases where the PROs own the sorted recyclate, they are able to negotiate contracts with reprocessors to receive secondary raw materials to the quality required by producers.

While there may be few current cases where the ownership of recyclate resides with producers, it is recommended that this is likely to be the most appropriate approach within a full net cost recovery system in Serbia, depending on the priorities of producers. In the initial stages of operation of the EPR scheme, the producers may discharge ownership through arrangements with sorting entities, including municipalities. Ultimately, as the need for improved reprocessor capacity influences the system, PROs can strategize over their future reprocessing needs and let contracts to reprocessors that will enable them to make the necessary investments into

reprocessing infrastructure. If the ownership of recyclate were to be left with municipalities, the resulting tonnages would be fragmented across Serbia and beyond and it will be more difficult to produce a coherent national strategy for investing in reprocessing infrastructure or to source secondary materials from within Serbia for the use of Serbian industry.

The value of recyclables is driven by changes in the balance of supply and demand. In most cases, unless there are (as is the case for food-grade recycled PET) targets and/or solid commitments to increase the use of recycled materials, then the prices paid for secondary materials tend to follow the prices paid for primary ones. Municipalities (or their contractors) have relatively fixed collection and sorting costs over the short-term. They have no reasonable way of influencing the supply of recyclable materials, especially where they have obligations to meet recycling targets. They are, therefore, vulnerable to fluctuations in the prices paid for recycled materials. The concept of full net cost recovery should change this. In principle, as the prices paid for secondary materials rise or fall, the net costs, and the fees paid by producers, should also vary so as to offset the lost material revenue. Municipalities and/or their contractors should not be exposed to this risk in future, which will provide greater certainty for them and enable long-term investment.

Producers are far more suited as the appropriate entities to deal with the risk of commodity price fluctuations. To the extent that secondary material prices follow primary ones, when primary material prices are high, the value of secondary materials is likely to be high also, reducing the net costs that producers need to pay for waste management at times when their raw material costs are higher. The opposite also applies: when primary material prices are low, the secondary material prices will also be low, and the net costs of recycling will be higher. However, with a larger share of raw materials coming from secondary sources, whose costs of production are relatively consistent, the effect may be to somewhat lessen material price variation for packaging inputs.

Additionally, the aggregation of larger quantities of recyclables may make it possible to negotiate better terms for the onward processing of materials that have been sorted for recycling. Significant economies of scale are possible when PROs are responsible for trading recyclables, as they will be dealing with a significantly higher tonnage than individual municipalities. This should allow for better prices to be achieved for the materials which are being marketed, for example by supplying the needs of larger producers than a single municipality could do on its own. With this ownership structure, it would also seem more likely that producers can shape arrangements so that reprocessors' secondary raw materials are suitable for the same producer manufacturing chain.

In the event that the PRO does not take responsibility for sales, it will reduce the direct costs of the PRO (because it will not need to maintain a materials marketing function). However, leaving sales to third parties may ultimately lead to greater costs and a diminution of material income and thus an increase in the net costs of the system. This is because the EPR system would then need to fund the activities of multiple material sales functions within different collectors; and because it is likely that not all such sales functions will be equally effective at securing the best price for materials – not least because they are assured of having their net costs met and will be less motivated to achieve the best possible price.

4.2.4.1 Recommendation Regarding Material Sales

In summary, in Serbia's EPR scheme, commodity (materials) price risk will sit with the producers, regardless of who is responsible for undertaking materials sales activity. There are arguments for leaving responsibility for undertaking material sales with municipalities and waste operators. However, there appear to be greater potential advantages in producers taking more active control over the sale of materials, as this may give rise to higher sales prices and the opportunity for greater co-ordination of the sale of secondary materials to ensure that there is adequate supply to meet producers' requirements. Where one or more PROs are in control of the terms upon which recyclables are sold, this may also create a better investment framework for sorting and reprocessing infrastructure.

4.2.5 Who Pays?

In many countries, current producer responsibility schemes focus on consumer packaging. Often, only producers (brands) and retailers (some of whom have their own branded products) and importers of packaged products and distance sellers have to pay fees. However, if a scheme is to cover all packaging (as required in the PPWD), then there may be an argument for including, as producers and fee-payers, all parts of the packaging supply chain. This approach has been adopted in Ireland under the principle of 'shared responsibility'. Under this scheme, those in the packaging supply chain pay different shares of producer responsibility costs.

There is a linked question regarding how data is to be acquired, so as to include all packaging and all businesses. Collecting and auditing data from all relevant businesses may be a major task unless the data capture system for waste management is upgraded significantly. The alternative would be to limit – as happens in many other countries – the attention to consumer/sales packaging, limiting the number of producers contributing fees, and simplifying data capture for what is covered by EPR. However, this would leave open the question of how producers should support recycling packaging's full net costs outside the EPR scheme.

These questions are essential in the design of the scheme as a whole. They are necessary to ensure that the performance data for packaging waste in Serbia reflects all packaging, not only consumer/sales packaging. One possibility would be to follow an approach similar to that of Belgium, where two PROs operate in different arenas[21]. Another concern is that commercial/industrial collected material tends to be of higher quality than household waste, as it is more homogenous and generally cleaner. This single PRO can ensure that each producer pays the full net costs according to the quality of the material, and not more.

[21] Fost Plus covers consumer/sales packaging, whereas Val-i-Pac covers packaging waste collected from commerce and industry.

4.2.6 Role of Government

While it is commendable that producers are taking such a major role in developing proposals for EPR in Serbia, there are important roles that only Government can play. In this section we describe briefly some of the activities that Government is likely to need to carry out in order to enable EPR to be implemented successfully, enabling it to achieve substantial change in recycling performance in Serbia.

The Government will need to provide an appropriate legislative framework that will ensure all actors influencing collection will contribute to reaching recycling targets. The government will need to coordinate the creation or appointment of an entity to act as the PRO and ensure appropriate coordination amongst all stakeholders is carried out through the PRO. The legislative support will need to include:

- Setting the targets that the Serbia will endeavour to meet;
- Designing and consulting upon legislative changes necessary to implement the EPR scheme to give responsibility to producers for meeting the packaging targets and to ensure that all producers (subject to any de minimis threshold) must contribute their fair share and to define a system by which payments to municipalities are determined;
- Designing and consulting upon legislative changes necessary to implement the DRS (if this option is selected);
- Putting in place the legal arrangements for producer responsibility schemes, including the legal responsibilities and status of the PRO(s) and (if applicable) the Scheme Administrator for the DRS;
- Following consultation, placing relevant duties on:
    - municipalities to implement dry recycling collection services that meet a prescribed standard consistent with meeting the targets;
    - householders to separate their waste;
    - producers, waste collectors, sorters, reprocessors and exporters to report the quantity and (where relevant) composition of the material they handle; and
    - relevant public bodies to undertake enforcement to ensure that new (and established) legal obligations are fulfilled. This should include consideration of how their performance of new duties will be funded.

Once the overall legal framework has been established, the government will have a continued role in:

- Considering whether additional legislation is needed to achieve the required level of progress. This might include:
    - Taking further action to deter illegal dumping and the operation of low quality dump sites;

    - Placing additional duties on municipalities and householders[22] to separate additional streams of material (e.g. food waste);
    - Placing duties on businesses and their waste collectors to source separate material for recycling, and considering what role producers may have in funding collections from businesses;
    - Taking action to limit residual waste, which may include:
        - Encouraging/requiring municipalities to limit the effective weekly amount of residual waste household can present;
        - Allowing or prescribing charges (or higher charges) for residual waste;
        - Implementing a landfill tax;
        - Implementing an incineration tax, which could be set based on the fossil-derived CO_2 emissions from an incinerator. This would encourage separation of plastics from mixed waste before treatment/disposal.
- Ensuring that planning legislation allows for and encourages the development of the necessary infrastructure;
- Ensuring that there are opportunities for people to train for new roles that may be created within the EPR scheme (which may range from truck drivers to waste composition analysts to data auditors);
- Monitoring progress towards the targets, including ensuring that relevant statistics are published to ensure transparency; and
- Considering whether further action should be taken to ensure that the targets are met.

The government may also have a role in ensuring that the wellbeing of the informal sector is taken care of, which may involve protecting a (perhaps more limited) role for its participants, or putting in place schemes to enable them to retrain for new opportunities in the sector.

Table 4-3 Summary of current European EPR systems

	Belgium	France	Czechia	Germany	Austria	Lithuania
Single/ Multiple PROs (Household/Municipal derived packaging)	Single - Fost Plus	Single – CITEO	Single- EKO-KoM	MULTIPLE - 9 PROs (market shares of lightweight packaging for 4th quarter 2019): BellandVision GmbH (17.87%), Der Grüne Punkt – Duales System Deutschland GmbH (DSD) (31.47%), INTERSEROH Dienstleistungs GmbH (23.83%)	MULTIPLE - 6 PROs, which are being coordinated by a central body (VKS) to ensure competition is fair: ARA Altstoff Recycling Austria AG is the largest one. Only one PRO addresses C&I.	MULTIPLE: Believed to be 3 PROs, Žaliasis taškas (Green Dot) is the largest PRO with 70% market share
Single/ Multiple PROs (C&I derived packaging)	Single - Valipac	Single				
Entity lawfully responsible for providing collections	Municipalities			PROs		
Sorting responsibility	Municipalities tender contracts or provide service			PROs contract sorting facilities		
Ownership of Sorted Recyclables	PRO	Ownership is municipality / sorter, but with assistance in marketing material.		Essentially the PRO, though often discharged to the sorter	Essentially the PRO, though often discharged to the sorter	
Estimated Producer Fees (Euros)						
Approx. weighted producer fee	101	129	105	435	208	81
Recycling Rates (2017)						
Overall (%)	84	68	74	69	66	59

5.0 Definition of Overall Preferred Solution

Based on the analysis carried out, the following recommendations are made regarding the preferred solution.

5.1 EPR Operational Design

Regarding the options for the collection systems to be implemented under a refreshed EPR scheme, it is recommended that:

- **Coverage.** A comprehensive packaging recycling system should be made available to **all households** within Serbia. Door-to-door collection services **should be provided in rural areas**, as this would deliver a meaningfully greater recycling performance that will contribute to meeting the targets (especially the plastic target) and thus justifies the relatively modest additional cost.
- **Collection system.** Alongside a DRS, a **dual stream** collection system should be implemented, collecting one stream of plastics, metals, cartons, and glass, and another stream of paper and cardboard.
    - This provides a cost-effective system that delivers the large majority of the available environmental benefit, and preserves material quality for films and papers.
    - With a high proportion of glass captured into the DRS, a separate glass collection is costly and the additional environmental benefits are low.
    - If no DRS, or a DRS with limited scope, were to be implemented, there would be greater benefits (particularly for recycling targets) from a separate glass collection, and a three stream system might then be preferable.
    - The inclusion of non-packaging papers, due to the revenues obtained from the material for minor additional collection costs, is a net benefit to system costs for cardboard and paper packaging. There is the additional potential that a contribution to the scheme for the collection and recycling of non-packaging paper could be sought in future, reducing packaging EPR costs further.
- **Mixed waste sorting.** EPR subsidies should be made available for the recovery of material from mixed waste as mixed waste sorting may be necessary to meet packaging recycling targets. The business case for modern mixed waste sorting plants should be assessed to identify the additional policy support and conditions that would be needed, alongside EPR fees, to ensure that mixed waste sorting facilities are viable.
- **Wider waste policies.** Alongside the roll-out of recycling collections, the Government should consider enacting an accompanying set of waste policies. One priority would be to deter the use of residual containers for recyclable packaging waste. This might be via direct measures (e.g. requiring certain levels of charges be applied to residual waste collections, prescribing a low effective

weekly volume of residual waste a household may have collected) or indirect ones (e.g. giving municipalities powers to fine people who put recyclable items in the residual waste, setting a level of landfill tax and/or incineration tax that disincentivise disposal of packaging materials).

- **Communications and Enforcement.** To ensure the high participation and capture rates modelled for the different recycling systems, there will need to be additional communication and enforcement. It is reasonable that these costs, insofar as they are necessary to meet the targets, should be borne by producers.

5.2 EPR System Design

It is recommended that the design of an EPR system for the Serbian context should have the following features:

- **Cost recovery.** Producers should cover 100% of the net necessary costs of the disposal/recovery of packaging waste fractions.
  - This approach is the only one that will ensure that there is funding for an adequate collection and sorting system of packaging waste from residual waste, which will be necessary to meet future targets;
- **Cost coverage.** In order to properly incentivise the switch to more recyclable packaging and ensure brands are not harmed by being associated by litter, costs that are met by producers should extend beyond the minimum requirements of the Waste Framework Directive to include:
  - The costs of managing the remaining packaging within residual waste; and
  - The costs of clean-up of all littered packaging, rather than this requirement being limited to certain single-use plastic (SUP) items specified in the SUP Directive.
- **Collection.** Municipalities should maintain responsibility for collection of household waste but the design of collection services should be aligned to a national service standard.
  - Changing the current responsibility would risk creating inefficiency and potential problems of coordination in delivering the collection service;
  - Municipalities that demonstrate that their services are being operated efficiently should have their collection services fully funded; and
  - Producers should encourage efficiency by paying municipalities only the "necessary costs" of collecting packaging, which may be established through benchmarking or modelling.
- **Sorting.** The responsibility for sorting separately collected packaging should generally sit with the municipalities that collect the material, with some conditions to allow for a Producer Responsibility Organisation (PRO) to meet their reasonable requirements.
  - Municipalities should have the option to opt-out of sorting responsibilities. Sorting responsibilities would then revert to the PRO (with an appropriate notice period);

    - Collectors should be expected to deliver a minimum quality of material to sorting facilities and be subject to pay deductions where the quality is substandard; and
    - Sorting facilities should be required to deliver, as outputs, materials of a grade suitable for onward reprocessing. The approach to procurement should be designed to deliver, over time, a high-quality sorting infrastructure of appropriate scale and geographic distribution. Producers should pay municipalities (and private sector sorters, where applicable) the necessary costs for sorting.
- **Material sales.** The responsibility for arranging material sales should sit with producers. Within an EPR scheme, the producers, or those acting on their behalf, have the greatest incentive to realise the maximum value from material sales, can build expertise in sales and can minimise the cost of sales by selling frequently and in volume. Where one or more PROs are in control of the terms upon which recyclables are sold, they ought to be able to create a better investment framework for sorting and reprocessing infrastructure.
- **Governance.** There appear to be few advantages to a system with multiple competing PROs that cannot be achieved through a well-functioning single PRO. A single PRO also reduces the administrative costs of the system over all. The PRO must be transparent about its costs and the results it achieves and must be responsive to the needs of stakeholders. The legislative framework must put regulation in place to minimise the risk of collusion and monopolistic behaviour.
- **Legislation.** The Government of Serbia should take the lead on preparing and consulting upon the necessary legislation to implement the EPR system and to set the responsibilities and roles of all actors within the waste system. It should also put effective enforcement systems in place to help ensure compliance.
- **Transition.** The transition from the existing system to the new one will take time for adjustments, and there are contractual relationships that will be affected. The earlier decisions are taken, the longer the period for adjustment and the less problematic and costly the transition is likely to be.

6.0 Deeper Analysis of Preferred Option

6.1 Introduction

In section 5.0 above, it is recommended that Serbia adopts a dual stream system for packaging waste collection, based on modelling analysis of the likely costs and performance of different collection options. In this section, we provide further analysis to:

- test the robustness of the collection system recommendation (dual stream with DRS including glass) against the main identified alternative (three stream with DRS excluding glass) (section 6.2), compared to a hybrid system of implementing separate glass collection in cities only (6.3), and against sensitivities in the assumptions within the model (6.4);
- outline risks to system implementation (section 6.5); and
- present a high-level implementation plan (section 6.6).

6.2 Full System Comparison Including DRS

In section 5.0, different collection systems were compared on the assumption that a DRS would be implemented that would include all single use glass beverage containers, including wine and spirits bottles. However, were glass to be excluded from the DRS, it would substantially change the volume of glass available at the kerbside and might make a separate glass collection a more attractive option. The larger volume of glass would improve the logistics of a separate glass collection, while in the absence of a DRS a separate glass stream, which would be likely to give rise to reduced sorting and processing losses and a greater volume of glass suitable for closed loop recycling.

This section compares whole system costs and performance of these two approaches to capturing glass:

- A deposit scheme with the full range of glass in scope, with dual stream EPR collections (recommended option); and
- A deposit scheme without glass in scope, with three stream EPR collections (the main alternative).

Our analysis, the results of which are presented in Table 6-1, indicates that, so long as there is a recycling route for glass sorted from MRFs, the glass packaging recycling rate exceeds the future target under the recommended option. Under the main alternative, it appears unlikely that a 75% glass packaging recycling target would be met. Including glass in a DRS is therefore likely to be necessary to reach the targets.

Table 6-1: Whole System Performance Comparison

	Dual Stream; DRS with glass	Three Stream; DRS without glass	Difference
Glass Packaging Sorted for Recycling Rate	78%	62%	-16%
EPR Recycling Net Collection Cost per Household	€ 7.4	€ 9.2	€ 1.8
DRS Recycling Net Collection Cost per Household	€ 10.1	€ 8.5	-€ 1.7
Residual Disposal Cost Saving per Household	-€ 2.4	-€ 2.3	€ 0.1
System Net Cost per Household	€ 15.1	€ 15.4	€ 0.3
Net GHG Emissions Savings from Recycling per Household	-51.5 kgCO2e	-51.2 kgCO2e	0.3 kgCO2e

The full system cost and benefit comparison, presented in Table 6-2, shows that the recommended option also results in lower net system costs than the alternative with glass not included in the DRS. This is because, while the additional cost of integrating glass collection in the DRS is comparable to implementing a full household glass separate collection, the additional system revenue from unredeemed glass deposits helps to offset the DRS costs[23].

Our analysis also indicates that the recommended option results in greater GHG benefit than the main alternative. GHG emissions savings are only modelled where glass is re-melted for container glass or insulation. Though less glass is recycled under the main alternative approach, the majority is assumed to be used for re-melt. As a result, there is greater GHG benefit from glass recycling in the main alternative than in the recommended option, since in the latter MRF glass (one third of glass recycled in that option) is assumed generally to be used for aggregate. However, the GHG savings per tonne of glass recycled are relatively small, and therefore the GHG emissions from the additional vehicles required to collect glass from households separately in the main alternative more than offset the greater GHG emissions savings delivered by the additional re-melt recycling it achieves.

[23] See DRS report for assumptions

Table 6-2: Annual Cost Difference Breakdown, €Million

	Dual Stream; DRS with glass	Three Stream; DRS without glass	Difference
EPR Collection Cost, €M	26.46	32.15	5.69
EPR Sorting Cost, €M	5.41	4.83	-0.58
DRS Costs, €M	40.95	35.27	-5.68
EPR Revenues (Glass Only) , €M	-0.17	-0.83	-0.66
DRS Revenues Glass, €M	-0.75	0.00	0.75
DRS Unredeemed Deposits, €M	-0.59	0.00	0.59
Glass Residuals Disposal Cost, €M	0.48	0.81	0.33
Total Cost Difference, €M			**0.43**
Net Cost Difference, €/hhld			€0.17

Following this additional analysis, the recommended option therefore remains preferable to any of the alternatives considered.

6.3 Separate Glass Collection in Cities

Collection costs are generally lower in urban environments than in rural ones due to households being closer together. This improves collection logistics – more time is spent emptying bins and less time driving between properties. Implementing separate glass collections only in cities would ensure a portion of the non-beverage glass was captured at a higher quality, whilst not increasing total costs to the same degree as a universal three-stream system. However, doing this would go against the principle of provision of consistent, universal recycling collection, and would not lower sorting costs substantially as the majority of MRFs would need to be designed to accept recycling that includes glass.

The risks to glass recycling performance and system costs associated with the quality of glass material sorted from MRFs are outlined below in section 6.4.1. Collecting a portion of glass separately would mitigate against these risks.

As shown in Table 6-3, an “urban only” system of separate glass collections would lead to costs and benefits sitting between the two-stream and three-stream scenarios already analysed. Separate glass collections in city municipalities, which account for 64% of

households[24], would allow over half of kerbside glass to be collected separately at a higher quality than the dual stream output. This would ensure that this portion of material could be counted fully towards recycling rates and provide maximum environmental benefit, whilst reducing the amount of MRF glass that has greater risk of being unable to find a market (other than for aggregate).

The net cost of the urban-only glass collections adds €0.80 to the annual cost of recycling collections per household, with the total cost (€8.2) falling half way between the two-stream and three-stream options, for collections covering 64% of households. However, the net additional cost per additional tonne of GHG emissions savings remains high, at over €1,100/tonneCO2e.

Implementing separate glass collections just in Belgrade would be more cost efficient, adding just the equivalent of €0.2 per household nationally (or €0.6 per household in Belgrade). This is likely more reflective of the costs and benefits of implementing glass collections solely in dense urban areas. The net additional cost per tonne of GHG emissions is considerably lower but still sits at a calculated €500/tonneCO2e.

Table 6-3: Separate Glass Collection in City Municipalities Sensitivity

	Dual Stream	Three Stream	Hybrid (Glass collections in Belgrade and Other City Municipalities)	Hybrid (Glass collections in Belgrade only)
Recycling Rate of Glass Packaging	78%	79%	78%	78%
GHG Benefit from Recycling (Kg CO_2 per Hhld)	-31.2	-33.1	-32.2	-31.5
GHG Impact of Collection, Transport and Sorting (Kg CO_2 per Hhld)	9.1	10.0	9.5	9.2
Net GHG (Kg CO_2 per Hhld)	-22.1	-23.2	-22.8	-22.3

[24] SEPA (2019) Packaging and Packaging Waste in the Republic of Serbia Annual Report

	Dual Stream	Three Stream	Hybrid (Glass collections in Belgrade and Other City Municipalities)	Hybrid (Glass collections in Belgrade only)
EPR Cost of Collection and Sorting per Hhld	€12.8	€14.5	€13.6	€13.0
Material Revenue per Hhld	-€5.4	-€5.5	-€5.4	-€5.4
Residual Disposal Cost Saving per Hhld	-€1.9	-€1.8	-€ 1.8	-€ 1.8
Net Recycling Collection Cost per Hhld	€7.4	€9.0	€8.2	€7.6
Cost of GHG Emissions Savings (€/tonne)	65.7	78.8	72.0	66.9
Marginal Cost of Additional GHG Emissions Compared to Dual Stream	n/a	€1,424	€1,111	€535

So long as MRF glass can be recycled, the recycling and environmental benefits for urban glass collections do not provide a clear justification for the additional system cost.

The cost of separate collections would be reduced further were communal/bring site containers to be used to provide services to urban households for collection of glass, instead of individual kerbside containers. However, this approach would be likely to yield a lower recycling rate than can be achieved through door to door collection.

6.4 Sensitivity Analysis

To test the robustness of the selection of the preferred option, the following section explores some key sensitivities that could affect the order of results.

6.4.1 Glass Recycling Variations

When glass is collected with other packaging materials rather than in a separate stream, the sorted glass from the MRF is not suitable for use to make new glass containers without further sorting and cleaning steps. The glass is typically crushed during

compaction in the collection vehicles, resulting in a larger quantity of glass fines and a lower average particle size (below the input specification for most glass processors producing a furnace-ready cullet).

The availability of different markets for this glass, and the material revenues obtained for MRF-sorted glass, will have an impact on the comparative recycling and cost performance of the dual stream collection system compared to collecting glass separately.

Under the preferred dual stream option modelled above (with wines and spirits in scope of the DRS), in the region of 23kt of glass would be processed out of Serbia's MRFs, compared to 33kt collected through the DRS.

This sensitivity analysis explores in more detail the different potential outcomes for the glass stream, and the implications for recycling, environmental, and cost performance.

The main uses of recycled glass in Europe are:

- Re-melt for new container manufacturing, which requires colour-sorted cullet;
- Re-melt for glass wool or glass fibre insulation, which requires clean but not colour-sorted cullet;
- As aggregate for use in construction, mixed with other materials.

Additionally, some cleaned crushed glass is utilised in filtration media and in sandblasting.

Central Case Presented

In the preferred option modelled above, the MRF costs already included involve processing the glass sufficiently suitably for use as aggregate. It is assumed that local aggregate uses for this material are developed, as they have done in other regions (US, UK, France) with MRF-output glass. Though there are limits to the demand for such material, the output is of a small enough scale to be relatively confident this material could be utilised.

Though not displacing the use of sand in the manufacture of new glass, the use of glass for aggregate is classed in Europe as a recycling operation, though a lower quality route. No GHG benefit is associated with this recycling.

No End Markets Sensitivity

In the first glass sensitivity explored, it is assumed that no aggregate market for MRF glass develops in Serbia, and glass from MRFs is instead sent to landfill.

If glass sorted from MRFs were to be disposed rather than recycled, the glass recycling rate would drop to in the region of 53%. (If separate glass collections were provided in cities, the drop in the recycling rate would be less, to 67%). Since there is no additional GHG benefit associated with glass aggregate recycling, the net GHG benefit does not change, but system costs increase by €0.5M due to additional disposal costs.

Cost of Recycling Sensitivity

In the second glass sensitivity explored, it is assumed that instead of receiving a very small revenue per tonne for MRF glass output, a price in the same region of the disposal cost needs to be paid in order for the construction industry to integrate the MRF glass output. Since there is no additional GHG benefit associated with glass aggregate recycling, and the cost of recycling is the same as the cost of disposal, the financial and environmental outcomes are the same as the 'no end markets' sensitivity, but the glass recycling rate target is met. This narrows slightly the cost difference between the dual and three stream options, but the net additional cost is still large at €4.1M or €1.65/hhld.

Additional Glass Cleaning Sensitivity

In this option, glass from each sorting plant would need to be transported to a central cleaning facility, where additional cleaning steps (using a combination of manual quality control, air flow, magnets, eddy currents, and cullet drying) can be applied to the MRF-sorted glass to make it suitable for use in applications such as making glass wool or glass fibre insulation, or for use in filtration media or sand blasting, where the smaller particle size and lack of colour sorting are not an issue.

Additionally, the larger sized cullet (in the region of 1/3 of the input glass) can be screened and colour sorted for use in container remelt, with the addition of sizing screens and NIR colour sorters.

The Glass Recycling Coalition in the USA has awarded nine 'gold star' status to MRFs who have additional equipment and/or operational procedures to clean up glass collected in mixed recycling suitable for a mix of container to container and glass insulation. Most use a further glass cleaning facility in addition to initial clean-up steps within the MRFs, and the smallest operation in receipt of a gold star award processes 30kt of glass per year.

The scale of the tonnage involved and the distance to potential glass recyclers makes this option expensive (the closest manufacturing locations of glass insulation products identify by internet desk research are Czechia and Italy). There is also a small additional energy demand in the additional processing steps, which offset the additional recycling benefit.[25]

However, if there were no demand for glass aggregate, these clean up steps could recover 30-50% of cullet for use in glass remelt, with the remainder mixed colour fines suitable for use in insulation. Considering the higher revenues obtained, the cost of glass clean-up and additional haulage would need to reach €230 per tonne of glass recycled to be more expensive than a separate household glass collection. Glass clean-up processes

[25] This additional energy demand is modelled as equivalent again to the energy use per tonne of an automated MRF. A level of sorting and cleaning energy use is already included in the carbon benefit ascribed to glass recycling.

are implemented, commercially, at a scale of 30kt in the US, and so must operate at a cost considerably below this cost. A highly conservative cost of €150/tonne is assumed for the below assessment.

Such an operation would not be commercially viable without sufficient levels of EPR support, so would need to be centrally funded. It is also unlikely that this kind of operation would be viable with only the glass collected in smaller towns and rural areas.

Table 6-4: Glass Markets Sensitivities

	Three Stream	Dual Stream	No End Markets	Cost of Recycling	Additional Glass Cleaning
Recycling Rate of Glass Packaging	79%	78%	53%	78%	78%
GHG Benefit from Glass Recycling	-12,581	-7,737	-7,737	-7,737	-11,769
GHG Impact of Collection, Transport and Sorting	21,860	19,799	19,799	19,799	20,537
Net GHG Change from Three Stream		**2,783**	**2,783**	**2,783**	**-512**
EPR Cost of Collection and Sorting	37.0	31.9	31.9	31.9	31.9
Additional Glass Clean-up					3.3
Material Revenue from Glass (EPR)	-0.4	0.0	0.0	0.5	-0.4
Municipality Disposal Cost Saving	0.4	0.5	1.0	0.5	0.5
Net Cost Change from Three Stream		**-4.6**	**-4.1**	**-4.1**	**-1.7**

In conclusion, the risk that no markets develop to utilise glass aggregate is a risk to achieving the glass recycling targets, but the likelihood of this is low. Furthermore, if no aggregate market can be developed, it is very likely that the additional costs of a glass

cleaning facility and potential onward haulage costs would still be lower than the additional cost of implementing separate glass collections, at a lower net environmental impact.

However, if no market within a plausible transport distance can be identified or developed at all for anything other than container grade cullet, the option would remain to exclude glass from the door-to-door collection system, and set up a lower cost bring site network to collect a portion of the remaining non-deposit glass.

Therefore, the following are recommended:

- Further engagement with industry about the potential to utilise recycled glass in aggregate;
- Further exploration of the business case for a glass clean-up facility located within Serbia, including identification of potential off-takers for recycled glass for uses other than container manufacture.
- If no route to a glass market can be identified for anything other than cullet, implementing a bring-site based separate collection of non-deposit glass to minimise cost and GHG emissions from additional vehicles.

In light of the analyses carried out in the preceding sections, separate glass collections, whether for all households or urban households only, is still only recommended for Serbia if:

- Additional glass recycling is required in order to meet wider national recycling targets;
- Producers, or the Serbian Government, place an emphasis on circular resource recovery as a primary policy goal for glass, justifying the higher costs of separate collection; or
- As a fallback option in the event no viable markets can be identified for uses of recovered glass other than in remelt for containers.

6.4.2 Including Mixed Waste Sort

Mixed Waste Sorting (MWS) would allow more material to be recycled instead of sent for residual disposal. This would have environmental benefits and also help to meet packaging waste targets. However, MWS adds additional cost and would not be financially viable without a tax on residual disposal.

Using Eunomia's MWS model, we estimate the amount of recycling that could be recovered and the costs to process the residual tonnage. The overall packaging recycling rates under the EU measurement are shown in Table 6-5. Glass is not included as the output quality from MWS is likely to be too low due to the high level of organic waste and non-glass fines. The results show that MWS would deliver a good increase in recycling rates, and under the current set of plastic packaging composition and collection system performance assumptions, is likely to be necessary to meet plastic packaging recycling targets.

Table 6-5: Overall Packaging Recycling Rates, EU Measurement Method with and without MWS

	Dual Stream	Dual Stream + MWS	EU Packaging Targets (2025/2030)
Plastic	40%	60%	50%/55%
Metal	72%	90%	50%/60%
Card/Paper	88%	96%	75%/85%

However, the available composition data for residual municipal waste, taking account the additional material assumed captured into separate collections, indicate relatively low levels of recoverable waste and high organic content, making the business case for these facilities unviable without also addressing the organic waste stream.

High level modelling taking into account facility costs (modelled at a relatively low cost of €20/tonne), reduced residual disposal costs, and income of the recovered materials, and including assuming the EPR subsidy is paid for the recovered packaging materials, the additional subsidy per tonne of recycled/diverted material required would need to be in the region of €800. To reduce this, there would need to be more recoverable waste, which would increase the income, or less non-recoverable residual waste, which would reduce the size of facilities required.

Implementing a comprehensive household organics collection would reduce the arisings of non-recoverable waste in residual, which would also improve the quality and recovery potential of recoverable materials. Organics is currently modelled to account for 38% of residual under the dual stream option. An organics collection could achieve captures of around 50%, so reduce the overall residual tonnage by 19%.

The business case for the facilities could also be improved by additional material recovery, and by higher disposal costs through a tax on landfill or other disposal. The composition data available is not detailed or very recent, so it is possible that there would be more recyclable waste remaining in residual waste after a DRS and recycling collections were introduced than we have modelled. Initial high level modelling suggests that, with the implementation of organics collections, the percentage of material recovered (predominantly plastic, metal and cardboard, at average basket materials price of €260/tonne) would need to reach 8% of residual waste, alongside the introduction of a disposal tax of €50/tonne, for facilities to be viable.

On current information, modern mixed waste sorting plants do not appear viable in the short term. However, given their importance to recovery of plastic packaging in particular, we recommend the potential for modern mixed waste sorting plants needs to be considered again on the basis of improved, detailed waste compositional information, and that organic collections are advocated as an important component of enabling further recovery of packaging materials from mixed waste.

6.4.3 Material Value Variations

Material values can vary, and it is important that the preferred option still performs well relative to the other options at different price points.

As no Serbian data on historic material value variations was available, we calculated the variance in 12-month average UK values over 10 years and applied this to the central values modelled in this work. We then looked at the point where material values would give the highest and the lowest income.

The results are shown in Table 6-6. For both of the high and low income sensitivities, the pattern of results is very similar to the central modelling. Therefore, even if material values change dramatically, the recommendation would be the same.

Table 6-6: Net Recycling Collection Cost per Household for the Material Value Variations Sensitivity

	Mixed Dry	Dual Stream	Three Stream
Central	€ 6.5	€ 7.4	€ 9.0
High Income	€ 5.4	€ 6.2	€ 7.8
Low Income	€ 8.8	€ 9.9	€ 11.4

6.4.4 Productivity Variations

Assumptions regarding productivity make a significant difference to the costs of waste collection. While the assumptions used are reasonable and evidence-based, it is worthwhile to explore the degree to which the cost of collection systems varies relative to one another under different productivity assumptions.

We model sensitivities with productivity 10% higher or 10% lower than the central values.

The results are shown in Table 6-7. The pattern of results for both the high and low productivity scenarios is very similar to the central results. Higher productivity results in lower collection costs and lower productivity results in higher collection costs.

Table 6-7: Net Recycling Collection Cost per Household for the Productivity Variations Sensitivity

	Mixed Dry	Dual Stream	Three Stream
Central	€ 6.5	€ 7.4	€ 9.0
High Productivity	€ 6.1	€ 7.0	€ 8.4
Low Productivity	€ 6.9	€ 7.9	€ 9.6

6.4.5 Capture Rate Variations

The central modelling is based on good but achievable capture rates that rely on a well explained system and a smooth rollout. However, if there are issues with these, capture rates may not be as high.

We model a sensitivity with capture rates 20% lower for each material.

Table 6-8 and Table 6-9 show the results of this sensitivity. The pattern of results for cost and recycling rates is very similar to the central results. The cost per household is higher, due to lower material incomes, but similar collection costs. Recycling rates are lower due to the lower capture of material. Paper and card are the most affected material streams in terms of recycling rates, since this material is only collected through household recycling rather than the DRS. The 20% reduction in capture rate would mean that the 2030 target would not be met for this material. However, the reduction in recycling rates is very similar for the dual stream and the three stream option, so this does not change the conclusions of the results.

Table 6-8: Net Recycling Collection Cost per Household for the Capture Rate Variation Sensitivity

	Mixed Dry	Dual Stream	Three Stream
Central	€ 6.5	€ 7.4	€ 9.0
Low Capture Rates	€ 7.0	€ 8.0	€ 9.6

Table 6-9: Overall Packaging Recycling Rates, EU Measurement Method for the Capture Rate Variation Sensitivity

	Mixed Dry	Dual Stream	Three Stream	Difference from Central	EU Packaging Targets (2025/2030)
Plastic	37%	37%	37%	-3%	50%/55%
Metal	66%	66%	66%	-6%	50%/60%
Glass	73%	73%	74%	-5%	70%/75%
Card/Paper	82%	83%	83%	-5%	75%/85%
Beverage Cartons	94%	94%	94%	-3%	Same as Card/Paper

6.4.6 Packaging Waste Variations

There is some uncertainty on the current levels of household packaging waste being produced. The central modelling assumes that packaging waste is 40% higher than reported. Additionally, packaging waste is likely to grow in the future. Changes in the amount of waste needing collection will affect collection, sorting and haulage costs and material incomes.

We model a sensitivity with packaging waste at the rates currently reported and a future sensitivity based on the central modelling with growth in waste based on the previous five years, which averages 13% over all packaging materials.

Table 6-10 and Table 6-11 show the results of the packaging waste sensitivity. Both sensitivities show the same pattern of results as the main results. For the sensitivity with waste arisings as reported, net costs are higher because the service is less efficient (in terms of amount of waste collected per vehicle), but material incomes are lower. Conversely, in the future scenario where more waste is modelled, the service is more efficient and material incomes are higher.

The changes in collection efficiency are reflected in the cost of GHG emissions savings. Less efficient collections result in a higher cost per tonne of GHG emissions saved. For the sensitivity with waste as reported the difference in cost per tonne between dual stream and three stream becomes even more extreme, making the dual stream option even more attractive. For the future scenario, the difference between the dual stream and three stream is the same, leading to the same conclusions as the central modelling.

Table 6-10: Net Recycling Collection Cost per Household for the Packaging Waste Variation Sensitivity

	Mixed Dry	Dual Stream	Three Stream
Central	€ 6.5	€ 7.4	€ 9.0
As Reported Waste	€ 7.1	€ 8.0	€ 9.7
Future Waste	€ 6.3	€ 7.2	€ 8.7

Table 6-11: Cost of GHG Emissions Savings (€/tonne) for the Packaging Waste Variation Sensitivity

	Mixed Dry	Dual Stream	Three Stream
Central	61.9	65.7	78.8
As Reported Waste	79.8	82.8	99.8
Future Waste	57.5	60.3	72.9

6.4.7 Capital Cost Variations

The costs of constructing major infrastructure can vary if unexpected issues arise in the course of work on site, or if works vary from the initial specification. We therefore examine the impact of cost overruns on the preference order of options.

We model a sensitivity with a 20% increase to buildings and infrastructure costs.

The net recycling collection cost per household to one decimal place is unchanged for all the options. However, as Table 6-12 shows, more than €1M extra would be required up front for capital costs, with options requiring more sorting having the highest increase in costs.

Table 6-12: Capital Costs for the Capital Cost Variation Sensitivity

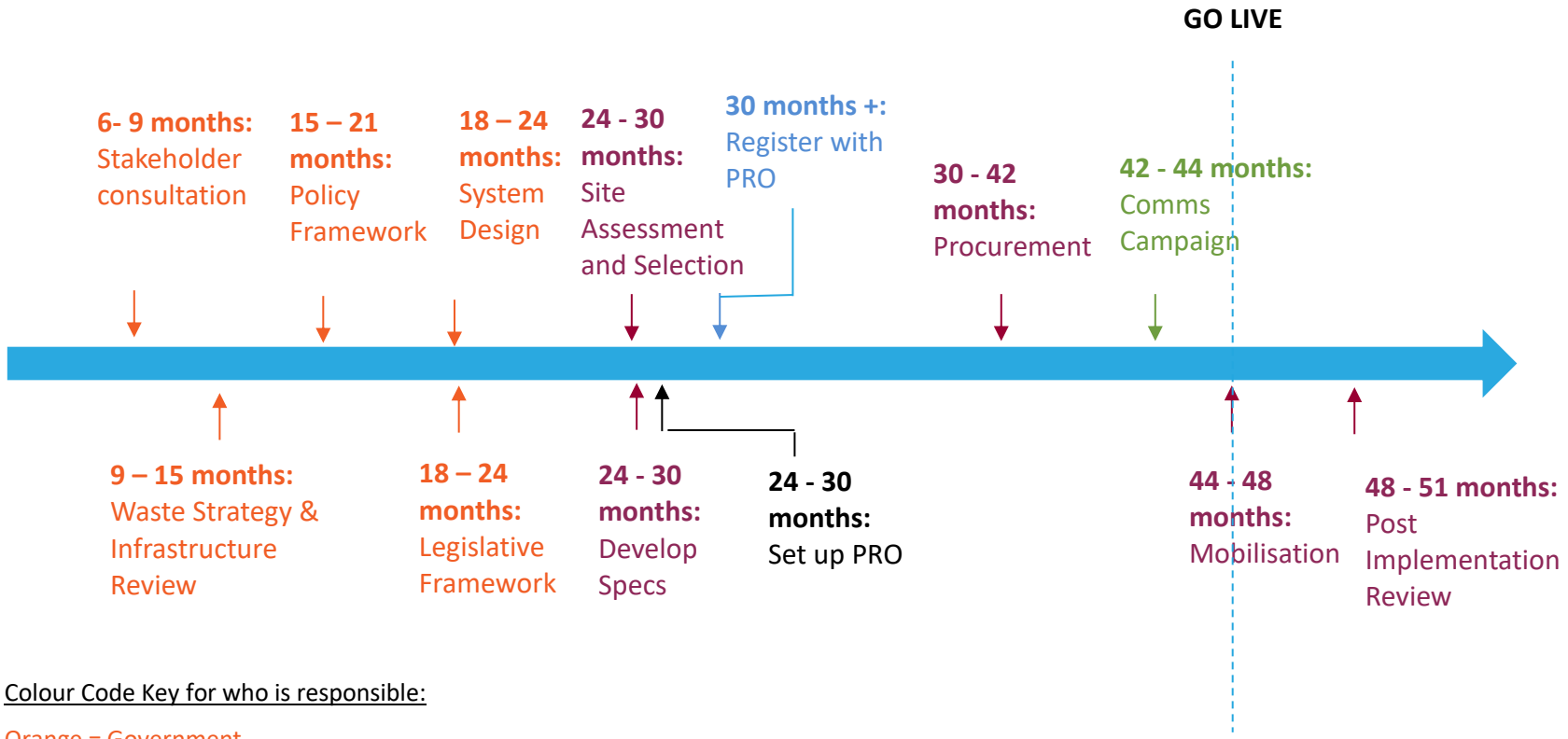
	Mixed Dry	Dual Stream	Three Stream
Central	£90.0M	£103.7M	£89.2M
Capital Cost Overrun	£92.4M	£105.5M	£90.9M

6.5 Risk Analysis

Risk	Summary	Who will be impacted	Mitigation	Likelihood	Impact	Overall
Unclear and overlapping roles	Overlapping roles may increase costs through inefficient system and unclear roles may create loopholes in the system which will also increase costs to producers.	Producers, PRO's, Government, Enforcement Agency, Municipalities, Collectors, Sorters, Reprocessors, enforcement and regulatory bodies	Assign specific functions to each stakeholder while avoiding as much as possible any overlap and loophole.	H	H	H
Free riding and online sales	Free-riding refers to situations where some producers do not adequately comply with their obligations under EPR. Free riding will increase costs to compliant producers.	Producers, PRO's.	Adequately fund the monitoring system to detect non-compliance and empower enforcement agency with the power to levy fines. Empower enforcement agency with licence revocation as a tool to sanction non-compliance.	H	M	M
Orphan products	Orphan products leave responsibility to finance their treatment to current producers.	Producers.	Only a small amount of packaging waste will take more than one year to enter the waste management system and therefore the impact will be small.	L	L	L
Illegal landfilling and waste exports	Illegal landfilling and waste exports will cause waste leakage from the system leading to environmental damage and health hazards potentially removing valuable material from the EPR scheme.	Producers, PRO's, Local communities.	Adequately fund the monitoring system to detect illegal waste activity and empower enforcement agency with the power to levy charges.	M	M	M
Unauthorised facilities and illegal recyclers	Inappropriate techniques by informal actors leads to loss of valuable material.	Producers, PRO's, Informal Sector.	Organise transition towards EPR and formal recycling while taking into account social issues involved and ensuring alternative employment opportunities and social protection frameworks are available for people who have livelihood in that sector. Design a system that is conducive to investment.	M	M	M

Risk	Summary	Who will be impacted	Mitigation	Likelihood	Impact	Overall
Lack of transparency & comparability of data	Lack of transparency in data may lead to unfair distribution of producer fees and difficulty in assessing cost effectiveness of waste management system.	Producers. PRO's.	A standard calculation method and data requirement must be established with clear definitions and audit systems. In order to ensure surveillance on all actors, a two tiered audit system was introduced in Austria. Under that system a Government agency is designated to act as a clearing house, giving responsibility of data collection and monitoring to producers and PRO's who are themselves in charge of auditing he collection and recycling operators with who they contract.	H	H	H
Lack of competition	Monopolistic PRO or collusion between them and may be difficult for entry into the market for new PRO's.	Producers, PRO's.	The legislative framework must put regulation in place to minimise the risk of collusion and monopolistic behaviour.	M	M	M
Insufficient Material Markets	Lack of material markets for separate material being collected for reprocessing.	Sorters, producers.	Engage with the material markets to ensure they have sufficient time to adapt to the changes in material entering the market.	L	H	M
Lack of participation from householders	Lack of participation from householders due to uncertainty about how to use the collection system or lack of understanding about benefits of recycling.	Producers, collectors, sorters, municipalities.	Allocate sufficient funding to communications campaign.	M	H	M
Supply of equipment and infrastructure components	A lack of supply of containers, vehicles and infrastructure components will delay implementation of the new service.	Producers, collectors, sorters, municipalities.	Engage early with suppliers to ensure they have sufficient time to prepare for the demands of the new waste management system.	L	H	M

6.6 High-level Implementation Plan



Colour Code Key for who is responsible:

Orange = Government

Purple = Municipalities

Green = Government and Municipalities

Blue = Producers

Black = PRO's

The implementation of a significant upgrade to a counties EPR system can be achieved successfully within a three to four year process but this should be viewed as the minimum period needed from the point of decision to proceed with the system, due to the time required for legislation, planning and installation of infrastructure.

The primary factors that can slow the implementation process down are:

- **Lack of cooperation** – where stakeholders prolong discussions and consultation in order to try and steer the EPR in line with their commercial interests.
- **if several countries decided to implement a system upgrade in the same year,** sourcing equipment, vehicles and the raw materials for infrastructure could be problematic if a large number of necessary components are ordered in a short time frame.

The main ways in which the Government can work to keep the implementation phase to a minimum are:

- Simple legislation that sets the parameters but leaves scope for industry to create the most efficient solution.
- A detailed feasibility study to allow a more rapid working up of the business plan.
- Coordinated dialogue with stakeholders to ensure a smooth implementation and facilitate an agreement on the system design.
- Early outlining of the obligations for producers to allow them maximum time for decision making and preparations.
- A clear tender process for external providers of infrastructure and transport facilities.

7.0 Summary of Refined Preferred Option

The preferred option of duel stream with DRS including glass was compared with three stream with DRS excluding glass to test the robustness of the collection system recommendation. Key findings are;

- when comparing **Dual stream with DRS including glass and three stream with DRS excluding glass,** the full system cost and benefit comparison shows that, collecting beverage glass through the DRS and non-beverage glass in two-stream collections results in lower net system costs, higher glass recycling and higher GHG benefit, compared to collecting all glass in a separate collection; and
- when modelling the impact of **separate glass collection in cities** the recycling and environmental benefits for urban glass collections do not provide a clear justification for the additional system cost.

The robustness of the preferred option was then tested to explore how key sensitivities could affect the order of results.

Glass sensitivities

In summary the glass market sensitivities show;

- if **no end markets are developed** for MRF glass, the glass recycling rate would drop to from 53% (from 78%), there would be no change to GHG benefits and the system costs would increase by €0.5M;
- if a **price in the same region of the disposal costs is received for MRF glass,** there is no change to the glass recycling rate or GHG benefit and the system costs would increase by the same as the no end markets sensitivity (€0.5M);
- if **additional glass cleaning steps were put in place**, there would be no change to the glass recycling rate but a significant increase in GHG benefits and also a significant increase in systems costs.

Separate, glass collections, whether for all households or urban households only, is still only recommended for Serbia if:

- Additional glass recycling is required in order to meet wider national recycling targets;
- Producers, or the Serbian Government, place an emphasis on circular resource recovery as a primary policy goal for glass, justifying the higher costs of separate collection; or
- As a fallback option in the event no viable markets can be identified for uses of recovered glass other than in remelt for containers.

Mixed waste sorting

The results show that **MWS would deliver a significant increase in recycling rates**, and is likely to be necessary to meet plastic packaging recycling targets. However, if MWS were to be implemented, rolling out a comprehensive household organics collection would reduce arisings of non-recoverable waste in residual, which would also improve quality and recovery potential of recoverable materials and increasing taxes on disposal would further improve the financial business case.

Other variations

Other sensitivities that were investigated that do not change the conclusion that duel stream with DRS including glass is the recommended collection system are;

- if material income fluctuated dramatically;
- if productivity of the system increased or reduced by 10%;
- if material capture rates reduced by 20%;
- if packaging waste being produced is at the rate it is currently being reported (as opposed to the assumption that its 40% higher than is currently being reported);

APPENDICES

A.1.0 Modelling Scope

The scope of the modelling is shown in Table7-1. The main area of consideration is household packaging waste collections. The costs and options explored here focus on a collection system targeted at households. Packaging waste collections from commercial premises, including small businesses, are out of scope. However, in practice, some packaging waste from small businesses may be deposited in on-street recycling containers.

Table7-1: Modelling Scope

Cost Impacts	Other Impacts	Environmental Impacts	Out of Scope
Household Separate Recycling Collections: • Collection costs • Transfer and haulage costs • Sorting costs • Material revenues • Communication and enforcement costs Impacts on residual collections: • Collection costs • Transfer and haulage costs • Disposal costs EPR management costs	• Capital investment required • Job impacts • Impacts on supply chain and material reprocessing	• Greenhouse Gas (GHG) emissions benefits from recycling • GHG emissions from collecting and sorting (electricity and fuel use) • Avoided GHG emissions from reduced disposal	Commercial collections

A.1.1 Modelling Approach

The modelling has the following key components:

- The waste flow model includes all household waste, focusing on identifying packaging materials within household waste. It models the flow of different packaging materials from individual households and collective housing (flats, apartments) into different collected waste streams (DRS, different separate collections, and residual waste). For each option and region, it models the quantity of packaging material expected to be collected within each stream, then subsequently, sorted, sold, and recycled.
- Cost models are used to model the resource and costs involved in the collection, transfer, haulage and sorting costs of different collected waste streams. These cost models are based on identifying resources required (vehicles, fuel, labour, facilities) for carrying out each component of the collection and management of packaging waste.
- The different modelling components are brought together with material revenues and GHG and Air Quality (AQ) factors, to calculate and compare the total costs and impacts of each option.

	Cost Modelling Approach
Collection	Household collection resource modelling is undertaken, using Eunomia's collection modelling tool Hermes2.0, to compare the resource requirements of the current collection system to the possible alternative systems. To reach a cost representative of the different regions within Serbia, collection resources, where modelled, model the comparative resource likely to be required for each different collection option. The three different regions that were modelled reflect key variation in collection efficiency, separating out the logistics in a) Belgrade, b) other city municipalities, and c) all other municipalities within Serbia.
Transfer and Haulage	The costs of establishing and running a sufficient number of transfer stations are included, based on estimated capital and operating costs. The haulage vehicle resource required modelled using GIS, modelling the resource required to transport each collected stream from where it arises across the country to a set of defined sorting locations.
Sorting	There is little available literature on which to base the capital and operational costs for differently configured sorting plants. Estimates were developed for the sorting resources and costs required for each option based on a combination of literature sources and on Eunomia's knowledge of sorting plant operations, reflecting the underlying differences in technology and resources required between the collection options.
Communications and Enforcement	To ensure the high participation and capture rates modelled for the different recycling systems, additional communication and enforcement costs would be necessary. It is assumed that these would be the same between the options. To reflect the additional costs of communications, an annual per household cost is added. To cover enforcement costs, additional municipality staff are modelled.

	Cost Modelling Approach
PRO Management	The UKs Department for Environment Food and Rural Affairs (DEFRA) have developed a model for calculating the PRO management costs for the UK system. This model methodology was used to calculate Serbian PRO costs. The UK assumptions for staff costs, office costs and resource costs were amended to make relevant to Serbia which were taken from the Statistical Yearbook 2020[26].

Appendix A.2.0 contains more detail on the cost modelling approach used for each component of waste collection and management.

The modelling approach estimates the number of vehicles, containers and other capital investments associated with the running of the EPR scheme option and the collection and recycling of packaging waste. Unit capital costs are applied to estimate the total capital investment requirements. Capital investment costs required may be lower when the existing stock of vehicles and sorting equipment are considered.

To calculate the change in greenhouse gas (GHG) emissions, the fuel and electricity usage of the different modelling components and the tonnages of the different materials collected are multiplied by carbon factors.

A.1.2 Supply chain impacts

The modelling undertaken will have an impact upon the existing supply chain in Serbia, as well as potentially creating opportunities for new supply chains. The systems modelled lead to a substantial increase in the recycling rate, and an improvement in the quality of material, which will be of benefit to producers that wish to make use of recycled material in their products.

Producers within the scheme may be impacted due to the requirement for them to provide bespoke labelling for items included within the system (DRS). This will likely increase costs for producers, but it will also provide opportunities for unique barcoding specialists to become a part of the supply chain.

Depending on the system design, these systems can be designed to be more capital intensive, or more labour intensive, with the latter producing greater employment opportunities in the supply chain.

Additionally, depending on the design of the collection system, there may be a need to develop new sorting infrastructure, which will need to be implemented at a suitable scale and with sufficient capacity to manage possible growth in future waste arisings.

[26] Statistical Yearbook of Serbia 2020

A.1.3 Data and Limitations

Data was gathered from official sources, and from project stakeholders including NALED, KOMDEL and packaging producers.

Data on municipalities, population, households and regions, urban and rural populations, and household types, were sourced from the Statistical Office.[27]

Baseline data on packaging waste arisings and collected is based on SEPA. However, the amount of packaging waste generated assumed within this study, following Deloitte's estimate, is 40% higher than the quantity reported by SEPA for 2019. Packaging waste quantities reported appear low in relation to total municipal waste arisings per capita, but due to the limited and dated detail on municipal waste compositions, this study was not able to gather the evidence base for an improved waste-based assessment of packaging waste quantities.

The estimation of the quantity of packaging waste that originates from households (and therefore is targeted by collection systems provided to households) was initially taken from Deloitte (2018). However, SEPA's 2019 data on commercial and industrial packaging waste reported by collective schemes imply higher proportions of paper and cardboard and packaging waste arising from non-household sources, shown in Table 7-2.

Table 7-2: Packaging Waste Arising from Households

	% Arising from Households (Deloitte)	% Arising from Households (Adjusted Assumption)
Paper and Cardboard	60%	37%
Plastic	70%	70%
Glass	80%	80%
Metal	75%	70%

Due to a lack of detail within compositions available for Serbia, additional European data sources were used to identify different packaging materials within the higher-level material groups.[28]

The modelling also requires an estimate of yields of packaging materials for the three different logistical regions considered in modelling: Belgrade, other city/urban municipalities, and the rest of the country. To form a suitable estimate for the purposes

[27] Statistical Office of the Republic of Serbia (2019) "Municipalities and regions of the Republic of Serbia, 2019" and other information from the Statistical Office website.
[28] Sources including Deloitte (2017) 'Blueprint for plastics packaging', and ongoing work for DG Env.

of modelling, municipal waste arisings and composition data for different household types were applied.[29]

Data on material collected in the baseline, where separate collection systems are in place, was taken from SEPA (overall packaging waste collected), information from Belgrade public authority, and further literature sources.

The data sources used are covered in more detail within Appendix A.3.0.

Cost data (salaries, vehicles and fuel costs, material revenues) was gathered from project stakeholders including NALED, KOMDEL and other stakeholders.

Tables of the specific cost data used within the modelling are detailed in Appendix A.3.4.

Number of areas where data availability is low or low level of confidence in existing data sources:

- Baseline household collection performance
- Distribution of packaging waste urban vs rural, individual vs collective housing
- Few existing household recycling services in Serbia to benchmark performance and collection efficiency against.

Where data availability was poor assumptions were made which is covered in detail in Appendix A.3.0.

A.2.0 Appendix 1: Modelling Methodology

The cost impacts considered within scope are:

- Household separate recycling collections
  - Collection costs
  - Transfer and haulage costs
  - Sorting costs
  - Material revenues
  - Communication and enforcement costs
- Impacts on residual collections
  - Collection, transfer, haulage and disposal costs
- EPR management costs

Other impacts considered:

- Capital investment requirements;
- Job impacts;

[29] Municipal waste composition information for Belgrade was provided by KOMDEL, and compositions for other urban, rural and collective households were taken from SEPA. http://www.sepa.gov.rs/download/otpad.pdf. MSW arisings by municipality were provided by KOMDEL.

- Impacts on supply chain and material reprocessing

Environmental impacts considered:

- Greenhouse Gas (GHG) emissions benefits from recycling
- GHG emissions from collection and sorting (electricity and fuel use)
- Avoided GHG emissions from reduced disposal

A.2.1 Current EPR Subsidies

The estimate of current subsidies per tonne of household packaging, shown in Table 3-1, are calculated based on the subsidy paid per tonne of collected waste multiplied by the baseline estimate of household packaging waste collected, divided by the total quantity of packaging placed on the market.

Table A - 1: Current EPR Subsidies

	Current Subsidy Per Tonne Sorted for Recycling (€)	Tonnes Collected for Recycling (Household), kt	Total Estimate of Current Subsidy, €M	Total Tonnage on the Market, kt	Subsidy Per Tonne on the Market, €
Plastic Packaging	€34-68	23.2kt	€0.8-1.6M	129.5kt	€6.1-12.2
Metal Packaging	€17-34	5.6kt	€0.1-0.2M	23.7kt	€4.0-8.0
Glass Packaging	€68-119	18.9kt	€1.3-2.3M	86.8kt	€14.8-26.0
Paper/Card Packaging	€34-60	16.8kt	€0.6-1.0M	169.9kt	€3.4-5.9

A.2.2 Collection Resource Modelling

The resource required and efficiency of collection operations depend on the density of collection points, the volumes collected at each collection point and the size and crewing levels of the collection vehicles.

To model the comparative resource likely to be required for each of the collection options, three different regions were modelled that reflect key variation in collection efficiency, separating out the logistics in a) Belgrade and b) other city municipalities, from other municipalities within Serbia.

Within these regions, we distinguish between collective households (dwellings with three or more households) and individual households since these households are provided with different containment.

Our proprietary model, 'Hermes2.0', has been used to calculate the performance associated with different waste collection scheme configurations. A 'baseline' model is created that represents the current service. This reflects the resources and logistics of the existing services as accurately as possible to serve as a foundation for testing various alternative collection options. Inputs to the baseline include information regarding Serbia's geography, number and type of households, current services and service performance, resources, and waste composition. Known inputs (from the perspective of the model, these include tonnages of each material type collected, numbers and types of households offered the service, depot and tipping locations) are calibrated to known outputs (which in modelling terms includes the numbers of crew and vehicles used to deliver the collection services). This helps to create a basis from which to establish the change in resource requirements for different potential future service configurations, ensuring that Serbia's specific constraints are properly reflected.

The waste flow modelling outputs and other changes relevant to the different options are overlaid onto the baseline model. The resulting model estimates the resource changes if the different options were implemented. The model outputs include:

- Vehicle numbers;
- Staff numbers;
- Fuel; and
- Container numbers.

A.2.3 Transfer Resource Modelling

Due to the need to aggregate collected waste in sorting and processing centres, a number of transfer stations will be needed. The costs will vary depending on the number of current transfer station locations which could be either fit for purpose or expanded, or the need to identify and establish new local transfer station locations.

The capital cost of transfer stations varies slightly depending on the number of collection streams, with additional streams requiring additional bay walls. However, this cost difference is minor in the context of redevelopment works and annualised over a number of years.

For this stage of the cost modelling, an average high level capital investment in transfer stations was modelled at €0.5 million per location, reflecting the investment likely to be

needed to cover building works.[30] Additional costs are likely to be needed for cost for site preparations and clearance, drainage, groundworks, foundations, surfacing surrounding the site building or the process of gaining consent for development. These costs are highly site specific and depend on the condition of existing potential sites.

The number of transfer stations required (28) were set based on the assumption of a maximum distance of 30km from a collection area to the transfer location where collected material is tipped. Each population centre within each area (NSTJ-3) was assumed to have a transfer location nearby, with a number of additional transfer locations needed where the area exceeded a 30km radius.

Due to the average throughput of material in these sites, a relatively low staffing level is expected to be required of an average of 3 FTE employees per site (higher in Belgrade), with additional operational expenditure on moving plant and fuel.

The costs of the transfer stations are then attributed to recycling or residual streams according to the relative volumes of waste transferred through the stations.

A.2.4 Haulage Resource Modelling

Demographic and GIS information was used to model the resource required to transport each collected stream from where it arises across the country to a set of defined sorting locations.

Using the packaging waste generation and collected waste in each stream already modelled across the three logistical regions, population data was used to model the distribution of collected waste in each collected waste stream was modelled across transfer stations located near to the main population centres within each of Serbia's areas (NSTJ-3). GIS was used to calculate the driving distance between the population centres of each area, and, using a set of defined regional locations for sorting facilities, the model calculates the drivetime from each transfer station location to its closest sorting facility.

Bulk density assumptions for collected material streams were applied to estimate the number of loads required (assuming an HGV volume of 90m^3).

From this information, the model calculates the total resources (number of vehicles, drivers, and quantity of fuel used) and other logistical parameters (loads required, total distances travelled).

[30] Costs based on calculation of average bay area required for handling material streams, space for vehicle movements, and according costs for framework and cladding (1,094m2), flooring (1,094m2), fireproof push walls (62-111m2), and 2 roller shutter doors.

A.2.5 Sorting Resource Modelling

The capital and operational costs of sorting facilities differ depending on the mix of materials sorted and the scale of the facility.

There is little publicly available literature on which to base the capital and operational costs for differently configured sorting plants. Estimates were developed for the sorting costs for each option based on a combination of literature sources and on Eunomia's knowledge of sorting plant operations, which reflect the underlying differences in technology and resources required between the collection options.

The capital costs, staff resources, and costs of sorting light packaging fraction (plastics and metals, with some packaging papers) were taken from Cimpan, C. et. al (2015), with the construction portion of labour costs adjusted for the differential between German and Serbian labour wages.[31] Serbian costs for electricity, diesel and labour costs were applied to estimate a sorting cost specific to the Serbian context. The resulting total sorting cost for plastics and metals sorting facility (€50/tonne) compares well with the sorting cost of €49/per tonne provided by NALED.

Additional capital, space, labour and maintenance costs for integrating glass sorting equipment and a glass processing line into sorting facilities were taken based on example facility data.

Table A - 2: Sorting Costs

	MRF 1 - full mix	MRF 3 - containers	MRF 4 - plastics/ metals	Paper Sorting
Capital Cost per Tonne	€123	€168	€216	€54
Annualised Capital Cost per Tonne	€14	€20	€26	€6
Operational cost per Tonne	€18	€22	€30	€14
Total Cost per Tonne	**€33**	**€42**	**€56**	**€21**

[31] Cimpan, C., et al. (2015) 'Techno-economic assessment of central sorting at material recovery facilities - the case of lightweight packaging waste', Journal of Cleaner Production, http://dx.doi.org/10.1016/j.jclepro.2015.09.011

A.2.6 Communications and Enforcement Costs

The high performance of the systems modelled relies on effective communication and education, as well as some low-level enforcement.

An annual cost of €1.50 per household is assumed for the development and dissemination of communication materials, based on Eunomia's experience of the level of communication spend required. This is comparable to the annual cost of €1.20 per household for the years 2015-17, recommended in the Kosovo WWMP produced by EuropeAid.

It is additionally recommended that municipalities employ staff to assist with low-level education and enforcement, at a level of at least 1 FTE per municipality at administrative grade. It is assumed municipalities with less than 20,000 households would require 1 FTE and municipalities with more than 20,000 households would require on average 2.

These costs are included in the comparisons above and are not assumed to change between the options.

A.2.7 EPR Management Costs

EPR management costs for Serbia were estimated using Defra's EPR management cost model for the UK. The Defra model assumptions were adjusted to produce an estimate for Serbia.

Defra's model was informed by estimates provided by WRAP and Valpak. The estimate makes some provision for the costs of administering producer obligations in relation to packaging waste management produced by businesses and public organisations. The costs included for are:

- Staff costs - The roles assumed to be required include account managers for producer members, for local authorities and commercial collectors, technical specialists, data analysts, financial professionals (raise invoices, credit control, process payments), administration, management, HR, audit, marketing and communications, and digital operations.
- Officer premises – rent and rates.
- Professional fees & other overheads – e.g., legal, tax, insurance.

WRAP's work was informed by their experience of running large voluntary industry programmes such as Courtauld 2025 and Valpak's from their experience of operating a producer responsibility compliance scheme for packaging, batteries and waste electronic and electrical equipment.

Adjustment factors shown in Table A-2 were calculated for office costs and staff costs to account for the differences in Serbian costs when compared to the UK.

Table A - 3: UK and Serbian office and salary assumptions

Costs	UK	Serbia	Reduction Factor	Source of Serbian Assumption
Office costs (Euro/m2/year) 2019	920	196	21.3%	https://www.statista.com/statistics/530157/office-real-estate-prime-rent-belgrade-serbia-europe/
Average Country public sector worker salary (Euro/year) 2019	43,680	8,033	18.4%	https://www.stat.gov.rs/en-us/publikacije/publication/?p=12694

The scheme administrator management costs are estimated to be 21.2 million Euros in 2023 with a total cost from 2023 to 2032 estimated to be 67.9 million Euros. See the Table A-3.

Table A - 4: Estimated scheme administrator management costs from 2023 to 2032 (Million Euro per year)

	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	Total
Packaging technologist costs	6.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.9
Training costs	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	4.8
Familiarisation costs	0.1	0.1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	4.1
Scheme admin costs	2.9	2.9	3.0	3.1	3.1	3.2	3.2	3.3	3.3	3.4	31.3
IT costs	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1.3
Admin costs for labelling	0.9	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7	7.8
Communications campaign costs	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.5
IT Investment costs	1.5	1.5	1.5	1.5	0.0	0.0	0.0	0.0	0.0	0.0	6.1
Total	12.1	12.1	6.5	6.5	5.0	5.1	5.1	5.1	5.2	5.2	67.9

A.2.8 Environmental Impacts

Three major changes in GHG emissions are considered:

- GHG emissions benefits from recycling;

- GHG emissions from collection and sorting (electricity and fuel use); and
- Avoided GHG emissions from reduced disposal.

Results are presented as a comparison to the baseline.

For increased recycling and reduced disposal benefits, tonnages of individual materials are multiplied by carbon factors for recycling, incineration or landfill.

The GHG emissions for collection and sorting cover fuel use of vehicles and electricity use within the sorting plant.

The DRS option also includes the GHG emissions from fuel of additional journeys made to return containers.

A.3.0 Data and Assumptions

A.3.1 Households

Data on municipalities, population, households and regions were taken from the Statistical Office publication "Municipalities and regions of the Republic of Serbia, 2019".[32]

The proportion of households assumed to be provided with communal rather than individual bins within each municipality is taken from the percentage of urban and rural households living in residential buildings with 3 and more dwellings.[33] This data, alongside the number of urban vs rural households within municipalities and regions, was downloaded from the Statistical Office website. This results in 67% of households having an individual bin and 33% having communal bins.

A.3.2 Household Packaging Waste

The amount of packaging waste generated assumed within this study, following Deloitte's estimate, is 40% higher than the quantity reported by SEPA for 2019.

For the main comparison of EPR options, no assumptions are made regarding future packaging waste growth (options have been modelled based on 2019 waste arisings).

[32] Statistical Office of the Republic of Serbia (2019) "Municipalities and regions of the Republic of Serbia, 2019"

[33] Some three-household dwellings may be suitable for individual containment. However, data on number of households living in residential buildings containing higher numbers of dwellings (for instance, greater than 5, 10 etc.) were not available.

The estimation of the quantity of packaging waste that originates from households (and therefore is targeted by collection systems provided to households) was initially taken from Deloitte (2018). However, SEPA's 2019 data on commercial and industrial packaging waste reported by collective schemes imply higher proportions of paper and cardboard and packaging waste arising from non-household sources.

Table A - 5: Household and Industrial Flow

	% Arising from Households (Deloitte)	% Arising from Households (Adjusted Assumption)	Tonnage Household Packaging	Tonnage C&I Packaging
Paper and Cardboard	60%	37%	53,440	116,414
Plastic	70%	70%	90,687	38,866
Glass	80%	80%	69,417	17,354
Metal	75%	70%	16,602	7,115

Different capture rates and material revenues apply to specific categories within these broad material groups, so each packaging group was split out into more detailed composition, using a combination of composition information and estimates from other European data. Data supplied by producers to the concurrent DRS project helped with the estimate of arisings of aluminium cans, beverage PET bottles, beverage glass, and beverage cartons. However, the data supplied did not cover the entirety of the market, and there was no source of data specific to Serbia with which to estimate other breakdowns of packaging materials. Therefore:

- The assumed composition of PET and non-PET plastic packaging by polymer and packaging format (bottles; pots, tubs and trays; and films) was taken from Deloitte (2017);[34]
- The apportioning of steel packaging into steel cans and other ferrous metals was taken from Eunomia's current work for the Commission developing a packaging waste baseline for the EU27.

Table A below shows the resulting assumed breakdown of household packaging materials.

[34] Deloitte (2017) 'Blueprint for plastics packaging'. The proportion of HDPE bottles is adjusted down by 50%, due to the presence in that study of countries with atypically high HDPE use for milk packaging.

Table A - 6: Household Packaging Arisings

	Household Packaging Arisings Modelled, tonnes	Household Packaging Arisings Modelled, kg/cap
Plastic Packaging	92,625	37.2
PET Beverage	17,492	7.0
PET Bottle Non-Beverage	2,544	1.0
PET Tray	8,577	3.4
HDPE	7,113	2.9
PP	12,717	5.1
PE Film	29,099	11.7
PP Film	5,748	2.3
Other rigid	3,112	1.3
Other film	6,224	2.5
Metal Packaging	16,602	6.7
Aluminium Cans	2,713	1.1
Steel Cans	5,923	2.4
Other Non-Ferrous	4,470	1.8
Other Ferrous	3,495	1.4
Glass Packaging	69,417	27.9
Glass Beverage	37,006	14.9
Other Glass	32,411	13.0
Paper/Cardboard	62,846	25.3
Packaging card	48,582	19.5

	Household Packaging Arisings Modelled, tonnes	Household Packaging Arisings Modelled, kg/cap
Packaging papers	4,858	2.0
Beverage cartons	9,406	3.8

The modelling also requires an estimate of yields of packaging materials for the three different logistical regions considered in modelling: Belgrade, other city/urban municipalities, and the rest of the country. Packaging waste arisings are estimated to be on average 80% lower in rural areas than urban areas. In the modelling, MSW and municipal waste composition variation was integrated to model the relative distribution of different packaging waste categories between different types of properties within the three logistical regions modelled. Municipal waste composition information for Belgrade was provided by KOMDEL, and compositions for other urban, rural and collective households were taken from SEPA.[35] MSW arisings by municipality were provided by KOMDEL.

The resulting arisings per household modelled are shown in the table below .

However, due to the inclusion of commercial waste in some MSW figures, the age of the study and uncertainty within the composition data, these figures are not highly reliable. However, since the costs of collection are not substantially impacted by small changes in average yields, It is recommended to explore a sensitivity based on a simpler set of assumptions, modelling all packaging waste arisings in rural areas at 80% (using the proportion of urban and rural properties within each logistical region to aggregate for Belgrade, other city municipalities, and the rest of the country respectively).

Table A - 7: Household Packaging Waste Arisings Modelled by Region, kg/hhld

	Belgrade			Other Cities			Rest		
	Urban Individual housing	Urban Collective housing	Rural	Urban Individual housing	Urban Collective housing	Rural	Urban Individual housing	Urban Collective housing	Rural
Plastic Packaging	39.6	34.7	29.0	26.0	23.2	30.3	53.5	35.0	34.5

[35] http://www.sepa.gov.rs/download/otpad.pdf

	Belgrade			Other Cities			Rest		
	Urban Individual housing	Urban Collective housing	Rural	Urban Individual housing	Urban Collective housing	Rural	Urban Individual housing	Urban Collective housing	Rural
PET Beverage	8.3	7.3	6.1	5.5	4.9	6.4	11.3	7.4	7.3
PET Bottle Non-Beverage	1.2	1.1	0.9	0.8	0.7	0.9	1.6	1.1	1.1
PET Tray	4.1	3.6	3.0	2.7	2.4	3.1	5.5	3.6	3.6
HDPE	3.4	3.0	2.5	2.2	2.0	2.6	4.6	3.0	2.9
PP	6.1	5.3	4.4	4.0	3.6	4.6	8.2	5.3	5.3
PE Film	13.9	12.1	10.2	9.1	8.1	10.6	18.7	12.2	12.1
PP Film	2.7	2.4	2.0	1.8	1.6	2.1	3.7	2.4	2.4
Other rigid	1.5	1.3	1.1	1.0	0.9	1.1	2.0	1.3	1.3
Other film	3.0	2.6	2.2	1.9	1.7	2.3	4.0	2.6	2.6
Metal Packaging	5.4	6.9	5.4	7.7	6.2	7.6	6.8	4.1	6.4
Aluminium Cans	1.2	1.1	1.2	1.2	1.2	1.1	1.2	1.0	0.8
Steel Cans	1.9	2.5	1.4	2.8	2.1	2.8	2.4	1.3	2.4
Other Non-Ferrous	1.3	1.9	1.6	2.1	1.6	2.1	1.8	1.0	1.8
Other Ferrous	1.0	1.5	1.2	1.6	1.2	1.6	1.4	0.8	1.4
Glass Packaging	47.7	18.1	10.8	21.4	22.0	32.0	45.0	26.4	30.3

	Belgrade			Other Cities			Rest		
	Urban Individual housing	Urban Collective housing	Rural	Urban Individual housing	Urban Collective housing	Rural	Urban Individual housing	Urban Collective housing	Rural
Glass Beverage	25.5	9.7	5.8	11.4	11.7	17.1	24.1	14.1	16.2
Other Glass	22.3	8.5	5.1	10.0	10.3	15.0	21.1	12.4	14.2
Paper/Card board	28.0	22.3	23.8	29.9	28.6	22.6	36.0	12.4	20.2
Packaging card	22.0	16.9	18.2	23.8	22.5	17.1	29.3	7.8	15.0
Packaging papers	2.2	1.7	1.8	2.4	2.3	1.7	2.9	0.8	1.5
Beverage cartons	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8

A.3.3 Capture Rate Assumptions

The capture rates assumed in the modelling are good practice household packaging capture rates, based on high-performing household schemes such as in Wales and Milan. It is possible for performance of household collection schemes to exceed this level of performance, but, so far, the evidence for schemes that do so consistently on a country-wide basis is limited.

Captures into recycling collections can also be supported most effectively where households have their own containers, since the frequency of residual waste collection systems and the volume provided can be used to encourage the appropriate use of recycling containers.

Captures into communal bins tend to be lower due to the relative inconvenience compared to a single disposal point, and there is less potential to use system design to encourage use of recycling containers. However, beyond sensible positioning of containers and good signage, PAYT systems for communal bins can have a similar impact on encouraging recycling, so long as there are also effective controls on responsible waste management more generally, and tight controls on contamination of recycling bins (including through use of material-specific openings in lids).

Table A - 8: Capture Rate Assumptions

	Door to Door (individual household collections)	Near-entry Bring (urban/town communal bin collections): x80%	Bring (rural communal bin collections): x60%
Plastic Bottles	65%	52%	39%
Other Rigid Plastic Packaging	50%	40%	30%
Plastic Films	40%	30%	24%
Aluminium Cans	60%	48%	36%
Steel Cans	70%	56%	42%
Cardboard	80%	64%	48%
TetraPak	70%	56%	42%
Glass packaging	65%	52%	39%

A.3.4 Cost Assumptions

A.3.4.1 Vehicle Costs

Vehicle assumptions are shown in the table below. Capital costs were provided by KOMDEL, apart from the large RCV, which is factored up from the small RCV, based on our knowledge of price differences within the UK. Vehicles are assumed to be depreciated over 10 years. Maintenance is assumed to be 6% of capital costs, as provided by KOMDEL. Registration and Insurance costs are based on information provided by Carlsberg & CCHB.

Table A - 9: Vehicle Costs

Collection	Vehicle Type	Capital Cost	Registration and Insurance
Communal Collections	Large RCV	€160,000	€600

Collection	Vehicle Type	Capital Cost	Registration and Insurance
Door to Door Collections	Small RCV	€110,000	€550
Glass Collections	Mini RCV	€75,000	€550
Haulage	Large HGV	€120,000	€600

A.3.4.2 Staff Costs

Staff costs are shown in the table below and were provided by Carlsberg & CCHB and NALED. Employer's pension and disability insurance was added at 11.5% and health insurance at 5.15%. Holiday and sick leave were added at 15%.

Crewing levels are assumed to be on average:

- Driver plus 2 loaders in Belgrade region;
- Driver plus 1.5 loaders in other cities region; and
- Driver plus 1 loader in the rural region.

Table A - 10: Staff Costs

Staff Type	Salary	Total Modelled Cost
Belgrade Driver	€10,200	€13,428
Other Cities Driver	€9,435	€12,421
Rural Driver	€8,670	€11,414
Belgrade Loader	€6,630	€8,728
Other Cities Loader	€6,120	€8,057
Rural Loader	€5,610	€7,386
Manual Operative	€5,610	€7,386
Skilled Operative	€7,808	€10,279
Plant Driver	€7,808	€10,279
Supervisor	€17,400	€22,907
Management	€17,400	€22,907

A.3.4.3 Material Revenues and Residual Disposal Costs

Material revenues fluctuate, and the net costs of EPR are affected by this fluctuation. Material revenues used in this report are based on Serbian market averages in November 2020, provided by NALED and shown in Table A-10.

For glass, other stakeholders provided a lower cost of €0-20/tonne. Though revenues from glass sold for remelt are in the region of €40-50/tonne, high transport costs of €25-30/tonne bring net revenues down to below €20/tonne.

Table A - 11: Material Revenues

Item	Further Info / Units	Market Price for Material following Sorting (RSD)	Market Price for Material following Sorting (EUR)
PET Bottles	Price per tonne	27,000	230
HDPE	Price per tonne	29,000	247
PP	Price per tonne	29,000	247
Aluminium	Price per tonne	106,000	901
Steel	Price per tonne	23,500	200
Glass	Price per tonne	4,700	40
Glass (remelt)	*Incl. transport*		*18*
Glass (aggregate)	*Incl. transport*		*8*
Cardboard (OCC)	Price per tonne	9,400	80
Paper	Price per tonne	17,700	151
Mixed Paper	Price per tonne	5,900	50
Beverage Cartons	Price per tonne	2,300	20

Disposal of residual at landfill is modelled at €25/tonne, based on the data provided.

A.3.4.4 Container Costs

The container assumptions are shown in the table below. These are Eunomia assumptions based on UK container cost datasets.

Table A - 12: Container Assumptions

	Unit Cost	Replacement Rate	Lifetime (years)
1100 L bin	€151	1.5%	10
140 L bin	€17	1.5%	9
Glass Box	€3	4%	5

	Unit Cost	Replacement Rate	Lifetime (years)
Single-use Sacks (one year's supply)	€1	n/a	1

A.3.5 Environmental Assumptions

A.3.5.1 Greenhouse Gas Emissions Factors

The following table details the GHG emissions factors used in the modelling.

Table A - 13: Material GHG Emissions Factors

	Recycling	Landfill	Incineration
PET bottles	-2.20	0.00	0.93
HDPE	-1.67	0.00	0.93
PP	-1.48	0.00	0.93
PE	-1.67	0.00	0.67
Steel	-1.83	0.00	-1.09
Aluminium	-10.99	0.00	-2.70
Paper	-0.30	2.03	-0.55
Cardboard	-0.01	1.91	-0.57
Glass	-0.23	0.00	-0.03

The following emissions factors were used for fuel:

- Large vehicle fuel, kg CO_2 / litre: 2.63[36]
- Car fuel, kg CO_2 / litre: 2.51[37]

[36] Defra Company Reporting guidelines (2005)
[37] https://www.fiafoundation.org/media/44209/gfei-annual-report-2014.pdf (assumed 50% diesel, 50% petrol)

- Electricity, kg CO_2 / kWh: 0.763[38]

A.4.0 Appendix 2: Results Tables

This appendix includes additional results tables.

A-11 describes the EPR collection system, the extent of rural coverage and whether there is a DRS in place for each of the options. The options numbering is then used in the tables that follow. Dual stream recycling has containers (plastic, metal and glass) collected separately from paper and cardboard. Three stream recycling has plastic and metal; glass; and paper and cardboard collected separately.

Table A - 14: Options Description

	EPR Collection System	Rural Coverage	DRS
1	Mixed Dry Recycling	Door to Door	Yes
2	Dual Stream Recycling		
3	Three Stream		
1a	Mixed Dry Recycling	Communal	
2a	Dual Stream Recycling		
3a	Three Stream		
1b	Mixed Dry Recycling	Door to Door	No
2b	Dual Stream Recycling		
3b	Three Stream		

A.4.1 Tonnages and Recycling Rates

38 https://www.carbonfootprint.com/docs/2020_07_emissions_factors_sources_for_2020_electricity_v1_3.pdf

Table A - 15: Modelled Tonnages of Recycling and Total Waste Arisings

Material	Plastic	Metal	Glass		Paper/Cardboard (excl. beverage cartons)		Beverage Cartons
Option	All	All	Mixed Dry/ Dual Stream	Three Stream	Mixed Dry	Dual Stream/ Three Stream	All
C&I DRS	4,438	0	3,637	3,637	0	0	941
Household DRS	13,539	3,362	33,306	33,306	0	0	8,465
EPR	16,676	7,171	21,697	23,167	35,595	37,974	476
C&I	16,666	6,614	8,796	8,796	101,438	101,438	0
Total Recycling	**51,319**	**17,147**	**67,436**	**68,906**	**137,033**	**139,412**	**9,882**
Total Waste Arisings	**129,553**	**23,717**	**86,772**	**86,772**	**159,403**	**159,403**	**10,451**

Table A - 16: Household Packaging Recycling Rate

	Door to Door			Communal Sensitivity			DRS Sensitivity		
	1	2	3	1a	2a	3a	1b	2b	3b
Recycling Rate	64%	65%	50%	59%	60%	60%	55%	56%	58%

A.4.2 Collection Resources Required

The following tables show the resources and pass rates required for each option.

Table A - 17: Resources and Pass Rates for the Main Options

	1: Mixed Dry Recycling	2: Dual Stream: Papers (Packaging and non-packaging) and Containers		3: Three Stream: Papers, Light Packaging and Glass		
		Papers	Containers	Papers	Plastics & Metals	Glass
Door to Door						
Door to Door Containers	Wheeled bin	Wheeled bin or sack	Wheeled bin	Wheeled bin or sack	Sack	Box
Door to Door Vehicles	180	114	89	114	121	67
Door to Door Crew	412	261	203	261	276	153
Belgrade Door to Door Pass Rate	1,116	1,370	1,219	1,370	1,938	1,709
Other Urban Door to Door Pass Rate	1,023	1,213	1,027	1,213	1,536	1,380
Rural Door to Door Pass Rate	864	1,016	864	1,016	1,233	1,121

	1: Mixed Dry Recycling	2: Dual Stream: Papers (Packaging and non-packaging) and Containers		3: Three Stream: Papers, Light Packaging and Glass		
		Papers	Containers	Papers	Plastics & Metals	Glass
Communal						
Communal Containers	1100L container	1100L container	1100L container	1100L container	1100L container	Wheeled bin
Households per Location	9	18	18	18	18	18
Communal Vehicles	26	15	15	15	15	8
Communal Crew	65	38	37	38	37	20
Belgrade Communal Site Pass Rate	300	285	315	285	300	774
Other Urban Communal Site Pass Rate	134	115	115	115	115	212
Rural Communal Site Pass Rate	84	59	59	59	59	85
Belgrade Communal Hhld Pass Rate	2,700	5,131	5,661	5,131	5,407	13,931
Other Urban Communal Hhld Pass Rate	1,203	2,073	2,073	2,073	2,073	3,824
Rural Communal Hhld Pass Rate	757	1,060	1,060	1,060	1,060	1,533

Table A - 18: Resources and Pass Rates for the Communal Sensitivity

	1: Mixed Dry Recycling	2: Dual Stream: Papers (Packaging and non-packaging) and Containers		3: Three Stream: Papers, Light Packaging and Glass		
		Papers	Containers	Papers	Plastics & Metals	Glass
Door to Door						
Door to Door Containers	Wheeled bin	Wheeled bin or sack	Wheeled bin	Wheeled bin or sack	Sack	Box
Door to Door Vehicles	78	51	37	51	51	29
Door to Door Crew	186	121	88	121	120	68
Belgrade Door to Door Pass Rate	1,148	1,400	1,200	1,400	1,961	1,581
Other Urban Door to Door Pass Rate	976	1,092	1,053	1,092	1,551	1,392
Rural Door to Door Pass Rate	872	1,034	884	1,034	1,244	1,130
Communal						
Communal Containers	1100L container	1100L container	1100L container	1100L container	1100L container	Wheeled bin
Households per Location	9	18	18	18	18	18
Communal Vehicles	76	49	49	49	49	31
Communal Crew	175	111	109	111	110	68
Belgrade Communal Site Pass Rate	300	279	328	279	300	755

	1: Mixed Dry Recycling	2: Dual Stream: Papers (Packaging and non-packaging) and Containers		3: Three Stream: Papers, Light Packaging and Glass		
		Papers	Containers	Papers	Plastics & Metals	Glass
Other Urban Communal Site Pass Rate	134	115	115	115	115	206
Rural Communal Site Pass Rate	84	59	59	59	59	83
Belgrade Communal Hhld Pass Rate	2,700	5,028	5,906	5,028	5,407	13,586
Other Urban Communal Hhld Pass Rate	1,203	2,073	2,073	2,073	2,073	3,710
Rural Communal Hhld Pass Rate	757	1,060	1,060	1,060	1,060	1,490

Table A - 19: Resources and Pass Rates for the DRS Sensitivity

	1: Mixed Dry Recycling	2: Dual Stream: Papers (Packaging and non-packaging) and Containers		3: Three Stream: Papers, Light Packaging and Glass		
		Papers	Containers	Papers	Plastics & Metals	Glass
Door to Door						
Door to Door Containers	Wheeled bin	Wheeled bin or sack	Wheeled bin	Wheeled bin or sack	Sack	Box
Door to Door Vehicles	201	113	201	113	122	82
Door to Door Crew	461	259	213	259	279	186

	1: Mixed Dry Recycling	2: Dual Stream: Papers (Packaging and non-packaging) and Containers		3: Three Stream: Papers, Light Packaging and Glass		
		Papers	Containers	Papers	Plastics & Metals	Glass
Belgrade Door to Door Pass Rate	1,116	1,370	1,116	1,370	1,774	1,564
Other Urban Door to Door Pass Rate	879	1,231	1,027	1,231	1,536	1,174
Rural Door to Door Pass Rate	773	1,016	801	1,016	1,233	872
Communal						
Communal Containers	1100L container	1100L container	1100L container	1100L container	1100L container	Wheeled bin
Households per Location	9	18	18	18	18	18
Communal Vehicles	26	15	15	15	17	15
Communal Crew	65	38	37	38	42	37
Belgrade Communal Site Pass Rate	300	294	300	294	244	328
Other Urban Communal Site Pass Rate	134	115	115	115	106	115
Rural Communal Site Pass Rate	84	59	59	59	56	59
Belgrade Communal Hhld Pass Rate	2,700	5,295	5,407	5,295	4,392	5,906
Other Urban Communal Hhld Pass Rate	1,203	2,073	2,073	2,073	1,909	2,073

	1: Mixed Dry Recycling	2: Dual Stream: Papers (Packaging and non-packaging) and Containers		3: Three Stream: Papers, Light Packaging and Glass		
		Papers	Containers	Papers	Plastics & Metals	Glass
Rural Communal Hhld Pass Rate	757	1,060	1,060	1,060	1,012	1,060

A.4.3 Cost (€) and Environmental Performance

The following tables display detailed cost and environmental performance results for each of the options.

A.4.3.1 Options 1-3

Table 7-3 - Option 1

	Belgrade	Cities	Rest	Total
	Tonnage Recycled			
Plastics	8,846	11,504	16,069	36,419
of which DRS	3,991	4,969	6,783	15,743
Metals	2,327	4,535	3,670	10,533
of which DRS	833	1,450	1,078	3,362
Glass	10,800	19,583	24,620	55,003
of which DRS	6,688	11,903	14,715	33,306
Paper	9,724	18,834	15,978	44,536
of which DRS (beverage cartons)	2,063	3,370	3,032	8,465
	Recycling Rate			
Household Packaging Recycling Rate				61%
EPR Contribution to the Recycling Rate				4%
	Cost Per Household - Separate Collection			
Mixed Dry Recycling Collection	4.49	6.17	7.28	6.16
Containers Collection				
Plastic and Metals				
Paper and Cardboard Collection				
Glass Collection				
Communication & Enforcement Costs	2.69	2.69	2.69	2.69
Transfer/Haulage Costs	0.10	0.29	0.57	0.27

	Belgrade	Cities	Rest	Total
EPR Sorting Costs	2.59	2.52	2.94	2.51
	Cost Per Household - Mixed Waste Collection			
Residual Collection	11.23	18.36	20.85	17.51
Mixed Waste Haulage Costs Per Household	0.98	2.34	2.39	2.03
Sorting Costs Per Household	0.00	0.00	0.00	0.00
Residual Disposal	53.40	21.61	19.66	28.66
	Material Revenues			
EPR Materials Income	-4.93	-4.83	-6.74	-5.15
	Disposal Costs (Packaging)			
Packaging Materials per Household	53.67	21.86	19.97	28.94
Unredeemed Deposits per Household				-0.03
	GHG Impacts, Kg per Household			
Collection Fuel				5.4
Haulage Fuel				1.2
Sorting Fuel				0.3
Sorting Electricity				2.1
Recycling Materials Impact				-30.5
Residual Disposal Impact				41
	Impact on Jobs			
EPR Collection Jobs	198	198	477	198
EPR Sorting Jobs	8	9	19	8
EPR Haulage Jobs	50	53	117	50
Total Jobs	**257**	**260**	**614**	**257**
	Producer Fees per Tonne			
Plastic Packaging				88
Metal Packaging				13
Glass Packaging				77
Paper/Card Packaging				47
Beverage Cartons				91
	Household Costs			
Non-packaging collection, haulage and sorting costs	2	2	2	2
	Capital Investment Needed			
Vehicles (Collections + Haulage)				€24.8M
Containers				€41.5M
EPR Sorting				€23.7M

Table 7-4 - Option 2

	Belgrade	Cities	Rest	Total
	Tonnage Recycled			
Plastics	8,846	11,504	16,069	36,419
of which DRS	3,991	4,969	6,783	15,743
Metals	2,327	4,535	3,670	10,533
of which DRS	833	1,450	1,078	3,362
Glass	10,800	19,583	24,620	55,003
of which DRS	6,688	11,903	14,715	33,306
Paper	10,229	19,855	16,832	46,915
of which DRS (beverage cartons)	2,063	3,370	3,032	8,465
	Recycling Rate			
Household Packaging Recycling Rate				62%
EPR Contribution to the Recycling Rate				4%
	Cost Per Household - Separate Collection			
Mixed Dry Recycling Collection				
Containers Collection	2.47	3.78	4.56	3.74
Plastic and Metals				
Paper and Cardboard Collection	2.64	3.92	4.86	3.94
Glass Collection				
Communication & Enforcement Costs	2.69	2.69	2.69	2.69
Transfer/Haulage Costs	0.10	0.29	0.35	0.26
EPR Sorting Costs	2.04	2.00	2.46	2.17
	Cost Per Household - Mixed Waste Collection			
Residual Collection	11.23	18.36	20.85	17.51
Mixed Waste Haulage Costs Per Household	0.98	2.34	2.39	2.03
Sorting Costs Per Household	0.00	0.00	0.00	0.00
Residual Disposal	53.41	21.62	19.66	28.67
	Material Revenues			
EPR Materials Income	-5.16	-5.05	-5.90	-5.38
	Disposal Costs (Packaging)			
Packaging Materials per Household	53.56	21.75	19.86	28.83
Unredeemed Deposits per Household				-0.03
	GHG Impacts, Kg per Household			
Collection Fuel				5.7
Haulage Fuel				1.2
Sorting Fuel				0.3

	Belgrade	Cities	Rest	Total
Sorting Electricity				2.0
Recycling Materials Impact				-31.2
Residual Disposal Impact				33
	Impact on Jobs			
EPR Collection Jobs	85	224	228	537
EPR Sorting Jobs	2	8	9	19
EPR Haulage Jobs	27	43	45	115
Total Jobs	**114**	**275**	**283**	**671**
	Producer Fees per Tonne			
Plastic Packaging				98
Metal Packaging				17
Glass Packaging				77
Paper/Card Packaging				53
Beverage Cartons				96
	Household Costs			
Non-packaging collection, haulage and sorting costs	2	2	3	2
	Capital Investment Needed			
Vehicles (Collections + Haulage)				€28.0M
Containers				€56.5M
EPR Sorting				€19.2M

Table 7-5 - Option 3

	Belgrade	Cities	Rest	Total
	Tonnage Recycled			
Plastics	8,846	11,504	16,069	36,419
of which DRS	3,991	4,969	6,783	15,743
Metals	2,327	4,535	3,670	10,533
of which DRS	833	1,450	1,078	3,362
Glass	10,967	20,070	25,436	56,473
of which DRS	6,688	11,903	14,715	33,306
Paper	10,229	19,855	16,832	46,915
of which DRS (beverage cartons)	2,063	3,370	3,032	8,465
	Recycling Rate			
Household Packaging Recycling Rate				62%
EPR Contribution to the Recycling Rate				4%
	Cost Per Household - Separate Collection			

	Belgrade	Cities	Rest	Total
Mixed Dry Recycling Collection				
Containers Collection				
Plastic and Metals	2.39	3.78	4.80	3.81
Paper and Cardboard Collection	2.64	3.92	4.86	3.94
Glass Collection	0.92	1.78	2.38	1.79
Communication & Enforcement Costs	2.69	2.69	2.69	2.69
Transfer/Haulage Costs	0.11	0.34	0.43	0.31
EPR Sorting Costs	1.89	1.79	2.14	1.94
	Cost Per Household - Mixed Waste Collection			
Residual Collection	11.24	18.36	20.85	17.52
Mixed Waste Haulage Costs Per Household	0.97	2.32	2.37	2.01
Sorting Costs Per Household	0.00	0.00	0.00	0.00
Residual Disposal	53.44	21.64	19.69	28.69
	Material Revenues			
EPR Materials Income	-5.24	-5.14	-6.03	-5.48
	Disposal Costs (Packaging)			
Packaging Materials per Household	53.55	21.74	19.84	28.81
Unredeemed Deposits per Household				-0.03
	GHG Impacts, Kg per Household			
Collection Fuel				6.6
Haulage Fuel				1.2
Sorting Fuel				0.3
Sorting Electricity				1.9
Recycling Materials Impact				-33.1
Residual Disposal Impact				33
	Impact on Jobs			
EPR Collection Jobs	114	317	337	767
EPR Sorting Jobs	3	9	11	23
EPR Haulage Jobs	26	40	42	108
Total Jobs	**143**	**366**	**389**	**898**
	Producer Fees per Tonne			
Plastic Packaging				104
Metal Packaging				21
Glass Packaging				109
Paper/Card Packaging				53
Beverage Cartons				102
	Household Costs			

	Belgrade	Cities	Rest	Total
Non-packaging collection, haulage and sorting costs	2	2	3	2
	Capital Investment Needed			
Vehicles (Collections + Haulage)				€36.9M
Containers				€35.8M
EPR Sorting				€16.5M

A.4.3.2 Options 1a-3a

Table 7-6 - Option 1a

	Belgrade	Cities	Rest	Total
	Tonnage Recycled			
Plastics	8,694	10,998	14,336	34,028
of which DRS	3,991	4,969	6,783	15,743
Metals	2,281	4,311	3,175	9,767
of which DRS	833	1,450	1,078	3,362
Glass	10,729	18,916	22,756	52,402
of which DRS	6,688	11,903	14,715	33,306
Paper	9,438	17,977	13,474	40,889
of which DRS (beverage cartons)	2,063	3,370	3,032	8,465
	Recycling Rate			
Household Packaging Recycling Rate				57%
EPR Contribution to the Recycling Rate				3%
	Cost Per Household - Separate Collection			
Mixed Dry Recycling Collection	3.77	5.38	6.13	5.25
Containers Collection				
Plastic and Metals				
Paper and Cardboard Collection				
Glass Collection				
Communication & Enforcement Costs	2.69	2.69	2.69	2.69
Transfer/Haulage Costs	0.09	0.27	0.29	0.23
EPR Sorting Costs	2.49	2.37	2.39	2.25
	Cost Per Household - Mixed Waste Collection			
Residual Collection	11.23	18.36	20.85	17.51

	Belgrade	Cities	Rest	Total
Mixed Waste Haulage Costs Per Household	0.98	2.36	2.44	2.05
Sorting Costs Per Household	0.00	0.00	0.00	0.00
Residual Disposal	53.47	21.72	20.05	28.86
	Material Revenues			
EPR Materials Income	-4.75	-4.52	-4.60	-4.60
	Disposal Costs (Packaging)			
Packaging Materials per Household	53.73	21.95	20.30	29.11
Unredeemed Deposits per Household				-0.03
	GHG Impacts, Kg per Household			
Collection Fuel				5.2
Haulage Fuel				1.2
Sorting Fuel				0.3
Sorting Electricity				1.8
Recycling Materials Impact				-27.2
Residual Disposal Impact				49
	Impact on Jobs			
EPR Collection Jobs	59	158	144	361
EPR Sorting Jobs	2	8	7	17
EPR Haulage Jobs	30	47	43	105
Total Jobs	**92**	**213**	**194**	**482**
	Producer Fees per Tonne			
Plastic Packaging				85
Metal Packaging				16
Glass Packaging				76
Paper/Card Packaging				44
Beverage Cartons				88
	Household Costs			
Non-packaging collection, haulage and sorting costs	1	2	2	2
	Capital Investment Needed			
Vehicles (Collections + Haulage)				€21.7M
Containers				€41.6M
EPR Sorting				€20.2M

Table 7-7 - Option 2a

	Belgrade	Cities	Rest	Total
	Tonnage Recycled			
Plastics	8,694	10,998	14,336	34,028
of which DRS	3,991	4,969	6,783	15,743
Metals	2,281	4,311	3,175	9,767
of which DRS	833	1,450	1,078	3,362
Glass	10,729	18,916	22,756	52,402
of which DRS	6,688	11,903	14,715	33,306
Paper	9,924	18,942	14,162	43,028
of which DRS (beverage cartons)	2,063	3,370	3,032	8,465
	Recycling Rate			
Household Packaging Recycling Rate				58%
EPR Contribution to the Recycling Rate				4%
	Cost Per Household - Separate Collection			
Mixed Dry Recycling Collection				
Containers Collection	2.00	3.09	3.92	3.12
Plastic and Metals				
Paper and Cardboard Collection	2.13	3.33	4.02	3.29
Glass Collection				
Communication & Enforcement Costs	2.69	2.69	2.69	2.69
Transfer/Haulage Costs	0.09	0.27	0.29	0.23
EPR Sorting Costs	1.97	1.87	2.00	1.94
	Cost Per Household - Mixed Waste Collection			
Residual Collection	11.23	18.36	20.85	17.51
Mixed Waste Haulage Costs Per Household	0.98	2.36	2.44	2.05
Sorting Costs Per Household	0.00	0.00	0.00	0.00
Residual Disposal	53.48	21.73	20.05	28.87
	Material Revenues			
EPR Materials Income	-4.97	-4.73	-4.79	-4.81
	Disposal Costs (Packaging)			
Packaging Materials per Household	53.63	21.86	20.22	29.01
Unredeemed Deposits per Household				-0.03
	GHG Impacts, Kg per Household			
Collection Fuel				5.5
Haulage Fuel				1.2
Sorting Fuel				0.3
Sorting Electricity				1.8
Recycling Materials Impact				-27.8

	Belgrade	Cities	Rest	Total
Residual Disposal Impact				42
	Impact on Jobs			
EPR Collection Jobs	62	181	187	429
EPR Sorting Jobs	2	8	7	17
EPR Haulage Jobs	26	40	37	103
Total Jobs	**90**	**229**	**231**	**550**
	Producer Fees per Tonne			
Plastic Packaging				91
Metal Packaging				18
Glass Packaging				76
Paper/Card Packaging				48
Beverage Cartons				92
	Household Costs			
Non-packaging collection, haulage and sorting costs	1	2	2	2
	Capital Investment Needed			
Vehicles (Collections + Haulage)				€26.2M
Containers				€48.2M
EPR Sorting				€16.1M

Table 7-8 - Option 3a

	Belgrade	Cities	Rest	Total
	Tonnage Recycled			
Plastics	8,694	10,998	14,336	34,028
of which DRS	3,991	4,969	6,783	15,743
Metals	2,281	4,311	3,175	9,767
of which DRS	833	1,450	1,078	3,362
Glass	10,859	19,053	22,595	52,507
of which DRS	6,688	11,903	14,715	33,306
Paper	9,924	18,942	14,162	43,028
of which DRS (beverage cartons)	2,063	3,370	3,032	8,465
	Recycling Rate			
Household Packaging Recycling Rate				58%
EPR Contribution to the Recycling Rate				4%
	Cost Per Household - Separate Collection			
Mixed Dry Recycling Collection				
Containers Collection				

	Belgrade	Cities	Rest	Total
Plastic and Metals	1.97	3.10	4.01	3.15
Paper and Cardboard Collection	2.13	3.33	4.02	3.29
Glass Collection	0.64	1.34	1.83	1.35
Communication & Enforcement Costs	2.69	2.69	2.69	2.69
Transfer/Haulage Costs	0.11	0.32	0.35	0.28
EPR Sorting Costs	1.82	1.67	1.74	1.74
	Cost Per Household - Mixed Waste Collection			
Residual Collection	11.24	18.36	20.85	17.52
Mixed Waste Haulage Costs Per Household	0.98	2.34	2.43	2.04
Sorting Costs Per Household	0.00	0.00	0.00	0.00
Residual Disposal	53.51	21.76	20.10	28.91
	Material Revenues			
EPR Materials Income	-5.04	-4.81	-4.88	-4.89
	Disposal Costs (Packaging)			
Packaging Materials per Household	53.62	21.85	20.22	29.01
Unredeemed Deposits per Household				0.03
	GHG Impacts, Kg per Household			
Collection Fuel				6.21
Haulage Fuel				1.25
Sorting Fuel				0.26
Sorting Electricity				1.76
Recycling Materials Impact				-36.00
Residual Disposal Impact				42.54
	Impact on Jobs			
EPR Collection Jobs	82	248	261	592
EPR Sorting Jobs	3	9	9	20
EPR Haulage Jobs	25	38	34	97
Total Jobs	**109**	**295**	**304**	**709**
	Producer Fees per Tonne			
Plastic Packaging				96
Metal Packaging				22
Glass Packaging				98
Paper/Card Packaging				48
Beverage Cartons				96
	Household Costs			
Non-packaging collection, haulage and sorting costs	1	2	2	2
	Capital Investment Needed			

	Belgrade	Cities	Rest	Total
Vehicles (Collections + Haulage)				€32.3M
Containers				€39.5M
EPR Sorting				€13.8M

A.4.3.3 Options 1b-3b

Table 7-9 - Option 1b

	Belgrade	Cities	Rest	Total
	Tonnage Recycled			
Plastics	7,101	9,558	13,582	30,241
of which DRS	0	0	0	0
Metals	1,954	3,946	3,263	9,162
of which DRS	0	0	0	0
Glass	7,905	14,764	19,040	41,709
of which DRS	0	0	0	0
Paper	8,634	17,169	14,552	40,355
of which DRS (beverage cartons)	0	0	0	0
	Recycling Rate			
Household Packaging Recycling Rate				50%
EPR Contribution to the Recycling Rate				5%
	Cost Per Household - Separate Collection			
Mixed Dry Recycling Collection	4.49	6.72	7.84	6.58
Containers Collection				
Plastic and Metals				
Paper and Cardboard Collection				
Glass Collection				
Communication & Enforcement Costs	2.69	2.69	2.69	2.69
Transfer/Haulage Costs	0.12	0.36	0.46	0.33
EPR Sorting Costs	3.11	3.07	3.69	3.09
	Cost Per Household - Mixed Waste Collection			
Residual Collection	11.28	18.36	20.85	17.53
Mixed Waste Haulage Costs Per Household	1.00	2.40	2.45	2.08
Sorting Costs Per Household	0.00	0.00	0.00	0.00
Residual Disposal	53.58	21.76	19.84	28.83
	Material Revenues			
EPR Materials Income	-6.47	-6.28	-7.48	-6.76

	Belgrade	Cities	Rest	Total
	Disposal Costs (Packaging)			
Packaging Materials per Household	53.91	22.07	20.23	29.17
Unredeemed Deposits per Household				0
	GHG Impacts, Kg per Household			
Collection Fuel				5.5
Haulage Fuel				1.2
Sorting Fuel				0.4
Sorting Electricity				2.5
Recycling Materials Impact				-43.8
Residual Disposal Impact				44
	Impact on Jobs			
EPR Collection Jobs	81	225	220	526
EPR Sorting Jobs	3	10	12	25
EPR Haulage Jobs	38	61	66	144
Total Jobs	**122**	**297**	**298**	**695**
	Producer Fees per Tonne			
Plastic Packaging				81
Metal Packaging				0
Glass Packaging				85
Paper/Card Packaging				42
Beverage Cartons				249
	Household Costs			
Non-packaging collection, haulage and sorting costs	1	2	2	2
	Capital Investment Needed			
Vehicles (Collections + Haulage)				€27.4M
Containers				€41.5M
EPR Sorting				€27.8M

Table 7-10 - Option 2b

	Belgrade	Cities	Rest	Total
	Tonnage Recycled			
Plastics	7,101	9,558	13,582	30,241
of which DRS	0	0	0	0
Metals	1,954	3,946	3,263	9,162
of which DRS	0	0	0	0
Glass	7,905	14,764	19,040	41,709
of which DRS	0	0	0	0
Paper	9,139	18,190	15,406	42,734

	Belgrade	Cities	Rest	Total
of which DRS (beverage cartons)	0	0	0	0
	Recycling Rate			
Household Packaging Recycling Rate				51%
EPR Contribution to the Recycling Rate				6%
	Cost Per Household - Separate Collection			
Mixed Dry Recycling Collection				
Containers Collection	2.59	3.78	4.75	3.84
Plastic and Metals	2.63	3.92	4.86	3.94
Paper and Cardboard Collection	2.63	3.92	4.86	3.94
Glass Collection				
Communication & Enforcement Costs	2.69	2.69	2.69	2.69
Transfer/Haulage Costs	0.11	0.35	0.44	0.32
EPR Sorting Costs	2.69	2.68	3.40	2.94
	Cost Per Household - Mixed Waste Collection			
Residual Collection	11.28	18.36	20.85	17.53
Mixed Waste Haulage Costs Per Household	1.00	2.40	2.46	2.08
Sorting Costs Per Household	0.00	0.00	0.00	0.00
Residual Disposal	53.58	21.76	19.83	28.83
	Material Revenues			
EPR Materials Income	-6.70	-6.51	-7.71	-6.99
	Disposal Costs (Packaging)			
Packaging Materials per Household	53.80	21.97	20.12	29.07
Unredeemed Deposits per Household				0.00
	GHG Impacts, Kg per Household			
Collection Fuel				5.7
Haulage Fuel				1.2
Sorting Fuel				0.4
Sorting Electricity				2.5
Recycling Materials Impact				-44.5
Residual Disposal Impact				36
	Impact on Jobs			
EPR Collection Jobs	88	224	236	547
EPR Sorting Jobs	3	10	11	24
EPR Haulage Jobs	33	53	58	144
Total Jobs	**124**	**287**	**305**	**715**
	Producer Fees per Tonne			
Plastic Packaging				81
Metal Packaging				0

	Belgrade	Cities	Rest	Total
Glass Packaging				82
Paper/Card Packaging				53
Bverage Cartons				242
	Household Costs			
Non-packaging collection, haulage and sorting costs	2	2	3	2
	Capital Investment Needed			
Vehicles (Collections + Haulage)				€28.7M
Containers				€56.5M
EPR Sorting				€25.7M

Table 7-11 - Option 3b

	Belgrade	Cities	Rest	Total
	Tonnage Recycled			
Plastics	7,101	9,558	13,582	30,241
of which DRS	0	0	0	0
Metals	1,954	3,946	3,263	9,162
of which DRS	0	0	0	0
Glass	8,608	16,076	20,732	45,416
of which DRS	0	0	0	0
Paper	9,139	18,190	15,406	42,734
of which DRS (beverage cartons)	0	0	0	0
	Recycling Rate			
Household Packaging Recycling Rate				53%
EPR Contribution to the Recycling Rate				6%
	Cost Per Household - Separate Collection			
Mixed Dry Recycling Collection				
Containers Collection				
Plastic and Metals	2.86	3.95	4.86	4.01
Paper and Cardboard Collection	2.63	3.92	4.86	3.94
Glass Collection	1.15	2.21	3.01	2.24
Communication & Enforcement Costs	2.69	2.69	2.69	2.69
Transfer/Haulage Costs	0.14	0.42	0.54	0.39
EPR Sorting Costs	2.32	2.18	0.00	2.39
	Cost Per Household - Mixed Waste Collection			
Residual Collection	11.37	18.36	20.85	17.55

	Belgrade	Cities	Rest	Total
Mixed Waste Haulage Costs Per Household	0.99	2.37	2.43	2.06
Sorting Costs Per Household	0.00	0.00	0.00	0.00
Residual Disposal	53.61	21.80	19.88	28.87
	Material Revenues			
EPR Materials Income	-6.86	-6.69	-7.97	-7.19
	Disposal Costs (Packaging)			
Packaging Materials per Household	53.77	21.93	20.07	29.03
Unredeemed Deposits per Household				0.00
	GHG Impacts, Kg per Household			
Collection Fuel				6.9
Haulage Fuel				1.2
Sorting Fuel				0.3
Sorting Electricity				2.3
Recycling Materials Impact				-48.3
Residual Disposal Impact				36
	Impact on Jobs			
EPR Collection Jobs	126	337	358	821
EPR Sorting Jobs	3	12	14	29
EPR Haulage Jobs	30	46	0	125
Total Jobs	**159**	**396**	**371**	**975**
	Producer Fees per Tonne			
Plastic Packaging				85
Metal Packaging				0
Glass Packaging				118
Paper/Card Packaging				53
Beverage Cartons				281
	Household Costs			
Non-packaging collection, haulage and sorting costs	2	2	2	2
	Capital Investment Needed			
Vehicles (Collections + Haulage)				€39.0M
Containers				€39.5M
EPR Sorting				€19.8M