# NALED Serbia

## Deposit Return System Study

Final report

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## Version Control Table

| Version | Date | Description |
| --- | --- | --- |
| **V1.0** | 21/05/21 | Report Outline |
| **V2.0** | 30/06/21 | Draft Report |
| **V3.0** | 13/09/21 | Final Report without material sensitivities (section 5.4.1) |
| **V4.0** | 30/09/21 | Final Report |

# Executive Summary

## E.1.0 Introduction and Objectives

The National Alliance for Local Economic Development (NALED), in association with companies in the Serbian packaging supply chain, has commissioned Eunomia Research & Consulting (Eunomia) to undertake a comprehensive study and to determine the costs and benefits of the introduction of a Deposit Return System (DRS) in Serbia for beverage containers. This includes the consideration of a “Smart DRS” option, to ensure that the system proposed is futureproofed and cutting edge. To investigate this, three main scenarios have been analysed in this report: a conventional DRS, a Smart DRS with high cost estimates (named “Smart High”) and a Smart DRS with low cost estimates (named “Smart Low”).

The objectives of the project are:

- To provide a comprehensive study on introduction of Deposit Return System (DRS) in Serbia;
- To assess the organizational, managerial, financial and operational aspects of the introduction of the DRS; and
- To help to enable an effective and efficient system upon its potential introduction.

## E.2.0 System Design and Modelling

A DRS model was undertaken for the three scenarios based on different inputs; some data was provided by NALED members such as beverage containers placed on the market (PoM). Some key assumptions used are a return rate of 90% and different loss and fraud rates for each return technology. The Smart DRS has inherent uncertainties around its application due to its novelty – this is why a high-low range was used.

Additional to the three scenarios, four sensitivities were analysed which are compared to the model assumptions used for the central scenario, these are shown in Table E-1.

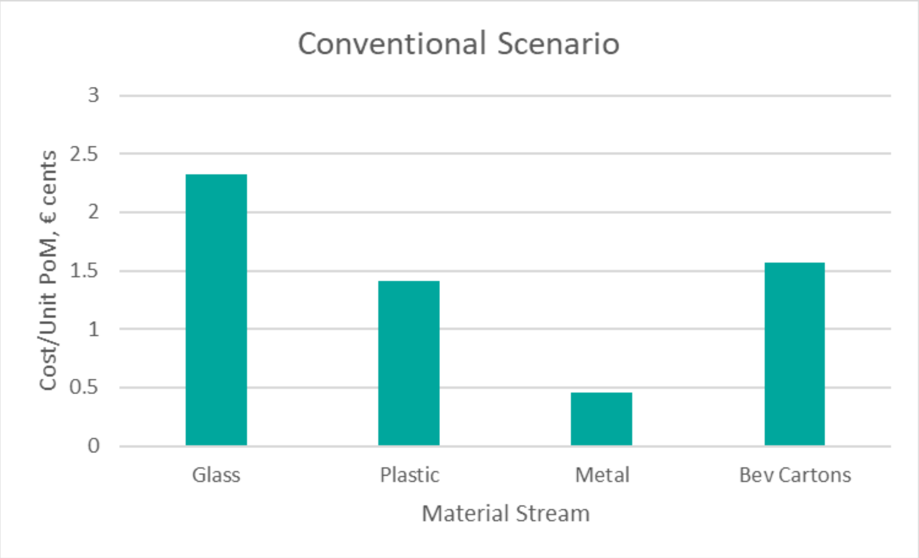
### Table E-1 Overview of Sensitivity Analysis

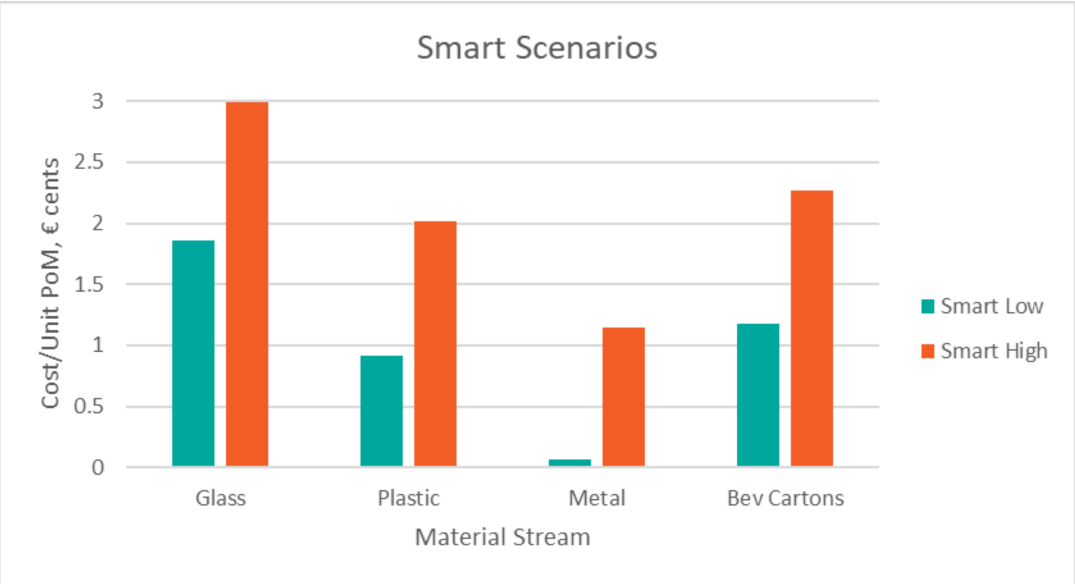
| | Central Scenario | Sensitivities |
|---|---:|---:|
| **Materials included** | Plastic, cans, glass and cartons | 1) Plastic and cans only;<br>2) Plastic, cans and cartons;<br>3) Plastic, cans and glass |
| **Wines and Spirits** | Included | Excluded |
| **Deposit level** | 5 RSD | Multi-level |
| **Return Rate** | 90% | Low (88%) and High (92%) |

## E.3.0 Results and Conclusions

The results found that the system net annual costs are €25.4 million for the Conventional scenario and €13.5-30.9 million for the Smart scenarios (high and low), to be funded by producer fees.

**Figures E-1 Producer fees per material stream in the three scenarios**




- The conventional DRS would result in a net cost of €1.4 cents per unit placed on the market to be funded by producer fee.
- The Smart DRS model has produced a range of costs (€0.9 to €2.0 cents per unit placed on the market) that suggest that a well-designed Smart DRS could achieve the same results as the Conventional DRS with slightly lower costs, but potentially also higher costs.

Four different sensitivities have been analysed:

- With the regards to the **materials included**, the cheapest option would be only including plastic and cans, followed by the options of excluding glass or beverage cartons. Finally having the four material streams would be the most expensive option, but there are other factors to be considered, such as the fairness of the approach, the reduction of litter, the contribution to the recycling targets and the availability of high-quality secondary materials.
- The scenario that excludes **wines and spirits** leads to higher costs so the inclusion of wines and spirits is recommended.
- The model suggests that the multi-level deposit would lead to a higher producer fee in conventional DRS while a lower fee in Smart DRS; therefore, and in the absence of a strong case for a multi-level structure, the simpler system of a **flat fee** is recommended.
- The **return rate** is a key variable of the DRS and it has been modelled at 90%; however a variation of 2pp of the rate (88% or 92%) would lead to much higher variations of the producer fee, according to the interplay of key variables such as material income, unredeemed deposits and transport and handling fees.

The implementation of a DRS in Serbia would have **social and environmental impacts**, summarised as:

- The creation of 1,270 jobs;
- More than doubling the number of deposit-bearing beverage containers that are recycled and reducing landfill and littering of containers to around a fifth of the current volumes;
- Monetised savings associated with greenhouse gas reductions and air quality improvements equivalent to €1.4 million annually; and
- Reduced litter disamenity estimated at €553 million annually.

Overall, the introduction of a well-designed and well-operated DRS in Serbia should reach high collection targets and, as a result, contribute to increased recycling rates, significant environmental benefits and employment.

## E.4.0 Implementation

The implementation of a DRS can be achieved successfully within a 24 -30 month timeframe but this should be viewed as the minimum period needed. Where countries have tried to implement a DRS in a much shorter time frame (e.g. Estonia in 16 months), they ran into “teething troubles”, that at later stage took a great deal of time and effort to resolve and created significant financial issues. Lithuania delivered a successful scheme within 18 months, but it is a small country by European standards. The primary factors that can slow the implementation process down are:

- **Lack of cooperation** – where stakeholders prolong discussions and consultation in order to try to steer the DRS in line with their commercial interests.
- **Unfamiliarity with DRS** – stakeholders that are unfamiliar with a DRS, such as national retailers may need time to come on board with the project.
- **Population** – scaling up for this – This will greatly affect the practical implementation by increasing the numbers of counting centres and return locations required.
- There may also be issues **if several countries decided to implement a DRS in the same year.** For instance, sourcing the raw materials for RVM components could be problematic if a large number of RVMs are ordered in a short timeframe.

The main ways in which the Government and Central System Operator (CSO) can work to keep the implementation phase to a minimum are:

- Simple legislation that sets the parameters for the CSO 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.
- Care in appointing the CSO CEO (and management) as this is a critical role requiring someone with management oversight and diplomatic tenacity.
- Coordinated dialogue with stakeholders to ensure a smooth implementation and facilitate an agreement on the handling fee.
- Early outlining of the obligations for producers and retailers to allow them maximum time for decision making and preparations.
- A clear tender process for external providers of infrastructure and transport facilities.

# Contents

# Glossary

| Acronym | Definition |
| --- | --- |
| **AQ** | air quality |
| **CC** | Counting Centres |
| **CSO** | Central System Operator |
| **DRS** | Deposit Return System |
| **ECL** | Error correction level |
| **EPR** | Extended Producer Responsibility |
| **GHG** | Greenhouse gas |
| **GTIN** | Global Trade Identification Number |
| **HORECA** | hotel / restaurant / café |
| **MRF** | Material recovery facility |
| **PET** | polyethylene terephthalate |
| **PoM** | Placed on the market |
| **PPP** | purchasing power parity |
| **PRO** | Producer Responsibility Organisation |
| **QR** | Quick response (code) |
| **RHF** | Retailer handling fee |
| **RFID** | Radio Frequency Identification |
| **RVM** | Reverse Vending Machine |
| **Smart DRS** | DRS that utilises newer technologies allowing for serialisation of each item (see sections 2.2 and A.2.0 for more details) |

# 1.0 Introduction

## 1.1 Background and objectives

The National Alliance for Local Economic Development (NALED), in association with companies in the Serbian packaging supply chain, has commissioned Eunomia Research & Consulting (Eunomia) to undertake a comprehensive study to determine the costs and benefits of the introduction of a Deposit Return System (DRS) in Serbia for beverage containers. This includes the consideration of a “Smart DRS” option, to help future-proof the DRS by taking into account emerging technologies, many of which are currently untested at large scale. To investigate this, Eunomia used a proprietary DRS Model, which models both conventional and smart DRS options for comparison.

The objectives of the project are:

- To provide a comprehensive study on the introduction of a Deposit Return System (DRS) in Serbia;
- To assess the organizational, managerial, financial and operational aspects of the introduction of the DRS; and
- To help to enable an effective and efficient system upon its potential introduction.

This report will provide a summary of the DRS modelling undertaken, including an explanation of the benefits of DRS, the results modelled, analysis of sensitivities and assumptions utilised.

## 1.2 Structure of the report and appendices

- Section 2.0 shows an overview of Conventional and Smart DRS; the full details can be found in
  - A.1.0 Background info on DRS
  - A.2.0 Smart DRS Approach
- Section 3.0 describes the System Design choices, both for Smart and Conventional scenarios modelled; the full details are available in a separate document entitled DRS System Design
- Section 4.0 shows an overview of the inputs and the assumptions; the full details can be found in A.4.0 DRS System Modelling;
- Section 5.0 shows the cost modelling results;
- Section 6.0 shows the environmental and social impacts; and
- Section 7.0 provides implementation considerations; and
- Section 8.0 provides conclusions.

In addition to this report, there is an accompanying document entitled **DRS System Design**.

Finally, this report will work together with the parallel **EPR study for Serbia**.

Figure 1-1 Model inputs/results mapped to sections of the report


# 2.0 DRS: Conventional and Smart scenarios

This section describes the two main scenarios analysed in this report: conventional and Smart. Section A.1.0 provides an overview of a DRS system, the objectives and benefits.

## 2.1 Conventional DRS

A DRS for one-way beverage containers is a system that incentivises the return of the beverage containers (most commonly cans and bottles) to collection points, using a refundable deposit (in the EU the deposit value is typically EUR ¢10-25 per item). Consumers pay the deposit when they purchase the beverage and the deposit is refunded when they return the used container to a designated collection point to be recycled. If a consumer chooses not to return the used container, then they lose the deposit. Under conventional DRS in European countries, collection points are located in, or near, retail outlets, with the vast majority of returns via automated 'reverse vending machines' (RVMs).

A number of EU Member States are actively considering the introduction of DRS, driven by a range of widely accepted benefits of a well-designed DRS, including:

- **Increased collection rates**: return rates for beverage packaging in high performing DRS often exceed 90% of packaging placed on the market. The evidence suggests that other approaches such as door-to-door collection cannot meet these very high return rates. Focus on DRS has increased considerably since the EU's Single Use Plastics Directive introduced a target of 90% separate collection for plastic beverage bottles by 2030, with the vast majority of non-DRS Member States actively considering the introduction of a DRS for beverage packaging.[1]

[1] Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L:2019:155:TOC

- **Reduced littering**: research indicates that a well-designed DRS could reduce the littering of beverage containers by 95%. On the basis that approximately 40% by volume of litter is comprised of beverage containers, the volume of all litter could be reduced by approximately a third.[2]
- **Reliable supply of high-quality material**: a DRS provides a well-defined single stream collection, with material collected generally of a higher quality and less contaminated than that obtained through other collection methods. As governments and brand owners seek to drive up recycled content in packaging, clean streams of food grade secondary material become increasingly important.

## 2.2 Smart DRS

A well designed 'conventional' DRS is a well-proven means to deliver high collection rates of good quality recyclable material. However, that does not mean that conventional DRS cannot be improved upon, especially with the advent of technological innovations such as QR (quick response) codes and powerful handheld hardware and software, not least in the form of the smartphone. The founding thesis of this study therefore is that a more efficient and effective DRS might be possible by redesigning the system to use Smart technology.[3] Smart DRS is similar to conventional DRS in the fact that it utilises retailers, hotels, restaurants, cafes and petrol stations, but also looks to add additional return locations, as well as to utilise new and novel technologies. A major difference is that a Smart DRS relies on serialisation, with each individual beverage container requiring a unique identifier.

The starting point for this has been an examination of areas where the already successful conventional DRS concept could be improved upon:

- **Cost**: high performing conventional DRS requires a payment from producers (typically EUR ¢1-3 per item placed on the market), which is generally passed on to consumers within the retail price of each beverage. The costs in conventional DRS are heavily driven by the capital, operating and hosting costs associated with RVMs. Materials collected from manual return points (small retailers and hotels, restaurants and cafes etc.) must also be sent to regional counting centres to be verified. To varying degrees, fraud can also be an issue with existing DRS. If DRS can become less reliant on conventional RVMs and counting centres, it may be possible to reduce overall costs. It is, however, worth noting that in the Swedish conventional DRS and the Estonian, for instance, there is no fee for aluminium cans and, in Norway, there is a "negative fee", so producers are effectively paid by the DRS for aluminium cans.[4]
- **Consumer Compatibility**: RVMs are a well-established technology that consumers tend to adapt to quickly, finding them convenient enough to deliver

[2] Eunomia Research & Consulting (2017) *Impacts of a Deposit Refund System for One-way Beverage Packaging on Local Authority Waste Services*, 2017

[3] Section A.2.0 provides more details about the return technologies of the Smart DRS.

[4] https://assets.rp-pm-prod.pantamera.nu/492f7c/globalassets/documents/bilaga-3---pant-och-avgifter.pdf; https://eestipandipakend.ee/wp-content/uploads/2019/11/Annex1-01012020.pdf; https://infinitum.no/kostnadskalkulator/

high return rates. However, they are designed around a consumer habit of regular in-store grocery shopping in medium-to-large supermarkets. Whilst almost universal when the first modern RVMs were installed in the 1990s, this retail channel is now under increasing threat from alternatives, including online shopping. Consumption of beverages outside the home has also increased dramatically, with in-store RVMs not necessarily a convenient return channel in the context of increasingly on-the-go lifestyles. As shopping and consuming habits continue to change, it seems likely that a wider range of return locations will increasingly be an advantage for a modern DRS.

- **Performance**: Most European countries with a DRS are already achieving DRS return rates in excess of 90% (Germany, for instance, reports a return rate of 98%).[5] This would, therefore, be sufficient to meet the SUP Directive target for plastic bottles. However, with the increasing political focus on carbon emissions, the benefits of incrementally higher recycling rates, especially for the most technically recyclable materials in our economy, are likely to become increasingly recognised and incentivised so it is important to consider possibilities that could support further increases in the return rate.

These three aspects will be further explored in section 2.3 to 2.5.

It has been proposed by stakeholders advocating the consideration of a Smart DRS that increasing the accessibility and 'lifestyle alignment' of return locations could, all else being equal, increase return rates and that, by leveraging new technology, costs could be reduced – addressing the potential areas for improvement identified above.

The DRS System Design report includes more details about Conventional and Smart DRS, and we reproduce here the summary table for comparison.

**Table 2-1 Comparison of Smart and Conventional DRS**

| | Smart DRS | Conventional DRS |
|---|---|---|
| **Return Opportunities** | RVMs at large retailers, manual returns at small retailers.<br><br>Smartphone enabled receptacles in a wide range of public places. More convenient and more locations than conventional.<br><br>Additional options needed to ensure the system is accessible for consumers without smartphones (e.g. hand-held scanners could be issued). | RVMs at large retailers, manual returns at small retailers, petrol stations and HORECA. |

[5] https://www.reloopplatform.org/wp-content/uploads/2020/12/2020-Global-Deposit-Book-WEB-version-1DEC2020.pdf

| | Smart DRS | Conventional DRS |
|---|---|---|
| **Fraud** | Serialisation prevents multiple redemption. | RVMs scan container barcodes, size and shape and provide data to identify unusually high volumes. Compaction prevents multiple redemption.<br>Counting centres needed for containers returned manually. |
| **Beverage Container Labels** | Unique identifier required – the economic feasibility of this could depend on the size of the beverage market and company's production and distribution lines. | No serialisation so production lines do not need to be changed, beyond incorporating deposit logo. National barcodes (entailing higher production/ distribution costs for producers) may be incentivised by lower producer fee. |
| **Material Quality** | More susceptible to contamination so material will be less pure and loss rates will be higher than in conventional DRS.[6] | RVMs can reject non-deposit-bearing items and separate containers by material. High quality material / limited contamination supports high material values and closed loop, bottle-to-bottle recycling. |
| **Return Rate** | While untested, the expanded and more convenient return opportunities should achieve a higher return rate than a comparable conventional system.<br>It is thought that this could compensate for the higher loss rates. | Well-designed systems reliably achieve over 90%. |
| **Retailers** | Retailers host RVMs or provide manual service and are paid a handling fee for each container they take back. Return points are also located in other places, so less likely that a universal take back obligation is placed on all retailers. | Retailers host RVMs or provide manual service and are paid a handling fee for each container they take back. Return points are exclusively located within retailers, HORECA and petrol stations. If a universal take back obligation is in place, all retailers must accept returned containers. |
| **Logistics** | Higher number of return locations and lack of compaction on site means costs, carbon emissions and air pollutants depend on whether containers are collected with other recycling services. | Majority of containers compacted before collection and reverse logistics / defined and limited collection points can be used to reduce financial and environmental costs. |
| **Capital Expenditure** | Lower set-up costs as less infrastructure required. | While the costs are annualised, RVMs and counting centres entail significant investment. |

[6] See System Design Report: some smart return technologies have higher contamination potential; for instance, once the hatch of the smart bin is opened, any object can be dropped in.

## 2.3 Cost

The costs of a conventional DRS relate to: RVMs, retailer resources, transport of the returned containers, counting centres, sorting and administration. Higher return rates will increase the total operating costs (but not necessarily the cost per container).

In conventional DRSs, the costs associated with the capital, operating and hosting of RVMs account for a substantial proportion of overall costs. While RVMs usually reduce total system costs compared to manual take-back (by reducing fraud and compacting the containers to reduce storage, transport and counting centre costs), they entail significant capital investment. On average, a full-size multi-material compacting RVM has a unit capital cost of around €36,000 to €45,000 plus installation, even if there are smaller models available. Relatively urbanised countries would require approximately one of these machines per 3,000 inhabitants (although the density could be as high as one for every 2,000 inhabitants), with the intention of utilising each RVM's throughput capacity.

Although the CSO provides the RVMs in some countries, they are more commonly purchased/ hired by retailers who recoup their costs through the Retailer Handling Fee (RHF). The RHF is an average fee paid to retailers by the CSO for each container they take back and is intended to compensate retailers for the average costs of RVMs, retail space used and staff time (meaning a higher RHF for retailers with an RVM than for retailers providing a manual service). Generally, the retailer will decide whether the costs of an RVM are justified by the number of containers they are likely to take back (i.e. whether they will earn enough RHF to cover the costs).

While CSOs seek to design the most efficient logistics operations to minimise the costs of transporting the containers, transport costs are nevertheless a significant outlay, particularly if the containers have not been compacted by a compacting RVM. Furthermore, containers returned manually necessitate regional counting centres to verify the materials collected. The number of these counting centres will depend on the population and geography of a country but the cost of manual returns per item placed on the market is typically higher relative to RVM returns.

Fraudulent activity within the system is also a potential cost, although most European systems have developed cost-effective prevention measures. In Norway, for instance, it is estimated that fraudulent containers account for just 0.1% of the total number of returned containers. In Sweden, the CSO estimates that less than 0.5% of returned cans are fraudulent (meaning a deposit refund is not owed).[7]

The essential functions performed by RVMs include verification (via print barcode scanning), counting, sorting and compacting each returned item. The RVM verification and compaction are designed to reject non-deposit bearing containers so that refunds are only issued for containers on which a deposit was paid in the first instance, and to make it physically impossible for a container to be returned for a refund more than once (because deposit refunds are only issued for intact containers with a readable barcode). Compaction also

[7] Private communications with Infinitum and Returpack

reduces transport costs by increasing the number of containers that can be carried by each vehicle.

The majority of DRS costs are typically covered by the sale of collected materials and 'unredeemed' deposits.[8] The remaining net costs are covered by beverage producers, with a Producer Fee for each container placed on the market (although aluminium cans often have a zero producer fee due to the high material value).

A CSO should be working to continually increase return rates, which would mean higher costs and reduced revenue from unredeemed deposits (albeit with an increased income from material sales), meaning an increase in costs for producers, all else being equal. Designing a system to be more efficient and to reduce operating costs – while the return rate, deposit value and material revenues are unchanged – will therefore mean lower costs for producers, which should then benefit their customers. This is especially important when considering these savings from a social inclusion point of view, as a relatively small change in price caused by a conventional DRS (the EUR ¢1-3 figure mentioned above) is likely to have a more significant impact on the consumers with the lowest disposable incomes.

## 2.4 Consumer Compatibility

Consumers generally adapt quickly to RVMs, a well-established technology, as they are found to be convenient and user-friendly, thus yielding high return rates across many countries.  However, when the first RVMs were installed in the 1990s, they were designed to fit into an aspect of life that was almost universal – the 'weekly shop'. As a result, many RVMs can be found in the vicinity of a supermarket. However, in existing DRS countries, such as Norway, supermarkets are becoming less relevant, primarily driven by increasingly on-the-go lifestyles and increased interest in local produce[9]. This has resulted in a more recent shift towards online shopping and home deliveries, the rise of 'mini-supermarkets' in cities and home delivered takeaway products – none of which fit naturally with the conventional RVM DRS system. In 2020, there was an indication of the return of the 'weekly shop' due to the 2020 COVID-19 pandemic. However, the long-term effects on retail due to the pandemic seem to point to an accelerated shift to online shopping.

Another crucial consequence of increasingly on-the-go lifestyles is the dramatic increase of beverages consumed outside the home[10], particularly when compared to the levels seen when modern RVMs were first being developed. This ultimately presents the consumer with a relatively simple choice, either they take a single item to a larger retailer with an RVM while out and about, a smaller retailer for manual takeback, or they take that container back home where they add it to their existing stock of empty containers to be taken to a return point at a later date. To tackle occasions when the deposit is not a sufficient incentive for the consumer to make the effort to return the empty container to a return point, many cities have fitted bins with a separate holder for consumers to deposit their containers.

[8] Unredeemed deposits relate to items that are not returned and instead, either become part of another waste management system or leak into the environment as litter.
[9] https://info.deloitte.no/rs/777-LHW-455/images/2019-11-deloitte-shopping-center-survey.pdf
[10] https://think.ing.com/articles/ready-to-drink-operates-at-the-intersection-of-several-trends

These are then collected and reverse-vended by another individual to whom the incentive of the deposit is sufficient.

**Figure 2-1 Example of fitted bins with separate holders**

In theory, this is a clever solution but in practice, this technique relies on the existence of economically marginalised people who are willing to collect the containers to potentially support their income. Although this solution supplies a potential income stream outside of the state benefits system, this informal part of the economy could raise a number of ethical concerns. For example, this could be seen as reliance on unpaid workers to clean up streets or bins, rather than fairly rewarded workers.

Clearly, even when well-designed conventional RVM systems have high capture rates, they still have their limitations. As behaviours surrounding shopping and consumer habits continue to change, it seems increasingly likely that a wider range of return locations (e.g. street corners, offices) will present an advantage for a modern DRS. If these collection networks are to be widened to account for more types of return locations, technological solutions beyond conventional RVMs are required.

## 2.5 Performance

It is widely evident that there is a positive relationship between the convenience of collection systems for recyclables and the recycling rates of target materials.[11] As a result of this, separate door-to-door collection of recycling and biowaste has proliferated, alongside the supply of 'near entry' collection points in apartment buildings. A combination of an appropriately priced deposit relative to purchasing power with an extended network of retail-based return locations is highly probable to yield high return rates. This combination of economic incentive and convenience of return location is indeed sufficient to achieve recycling rates that are significantly higher than any other combination of infrastructure ad incentives (for example, kerbside collection combined with 'pay-as-you-throw').

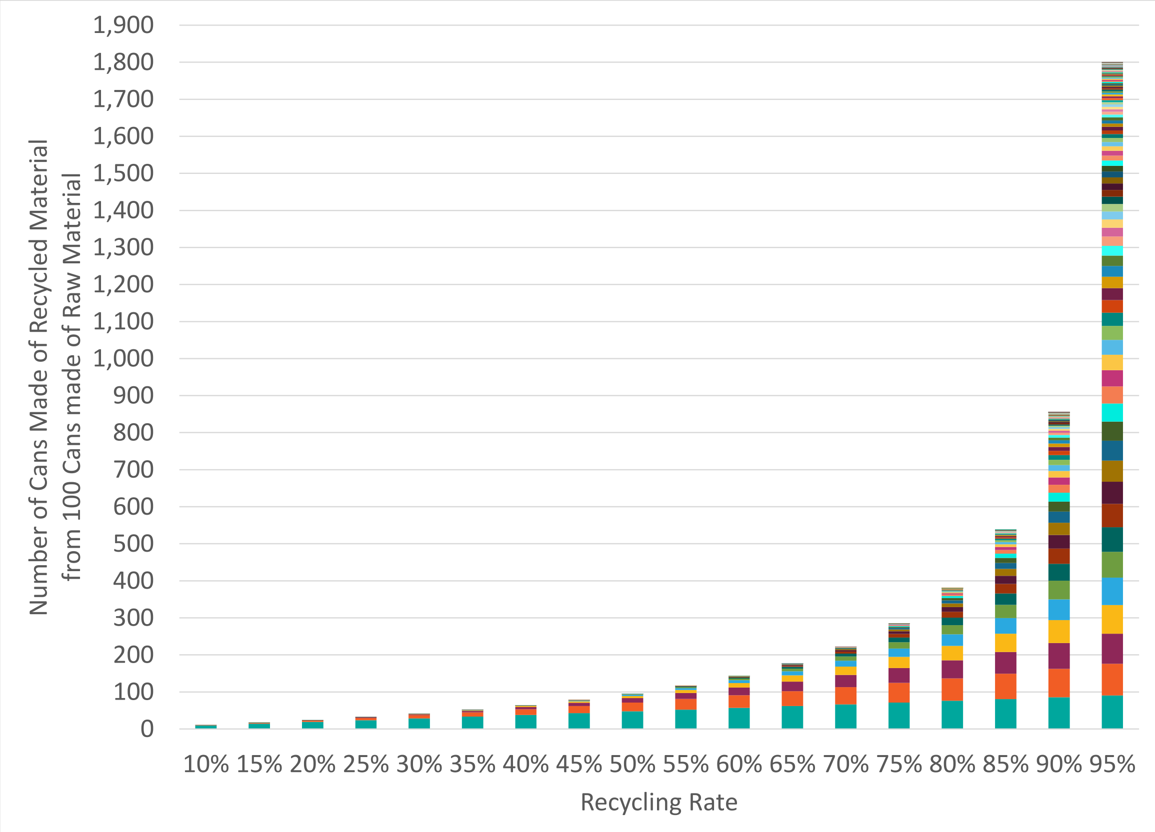
For numerous EU Member States, the 90% return rate required by the SUP Directive is likely to be achieved with a well-designed and implemented conventional DRS alongside a

[11] For example, DiGiacomo, Wu, Lenkic, Fraser, Zhao, Kingstone (2017) *Convenience Improves Composting and Recycling Rates in high-density residential buildings, Journal of Environmental Planning and Management*, April 2017

reasonable deposit level. However, several European countries are achieving DRS return rates far above 90%, which shows that it is achievable given the right investment. Ever increasing political focus on carbon emissions will likely also increase recognition of the benefits presented by very high recycling rates, especially for the most technically recyclable materials, and encourage incentivisation.

Figure 2-2 highlights the marginal benefit of increasing the return rate from 90% to 95% for aluminium cans which more than doubles the number of cans that can be produced from a notional unit of 'original' virgin aluminium cans (based on a conservative 95% yield of collected material into new cans). For a material that is highly carbon intensive to produce in the first instance but very recyclable, this is highly significant. Considering that there is only a minimal increase in cost from infrastructure and logistics aspects but potentially tremendous environmental benefits, the case for fully maximising return rates is compelling.

**Figure 2-2 Cumulative impact of high recycling rates**




When combining the desire to achieve maximum performance with the observations made on the limitations of conventional DRS with respect to convenience and coordination with consumer lifestyles, a hypothesis can be posed that increasing the number, accessibility and 'lifestyle alignment' of return locations should increase the return rate of a DRS, all else being equal. If it is possible to attain this at an affordable cost through the utilisation of new technology (and without leading to undesirable consequences), conventional DRS design and implementation could be significantly improved.

## 2.6 Supporting Technologies Required for Smart DRS

As previously discussed above, RVMs and manual return points with their counting centres are well tested and effective elements of conventional DRS. They are essential in optimising cost across both dense and sparse populations and aid in minimising fraud, however, a rise in novel and potentially disrupting technologies opens up developments within DRS design:

- Serialisation, a unique individual consumer item coding system;
- Printing and data handling technology, including blockchain encryption, with speeds that can match the fastest packaging and filling plants;
- Smartphone hardware, including cameras capable of reading barcodes, and software including digital wallets and reward scheme apps;
- 'Smart' waste bins equipped with low-cost identification technology including radio-frequency identification (RFID) tags.

### 2.6.1 Serialisation

Serialisation assigns and marks each product or product component with a unique identifying code. This process is primarily used for product authentication and also for tracking and tracing products in the supply chain, particularly for markets that are highly regulated. This is already well established in certain consumer goods sectors like tobacco products, pharmaceuticals and some luxury goods, and it is also utilised by organisations to help with process and inventory management. Serialisation is implemented via a 'data carrier', which typically occurs during the manufacturing process. 'Data carrier' is an umbrella term that includes a range of codes and numbers, for example a QR code, numeric code, Global Trade Item Number (GTIN), DataBar or Data Matrix code. They are applied to the product in question using different technologies including inkjet, laser, thermal transfer and print and apply labels.

Ultimately facilitating the tracking and tracing of a product throughout the supply chain, serialisation has been demonstrated to improve both of these things and is applied across many industries. An example within the pharmaceutical industry has shown that using serialisation *inter alia* has combatted counterfeiters which benefits patient safety and builds consumer trust. [12]

### 2.6.2 Data Carriers for Beverage Serialisation

In terms of beverage containers, some types of data carriers are more appropriate than others. For example, 'normal' bar codes (2D EAN) are usually long so they take up a relatively large amount of space on the packaging and they could cause printing problems. Moreover, experts consulted in a previous project estimated that it would take 10 years to develop a technology that enables the serialisation of barcodes. On the other hand, the data carriers that are more suited to beverage containers will have to accommodate a unique identified within a limited space. Another issue results from beverage containers being handled by multiple people and/or machines during their lifecycle, which can cover or remove parts of the data carrier. To tackle this, data carriers will need to have a high error correction level (ECL), which indicates the percentage of the code that can be destroyed before it is impossible to read.

[12] Cordon, C. et al. (2016) *Serialization in the Pharmaceutical Industry*

There are a number of data carriers that we have identified as having the potential to fulfil the requirements:

- **QR (Quick Response) codes**: Developed in 1994, QR codes are an established, standardised data carrier. They can also be printed in 3D which offers the opportunity to store significantly more data than on 2D codes. They require a good contrast between the background and the code to be readable and the ECL ranges from 7-30% (meaning that the QR code will still likely scan if below this 30% damage level), but increasing the ECL will result in lower storage capacity.[13] In the UK, trials are ongoing to incorporate QR codes into can production lines, and for bottle labels for plastic and glass bottles.[14]
- **Data Matrix codes**: These are standardised 2D codes that are frequently used for smaller products as they possess greater data density capacity than QR codes. They are readable at a 20% contrast ratio (the level at which the foreground is distinguishable from the foreground) and the ECL is dependent on the code size and remaining storage capacity, with a maximum ECL of 30%.
- **Digital Watermarking:** Digital watermarks are codes that integrate into the design of the packaging. These have been established by the 'Holy Grail' project (led by Proctor & Gamble and facilitated by the Ellen MacArthur Foundation) as a feasible option in the serialisation of barcodes as they can be read by smartphones, much like QR codes.[15,16] Other benefits include invisibility to the naked eye meaning more space for brand messaging and the ability to be scanned in a variety of positions which avoids having to rotate the product to scan the code. However, this technology is less developed, not very well established and has not been trialled to the same extent as QR codes.

### 2.6.3 Fraud Prevention, Data Management and Governance

The principal benefit of serialisation is that it only allows one redeemable deposit to be claimed for each unique container code and once it is scanned, it cannot be redeemed again. Despite this, the implementation of unique, monetizable codes will create new opportunities for fraud beyond the 'double scanning' risk in conventional DRS. Blockchain technology that encrypts and supplies codes to producers will help in preventing fraud associated with 'phantom code' generation and data theft. It also allows the producer to efficiently access their given block of codes themselves without the need for a 'middle man', while also keeping data confidential from competing producers who may want to interpolate sales data or other commercially confidential information. Code activation can occur at multiple points of the process and supply chain, e.g. at the point of printing, filling

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[13] QRCode Error Correction Feature, accessed 10 April 2020 at https://www.qrcode.com/en/about/error_correction.html

[14] Moblie QR Codes History of QR Codes, accessed 7 January 2020, http://www.mobile-qr-codes.org/history-of-qr-codes.html

[15] The project group also includes a wide variety of other partners, ranging from material producers, to packaging manufacturers, brands, retailers and recyclers. See http://go.pardot.com/l/110942/2019-05-28/lhts3n

[16] Sykes, T. (2018) Sorting the Plastic Recycling Problem, accessed 7 January 2020, https://packagingeurope.com/api/content/cc7827c2-cacb-11e8-bb7b-120e7ad5cf50/

or point of sale. Each of these activation points has their own advantages and disadvantages so it will require further consideration and stakeholder engagement.

Dual layer authentication can be applied at the deposit redemption stage which enables real-time identification of abnormal data patterns to reduce fraud relating to the reproduction of codes using a technique like taking photos of packaging in store. While there is some fraud that cannot be avoided without incurring disproportionate cost, transaction restrictions and thresholds for blocking abnormal redemption are viable options to keep the costs to a minimum and reduce the incentives to defraud the system, but this depends on the return point type that is used.

On the one hand, conventional RVMs can be relatively unregulated thanks to the extent of integrated verification in these machines. On the other hand, passive containers that rely on consumers scanning products with their smartphones could be based on redemption only to an online wallet linked to a personal bank account with a lower threshold for blocking payments resulting from abnormal patterns in quantities or code sequencing. The outcomes of this are that small-scale fraud is quickly identified and large-scale fraud (i.e. organised crime) becomes so labour-intensive, unrewarding and risky that it becomes unattractive. Additional fraud prevention measures can also be added including triple-layer authentication using pigmented label elements that are very difficult to replicate, but the best solutions would need to consider the balance between system cost of net fraud and optimising operational simplicity.

Considering fraud from a governance aspect, implementing a serialisation system that works in tandem with standard setting organisations will lend it more legitimacy and will aid in gaining trust from the whole supply chain. GS1 is a non-profit organisation that maintains global industry standards for business communication and regulates barcodes under the GTIN. There is even potential to create a new global standard for product serialisation and data carriers, which would have far-reaching implications that go well beyond the circular economy.

### 2.6.4 Printing and Labelling

Integrating serialisation onto product packaging necessitates considerable financial investment and process change. The speed of manufacturing and filling beverage packaging is a key challenge, as in the largest production plants, even the smallest degree of slowing the process down can lead to bottleneck issues and also material increases in unit cost. The problems posed by label-wrapped plastic glass bottles, however, seem like they can be addressed. It is highly likely that incorporating the serialisation into the label printing lines would be far more cost effective than attempting to add a unique code at the label wrapping stage. Nonetheless, it could require additional data handling and the management of slightly different fraud risks versus can-based beverages.

Aluminium cans do not require label wrapping but they print directly onto the sheet metal prior to the cutting and forming of each can, meaning they require a different solution. Either the unique code is printed onto the tab (a.k.a. ring-pull), or onto the bottom of the can. FACT flavoured water have successfully trialled and commercialised printing codes onto the tab (see Figure 2-3)[17].

**Figure 2-3 QR code beneath the ring-pull on FACT cans**

Adding a unique code to the tab of a can like in the FACT example can cause issues down the line when consumers attempt to return the containers to a RVM or a smart bin with scanning technology where the physical placement of the scanner and the angle of configuration may prevent scanners from identifying the unique code. Placing the code on the bottom of the can also presents challenges as this would require further development of scanning technology and it can result in a higher likelihood of generating reading errors. Despite this, trials show that when laser etching is used to create the code on the top of the tab, this is successful in both code rendering and reading and current production speeds would not be threatened.

### 2.6.5 Return Point Technologies

Two return methods are commonly employed in conventional DRS – automated return via Reverse Vending Machines (RVMs) and manual return, whereby retail or central return location staff members manually count or hand-held scan the containers returned by consumers. This study considers an additional range of return point technologies which may be more cost-effectively located in a wider range of location types, in order to optimise convenience of return for consumers. The type of return point used for a particular area would depend on footfall, accessibility and risk of contamination by littering.

These new return technologies enable a range of new return locations, in comparison with a conventional DRS. The modelled scenarios expand on the return-to-retail model on which high performing conventional DRS is predominantly based, adding a range of other return locations, including spaces such as shopping centres, workplaces, transport hubs, public open spaces and on-street locations. The full range of return locations included in the modelling is set out in section 3.2 presents the different types of technology used in the scenarios.

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[17] FACT (2019) FACT | Home, accessed 8 January 2020, http://drinkfact.com/#home

### Table 2-2 Smart DRS – Return Point Technologies

| Return Technology | Summary |
|---|---|
| **Simplified RVM** | Standalone system with internal storage and requiring a power supply. Like a conventional RVM, it can scan and accept 'in-scheme' (and reject 'non scheme') containers. Consumers would be able to either redeem their deposit into a digital wallet linked to their personal account or receive a printed voucher to be redeemed later, either via digital wallet or by a participating retailer. |
| **Smart Bin** | Smart Bins can communicate with a smartphone via radio frequency identification (RFID) in a system which controls the opening or unlocking of a hatch. Deposits would be redeemed into a digital wallet, with the risk of contamination being somewhat higher than in a simplified RVM. Smart bins can be solar powered or have a mains power supply. |
| **RFID enabled containers** | Regular bin or other conventional waste container with a passive RFID nested on the outside in secure housing. With the use of a scheme app, consumers would be able to read the RFID chip on the bin by putting their phone close to it. There would be no need for an external power source and could be deployed in low contamination risk locations. Appropriate for 'low contamination risk' settings. |

Conventional and simplified RVMs and Smart Bins will all have an automated aperture as a third layer authentication system. Locating these return points in public areas ensures contamination is kept to a minimum.

While smart bins and RVMs have mechanisms in place to prevent contamination, RFID enabled containers can be regular wheelie bins with no capacity to reject contaminated waste. Contamination of the waste stream is likely without more sophisticated technologies in place. This could cause material losses when returns are sorted in a Material Recovery Facility (MRF).

## 2.6.6 Smart Phones, Apps and Scanners

Smartphone-based scanning facilitated by an app would enable consumers to receive their deposit via a digital wallet and it allows the option to provide added value features such as consumption tracking. Many apps (e.g. We Recycle, Junker, Reward4Waste) have been developed to allow customers to scan product barcodes to discover whether and where they can be recycled. This information is tailored to the local area to account for different waste collection systems in different areas, and they can be geospatially enabled. Some apps like Junker are funded by municipalities as they benefit from high recycling rates and lower contamination due to user behavioural change that is facilitated by these apps. In Spain, a collaboration between EVRYTHNG and Recycl3R produced a similar app which also financially rewards users for recycling correctly. Numerous apps allow deposits to be collected into an online wallet, such as:

- MyTOMRA: Users of certain TOMRA RVMs scan their unique barcode to register their account for an online refund
- Reward4Waste: Developed by CryptoCycle this app uses a blockchain approach to reward consumers for returning single use items for recycling. It uses serialised barcodes that users scan before returning the items to a designated point.

From an accessibility perspective, the proliferation of smartphones continues to grow. In France, 75% of adults own a smartphone and global smartphone use is increasing[18]. For those that do not use a smartphone, the option to return empty containers using a conventional or simplified RVM would still exist. Additionally, to account for populations where smartphone ownership is lowest and for schemes incorporating a significant 'return at home' element, hand-held internet-enabled scanners can be provided, as unit costs have fallen drastically in recent years.

### 2.6.7 Logistics

Conventional DRS benefits from the considerable use of reverse logistics, utilising the backhaul capacity in the retail distribution system to transport and aggregate much of the material collected at RVMs. Although the dual function of delivery vehicles slightly compromises the backhaul fill rates, plastic bottles and cans are usually compacted in the RVMs and so the marginal cost of transport to the point of aggregation at regional distribution centres is kept low.

In contrast, the alternative return point technology envisaged for smart DRS (e.g. simplified RVMs and smart bins) would not have compaction capability due to the power requirement needed for this function. However, collection vehicles could have compaction capabilities, improving the efficiency of the collection of less dense materials such as cans and bottles. Moreover, emptying and transporting material from these return points would be likely require a special trip, as integration with retail would be much less common. As such, it is likely (and has been assumed in the modelling) that conventional waste collection vehicles (rear loaded with compaction) would be utilised. Therefore, although savings may be made in terms of capital costs of return points, the logistics associated with emptying return points and hauling material would represent a significant new cost.

### 2.6.8 Conclusions on Supporting Technologies

Although there is a considerable amount of further work to do in refining and optimising the technological components of a serialisation-based smart DRS, it has been possible to configure and cost a set of scenarios based on technology that is adequately well developed to meaningfully model cost and performance. Further development of technology components and their testing in the lab and in field trials would be necessary precursors to adoption, but it does seem that all technical challenges are likely to be surmountable without incurring disproportionate cost.

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[18] Pew Research Centre (2019*) Smartphone Ownership is Growing Rapidly Around the World, but Not Always Equally*, accessed 06/05/20: https://www.pewresearch.org/global/2019/02/05/smartphone-ownership-is-growing-rapidly-around-the-world-but-not-always-equally/

# 3.0 System Design & Scenarios

## 3.1 System Design

There are several elements that must be considered when designing a DRS, as shown in Figure 3-1.

**Figure 3-1 Elements of DRS Design**

| Strategy | Physical flows | Financial management |
|---|---|---|
| • System governance / nature of the operator<br>• Return rate targets | • Scope – type of beverage and containers<br>• Return infrastructure<br>  • Take-back technology<br>  • Return locations | • Deposit value<br>• Handling fee<br>• Fraud prevention<br>• Funding mechanisms |

A summary of the proposed design for Serbia DRS, for both Conventional and Smart scenarios is outlined in Table 3-1. A full description of the system design can be found within the 'System Design Report'.

**Table 3-1 Summary of Proposed DRS Design for Serbia**

<table>
<tr><th rowspan="2">Design Element</th><th colspan="2">Recommended for Serbia</th></tr>
<tr><th>Conventional scenario</th><th>Smart scenario</th></tr>
<tr><td>System Governance</td><td colspan="2">CSO, a centralised, single operator which is industry owned and operated. CSOs are usually supported by legislation and mandated to achieve distinct performance targets.</td></tr>
<tr><td>Governance Targets</td><td colspan="2">90% return rate target (three years to achieve)</td></tr>
<tr><td>Deposit Structure and Value</td><td colspan="2">Recommended: 5 RSD[19] Flat rate deposit across all container types, subject to periodic review by system operator<br>Alternative: Multi-level deposit<br>• ≤ 500ml = 4RSD[20]<br>• 500ml and ≤1L = 5RSD<br>• >1L = 6RSD[21]</td></tr>
</table>

[19] As the modelling is presented in Euros, this is equal to €0.04. The conversion rate used in all conversions is 1 EUR = 117.59 RSD

[20] Equal to €0.03

[21] Equal to €0.05

| Design Element | Recommended for Serbia | |
|---|---|---|
| | Conventional scenario | Smart scenario |
| Scope – Beverage Containers | PET bottles, aluminium cans, glass and cartons (50ml – 3L) | |
| Scope – Beverage Type | Water; soft drinks (carbonated, non-carbonated, juices, sports drinks, energy drinks, ready to drink teas and coffees); milk and dairy; beer.<br>Wine & spirits included (sensitivity analysis with exclusion) | |
| Return Infrastructure | Return to retail, with universal take-back obligation. Compacting RVMs where justified by return volumes, manual returns where not justified. | Return to retail, without universal take-back obligation. Compacting RVMs where justified by return volumes, manual returns where not justified.<br>System expands to include simplified RVMs, smart bins and RFID enabled containers at a range of convenient locations. |
| Funding Mechanisms | • System funded by material revenues (owned by CSO);<br>• Unredeemed deposits (owned by CSO); and<br>• Producer fees (set by CSO). | |
| Handling Fee | Variable handling fee based on retailers' costs. | Variable handling fee paid to the owner of the return location, based on reimbursing costs. |
| Labelling & Fraud Prevention | CSO-issued logo and choice of national or international barcode, with a higher producer fee for international barcodes. | CSO-issued logo. The use of serialisation (i.e. unique identifiers) and mobile phone scanning for lower tech return points minimises fraud. Redemption is not based on scanning barcodes. |

## 3.2 DRS modelled scenarios

As described in section 2.0, we have modelled two "scenarios" – conventional DRS and smart DRS, smart DRS is modelled with a high/low range to reflect the range of options for specifying the system and the impact this would have on costs and performance. The smart/low scenarios differ in the assumptions of:

- Number of locations (see section 0); and
- Cost of return technology (see section A.4.1.3).

Other aspects of system design and performance are modelled as sensitivities to understand the specific impact that this variance would have on the system. These are reported in Section 5.4.

Section 4.0 describes the key inputs and parameters for each scenario and the results of the modelling will be presented in section 5.0 and 6.0.

# 4.0 Model inputs and assumptions

This section provides an overview of the key inputs and assumptions utilised in the model: return rates, loss rates, fraud, return locations and return points. The rest of the assumptions and inputs to the model can be found in section A.4.0 in the appendix.

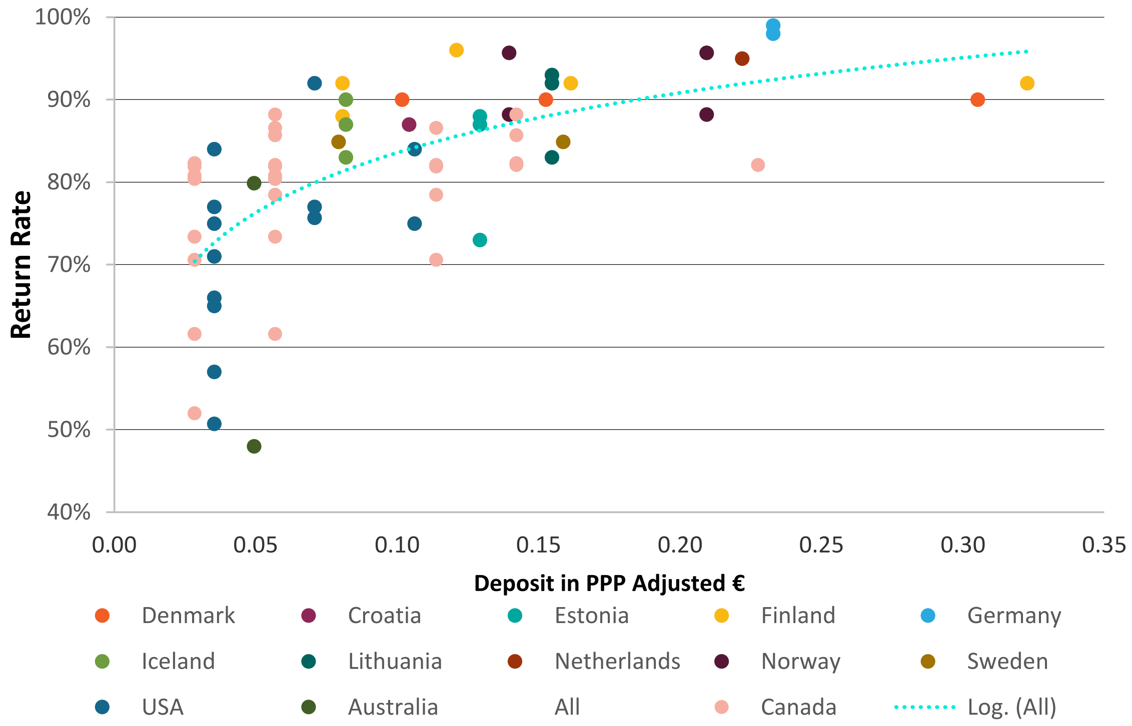
## 4.1 Key Model Considerations

### 4.1.1 Return Rates

Return rates describe the percentage of all DRS containers placed on the market that are returned through the system. Figure 4-1 presents the return rates in existing DRS in industrialised countries versus the deposit value, adjusted for purchasing power parity. For modelling purposes, 90% return rate is often seen as a realistic and attainable goal for countries adopting DRS, as countries such as Germany and Norway have successfully achieved this through their respective systems.

Whilst return rates are likely to vary due to the level of deposit, they are also likely to vary due to how convenient it is for consumers to return containers. As a result, in a well specified smart system that is overall more convenient (i.e. has better positioned return locations) than a conventional DRS, the return rate may be higher. However, it must be noted that as smart DRS is a new concept and has not been trialled in the real world, we do not have any data on which to base this assumption. Therefore, in the interests of a 'fair' comparison with conventional DRS, we have assumed the same return rate in the central scenario for both smart and conventional DRS.

**Figure 4-1: Return Rates in Existing DRS vs PPP-adjusted (purchasing power parity) Deposit Value**




*Source: Eunomia (2020)*

### 4.1.2 Loss Rates

Loss rates describe the **percentage of the material collected through the DRS that does not enter the recycling process**, due to material losses during sorting and reprocessing. The target material (e.g. aluminium cans) can be contaminated by other materials, including both residual food and drink (although this is already accounted for as the modelling is based on 'dry' material tonnage), and non-target materials. Non-target materials could include other material types or packaging made of the same material but not within the scope of the DRS.

The degree of contamination can be controlled to some extent with technology; for example, conventional RVMs do this well by not only scanning each container but also checking that the container size, weight and dimensions match the specifications of a DRS container. At the other extreme, RFID enabled bins offer no control on contamination – i.e. the consumer could leave any type of non-deposit bearing container or other litter in the bin. In the modelling, loss rates are therefore set based on the assumed level of contamination for each type of return technology, these assumptions can be found in Table 4-1.

**Table 4-1 Return Point Loss Rates**

| | Conventional RVM (compacted) | Manual | Simplified RVM | Smart Bin | RfID Enabled Container |
|---|---|---|---|---|---|
| **Glass Bottles** | 0.5% | 0.5% | 0.5% | 0.6% | 1.0% |
| **Plastic Bottles** | 1.9% | 1.9% | 1.9% | 2.3% | 3.8% |
| **Cans** | 0.8% | 0.8% | 0.8% | 0.9% | 1.5% |
| **Beverage Cartons** | 0.8% | 0.8% | 0.8% | 0.9% | 1.5% |

### 4.1.3 Fraud

Fraud can be enacted by both producers and redeemers, for example, producers may under-report sales so the deposits are not initiated and producer fees aren't paid. On the return side, a conventional DRS is potentially susceptible to fraud based on:

- repeat redemption of deposits on the same item; or
- non-deposit bearing containers being returned, either by
    - being outside of scope, or
    - being bought in another country and returned in Serbia.

The risk of individual deposit-bearing items being processed multiple times, and so deposits being issued multiple times, is mitigated by physically removing items from the system after the first deposit redemption. RVMs do this by creating a secure separation of the consumer-facing end of the machine and the back end of the machine, which can only be accessed by store staff. It should be noted that anti-fraud measures should be employed for those working in the system, as they have access to the materials that would otherwise be inaccessible. **Materials are generally also compacted**, making it impossible for them to pass through the RVM a second time. For manual returns, counting centres are used to verify the number of items upon which deposits have been redeemed. Additionally, the system operator plays an important role in **monitoring the data** – using the barcodes, the system operator can cross reference return volumes against sales numbers, and identify attempts to return unusually high numbers. This makes it quite difficult for well-organised fraud.

A practicable solution for reducing fraud is the use of **unique item coding**, enabling the deposit allocated to each individual item to be cancelled after redemption. Such an approach would allow for return channels that do not rely on physically securing or altering materials by compaction. A key benefit of unique item coding is the fact that only one redeemable deposit is associated with each unique container code, and once scanned, the deposit cannot be redeemed a second time. However, the generation and printing of unique, monetizable codes would open new avenues for fraud beyond the 'double scanning' risk associated with code reading in conventional DRS.

From a governance perspective, a **serialisation system** which works closely with standard setting organisations will ensure that the whole value chain will trust the system. GS1 is the not-for-profit organisation which maintains global industry standards for business communication. It regulates barcodes and produces the GS1 standard under the Global Trade Item Number (GTIN). Working with GS1 would build industry and political trust and ensure unique barcodes were used for multiple use cases across consumer goods markets, with the potential being widely recognised for a new global standard for product serialisation and data carriers to have far-reaching implications well beyond the circular economy. When considering the risk of containers being imported into Serbia to claim a deposit refund, it is necessary to examine the relative deposits. With regards to neighbouring countries, Croatia has a DRS system in place with a deposit value of 0.5 HRK; in the System Design Report the conversion has been estimated at 6.37 RSD, which would be higher than the proposed deposit value for Serbia. However, the exchange rates are volatile and the opposite could also happen – that the deposit value ends up being higher in Serbia than Croatia. Ultimately, if the deposit is higher in Croatia, people are less likely to take containers from Croatia to Serbia to claim the deposit. It is also important to note that any other neighbouring countries that do not have a DRS currently implemented represent a bigger risk if the labelling is not of a satisfactory standard, although Romania has at least confirmed that they will be introducing a DRS.

**Material value** is also a consideration for fraud. Certain Smart technologies, such as smart bins and RFID enabled containers, have no way of ensuring that the container is actually returned after it has been scanned, which could lead to some consumers scanning (and claiming the deposit) and retaining the container to be sold for its material value. This is more likely to be the case in regions where the material value has a higher relative worth for a consumer. It should be acknowledged that a system with unique item coding does not prevent this particular fraud risk if it has this type of return receptacles (that cannot guarantee the return of the container).

This is also arguably possible further down in the supply chain, i.e. without counting centres then **fraud during transit** from collection point to counting centre is possible – without counting there is no check that every container reaches a counting centre, and so containers could go missing. Such fraud is more serious in nature, as it would likely relate to large numbers of containers (e.g. a significant amount of a truck load). Because of this it may therefore be less likely as it is less opportunistic in nature and requires more planning. Whether the risk/reward of this stacks up based on the potential value of the material would need further consideration.

Finally, Table 4-2 shows the fraud that has been modelled per return technology, according to the considerations described above.

**Table 4-2 Fraud per return technology**

| Return technology | Assumed fraud per return technology, % |
|---:|---:|
| **Conventional RVM (compacted)** | 1.00% |
| **Manual (with scanning)** | 1.50% |
| **Manual (no scanning** | 1.50% |
| **Simplified RVM** | 1.50% |
| **Smart Bin** | 2.00% |
| **RfID Enabled Container** | 2.50% |

In section 2.2 we have discussed the potential advantages of a Smart system, noting that the unique serialisation could lead to lower fraud rates. However, in light of the novelty of the technology, fraud has been modelled at slightly higher rates for Smart technology than conventional.

## 4.2 Return locations and return points

Table 4-3 shows the mix and number of return locations that can contribute to each scenario. Each row shows the percentage of the possible number of return points that is included in each scenario; for example, for large retailers, it is assumed that 100% of them could participate in the Conventional scenario but only a maximum of 80% would participate in the Smart scenario.

- In the Conventional scenario, only four types are used: large retailers, small retailers, petrol stations and HORECA (hotel / restaurant / café)
- In the Smart scenario we have many more return locations, which increases the convenience for the citizens but also increases the complexity of return logistics. The Smart Low scenario has a lower number of return points that the Smart High scenario.

**Table 4-3 Return locations eligible for each scenarios**

| Return location | # return locations | % return locations in Conventional scenario | % return locations in Smart scenario (Low – High) | # opening days per week |
|---|---|---|---|---|
| **Apartments / Flats** | 15,360 | 0% | 10% - 40% | 7 |
| **Large Retailers** | 968 | 100% | 80% | 7 |
| **Small Retailers** | 13,599 | 40% | 20% - 40% | 6 |
| **Petrol Stations** | 893 | 100% | 15% - 25% | 6 |
| **HORECA** | 14,275 | 100% | 100% | 6 |
| **Shopping Centres** | 49 | 0% | 50% - 80% | 6 |
| **Workplaces** | 12,130 | 0% | 0% - 30% | 6 |
| **Education** | 2,083 | 0% | 0% - 50% | 6 |
| **Sports and Leisure** | 110 | 0% | 5% - 50% | 6 |
| **Religious Centres** | 3,410 | 0% | 0% - 30% | 6 |
| **Transport Hubs** | 690 | 0% | 50% - 80% | 7 |
| **Major Outdoor Events** | 800 | 0% | 10% - 30% | 5 |
| **Parks and Open Spaces** | 350 | 0% | 30% - 50% | 7 |
| **Town Halls** | 164 | 0% | 0% - 50% | 5 |
| **Government Buildings** | 161 | 0% | 0% - 50% | 5 |
| **Museums** | 100 | 0% | 0% - 40% | 6 |
| **Recycling Centres** | 28 | 0% | 100% | 5 |

*Note 1: For manual without scanners (where there is not technology required), this is equivalent to the number of return locations*

*Note 2: A full table explaining the methodology for the number of each return point can be found in A.4.1.3*

In the Conventional scenario, there are four possible types of return locations. RVMs are mostly placed at large retailers while the rest of return locations will mostly use manual without scanning. Table 4-4 shows the allocation of technology for each return point (every row adds up to 100%).

**Table 4-4 Return locations and return points/infrastructure - Conventional**

| Return location | RVM | Manual (no scan) |
|---|---|---|
| **Large Retailers** | 100% | |
| **Small Retailers** | 5% | 95% |
| **Petrol Stations** | 1% | 99% |
| **HORECA** | | 100% |

In the Smart scenario we continue having RVMs in large retailers and now recycling centres, the manual return locations have scanning and there are three additional technologies: simplified RVMs, smart bins and RfID enabled containers. Additionally, there are many more return locations, which increase the convenience of the consumers.

**Table 4-5 Return locations and return points/infrastructure – Smart DRS (both for Low and High scenarios)**

| Return location | RVM | Manual (with scan) | Simplified RVM | Smart Bin | RfID Enabled Container |
|---|---|---|---|---|---|
| **Apartments / Flats** | | | 20% | 30% | 50% |
| **Large Retailers** | 100% | | | | |
| **Small Retailers** | | 90% | 10% | | |
| **Petrol Stations** | | 100% | | | |
| **HORECA** | | 100% | | | |
| **Shopping Centres** | | | 70% | 30% | |
| **Workplaces** | | | 10% | 20% | 70% |
| **Education** | | | 33% | 33% | 33% |
| **Sports and Leisure** | | | | 20% | 80% |
| **Religious Centres** | | | | 20% | 80% |
| **Transport Hubs** | | | 70% | 30% | |
| **Major Outdoor Events** | | | 70% | 30% | |
| **Parks and Open Spaces** | | | | 50% | 50% |
| **Town Halls** | | | 50% | 40% | 10% |
| **Government Buildings** | | | 50% | 40% | 10% |
| **Museums** | | | 20% | 40% | 40% |

| Return location | RVM | Manual (with scan) | Simplified RVM | Smart Bin | RfID Enabled Container |
|---|---|---|---|---|---|
| **Recycling Centres** | 40% | | 60% | | |

**The final number of return points and technology** has been determined based on the material flows (see Table 5-1) and the throughput of each return technology. The throughout assumptions for each type of return technology are as follows:

### Table 4-6 Return Point Throughputs, Containers Per Day

| Conventional RVM (compacted) | Manual (with scanning) | Manual (no scanning | Simplified RVM | Smart Bin | RfID Enabled Container |
|---|---|---|---|---|---|
| 1,000 | 1,000 | n/a | 1,000 | 500 | 500 |

Table 4-7 and Table 4-8 show the total number of return technologies in each return location. We need to bear in mind that a return location can have more than one return unit; for instance:

- The conventional scenario assumes that an average of 1.6 conventional RVM will be placed per large retailer; and
- Smart technologies (simplified RVMs, smart bins and RfID enabled containers) can have multiple return units per return location; for example, a shopping centre can have up to 8 smart bins distributed in its surface.

### Table 4-7 Number of return technologies in Conventional scenario, number of units

| Return location | RVM | Manual (no scan) |
|---|---|---|
| **Large Retailers** | 968 | |
| **Small Retailers** | 272 | 5,168 |
| **Petrol Stations** | 9 | 884 |
| **HORECA** | | 14,275 |

### Table 4-8 Number of return technologies in Smart scenarios (Low-High), number of units

| Return Location | Conventional RVM (compacted) | Manual (with scanning) | Simplified RVM | Smart Bin | RfID Enabled Container |
|---|---|---|---|---|---|
| **Apartments / Flats** | | | 307 – 1,229 | 461 – 1,843 | 768 – 3,072 |
| **Large Retailers** | 774 | | | | |
| **Small Retailers** | | 2,448 - 4,896 | 272 - 544 | | |
| **Petrol Stations** | | 134 - 223 | | | |
| **HORECA** | | 14,275 | | | |
| **Shopping Centres** | | | 17 - 27 | 7 – 12 | |

| Return Location | Conventional RVM (compacted) | Manual (with scanning) | Simplified RVM | Smart Bin | RfID Enabled Container |
|---|---|---|---|---|---|
| Workplaces | | | 0 - 364 | 0 - 728 | 0 – 2,547 |
| Education | | | 0 – 347 | 0 - 347 | 0 - 347 |
| Sports and Leisure | | | | 1 - 11 | 4 - 44 |
| Religious Centres | | | | 0 - 205 | 0 - 818 |
| Transport Hubs | | | 242 - 386 | 104 - 166 | |
| Major Outdoor Events | | | 56 - 168 | 24 - 72 | |
| Parks and Open Spaces | | | | 53 - 88 | 53 - 88 |
| Town Halls | | | 0 – 41 | 0 - 33 | 0 - 8 |
| Government Buildings | | | 0 – 40 | 0 - 32 | 0 - 8 |
| Museums | | | 0 - 8 | 0 - 16 | 0 - 16 |
| Recycling Centres | 11 | | 17 | | |

Table 4-9 below shows the estimated costs for each type of return technology, based on the distribution of locations described earlier.

### Table 4-9 Return Infrastructure Costs per type of technology

| | Conventional RVM | Manual (with scan) | Manual (no scan)[1] | Simplified RVM | Smart Bin | RfID Enabled Container |
|---|---|---|---|---|---|---|
| Capital Cost, € | 15,000 - 28,000 | 50 | - | 5,000 - 10,000 | 1,676 – 3,500 | 210 |
| Installation Fee, € | 2,000 | - | - | 750 | 400 | 26 |
| Annualised Cost of Capital, €[3] | 2,938 – 5,185 | 18 | - | 906 - 1,693 | 327 - 614 | 37 |
| Other Annual Costs (Servicing, Renovation, IT etc.), € | 2,500 | 0 | - | 504 - 507 | 251 | 0 |
| Total Annualised Cost, € | **5,438 – 7,685** | **18** | - | **1,409 – 2,200** | **577 - 865** | **37** |
| Conventional scenario, number of units[2] | 1,842 | - | 20,327 | - | - | - |
| Smart scenario, number of units | 1,100 – 891 | 16,857 – 19,394 | - | 1,985 – 6,450 | 2.015 – 10,663 | 2,557 – 20,486 |

| | Conventional RVM | Manual (with scan) | Manual (no scan)[1] | Simplified RVM | Smart Bin | RfID Enabled Container |
|---|---|---|---|---|---|---|

***Notes:***

1. **For manual without scanners (where there is not technology required), this is equivalent to the number of return locations**
2. **Total units of return infrastructure to be installed**
3. **Based on 7 year loan repayment period (3 year for manual scanners)**

## 4.3 Data Limitations

The quality of results are dependent on the quality of data. Whilst we are confident the majority of assumptions and data points within the model, there are some key limitations to note:

- Data available to model certain sensitivities was limited and sometimes contradictory (multi-level, wines & spirits) so assumptions have been extrapolated where necessary. This means that some figures have been applied to all waste flow data on the basis of data points relating to returns from only a small number of stakeholders.
- Calculations have been made to determine a “rest of the market” figure where there were gaps.
- There is no well-established DRS that collects beverage cartons. Therefore, assumptions have been made on how the collection and sorting would work, even more so in the Smart DRS scenario.

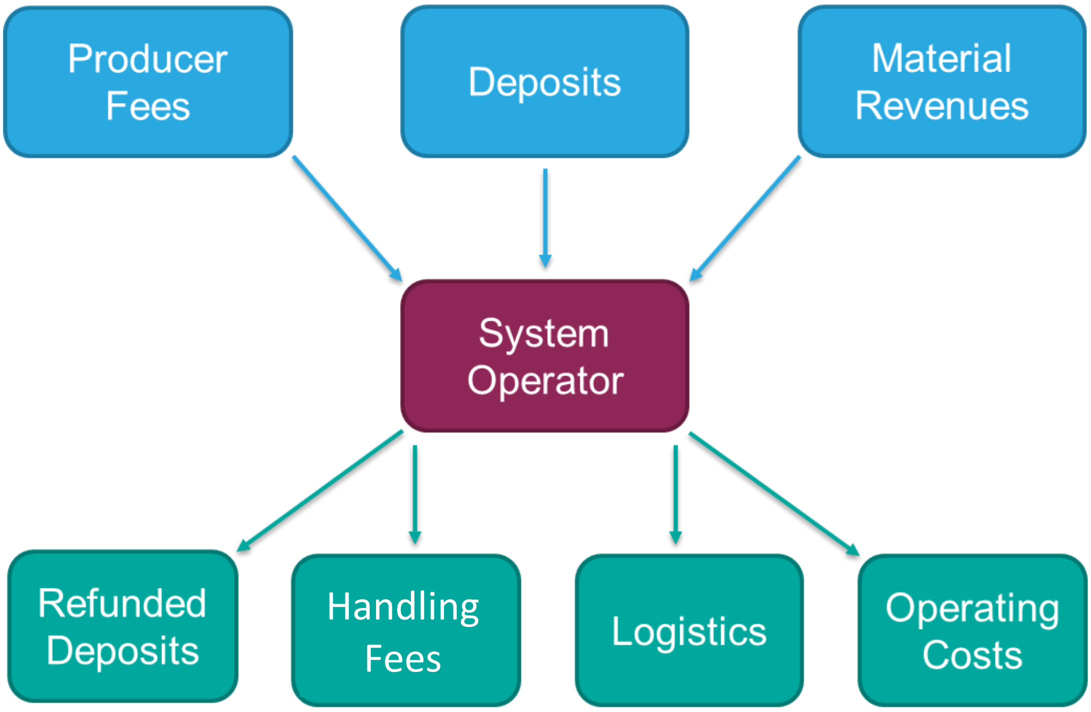
The key limitation specific to Smart DRS is the fact that this is an entirely theoretical system with no current established real-world systems from which to use an example. The modelling undertaken for the Conventional DRS is based on numerous systems that operate around the world in many different socioeconomic and geographic contexts. Regular and extensive conversations with system operators, material producers, governments and suppliers have allowed us, over time, to build up a database of assumptions that allow us to design systems that will work optimally in their specific locations. These examples also demonstrate key successes and failures that further allow us to refine the system design process. Unfortunately, none of this is currently available for a Smart DRS, meaning that a number of the assumptions and datapoints are highly speculative, and why results are presented as a range rather than one specific figure. Importantly, this also means that we currently do not know whether, in practice, a Smart DRS will be more expensive than a Conventional one, or the return and loss rates of the Smart scenario.

# 5.0 Model Results – Cost modelling

A model has been used to calculate the costs and impacts of the DRS in terms of mass flows (volumes of containers), financial flows (see diagram in Figure 5-1 below) and social and environmental impacts (see section 6.0).

All the results are shown annualised, unless otherwise indicated, and annualised set-up costs are included. For the Conventional scenario a single value is shown for each case; however for Smart DRS, a range of values is provided, in line with the Low and High scenario assumptions (see section 3.2). This way we can better reflect the uncertainty surrounding Smart DRS calculations (see section 4.3).

**Figure 5-1: System Income and Outgoings**




## 5.1 Summary Results

Table 5-1 below shows the containers placed on the market (PoM) and containers redeemed (based on a 90% return rate) for both scenarios.

**Table 5-1 Placed on Market (PoM) and Redeemed Containers**

| | Glass | Plastic | Metal | Bev Cartons | Total |
|---|---|---|---|---|---|
| **Placed on Market[22], million** | 158 | 1,072 | 232 | 359 | **1,821** |
| **Redeemed, million** | 142 | 965 | 209 | 323 | **1,639** |
| **Placed on Market, tonnes** | 33,496 | 26,811 | 3,654 | 4,303 | **68,263** |
| **Redeemed, tonnes[23]** | 30,146 | 24,130 | 3,288 | 3,872 | **61,437** |

[22] Placed on Market data received from NALED

[23] Average container weights based on previous Eunomia study

| | Glass | Plastic | Metal | Bev Cartons | Total |
|---|---|---|---|---|---|
| **Overall Return Rate** | 90% | 90% | 90% | 90% | **90%** |

As discussed in Section 4.1.1, return rates are a product primarily of the level of the deposit – with higher deposit levels generally associated with higher return rates – and also consumer convenience. Whilst the same return rate is assumed for both conventional and smart DRS in the central case, we have also modelled sensitivities in section 5.4.4 to show the variance in mass flows and economic impacts if return rates were higher or lower.

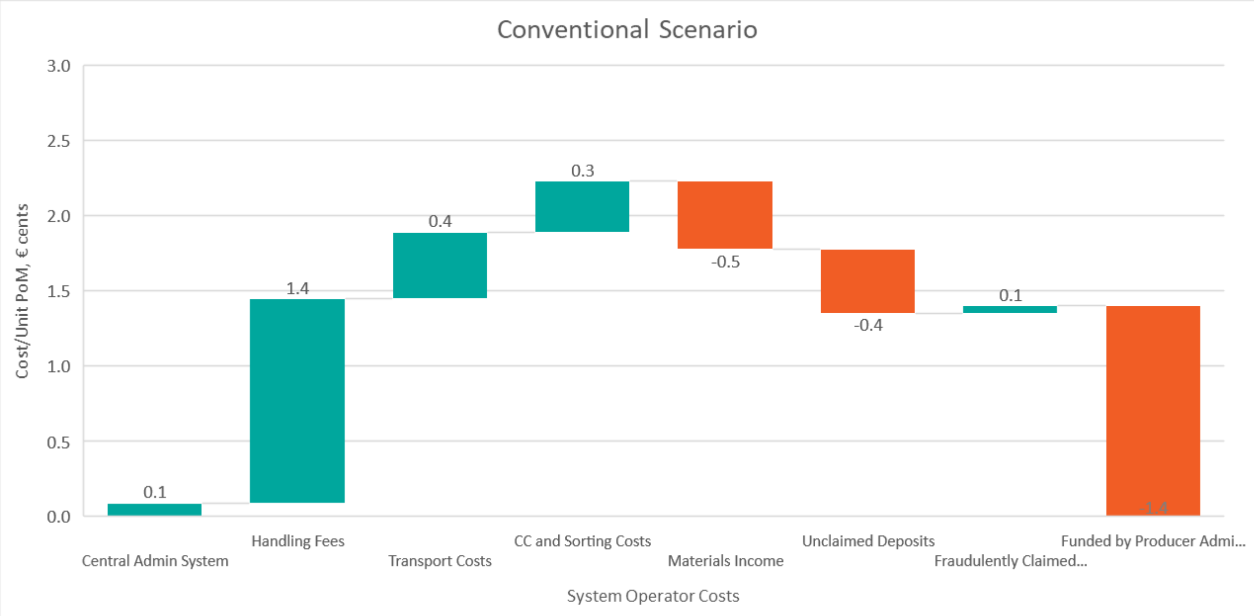
Table 5-2 presents the key costs and revenues of the system operator for each scenario. The costs are presented as positive values (e.g. handling fees) and the incomes as negative values (e.g. unclaimed deposits). Costs for containers placed on market (POM), allows for easy comparison between the scenarios listed below. The producer fee is the fee paid by the producer in order to fill the shortfall within the DRS system. Material revenues and unredeemed deposits are also deducted from the below, as these create a revenue in the system.

The assumptions and calculations for the key items can be found in section A.4.0 in the appendix, e.g. section A.4.5 describes Central Admin Costs, section A.4.3 describes Counting Centres locations and cost, section A.4.2 describes Transport Costs, etc.

**Table 5-2 Summary of system costs and revenues per scenario**

| Item | Conventional scenario | | Smart scenario - Low | | Smart Scenario - High | |
|---|---|---|---|---|---|---|
| **System Operator Costs** | **Total Cost, € million** | **Cost/Unit PoM, € cents** | **Total Cost, € million** | **Cost/Unit PoM, € cents** | **Total Cost, € million** | **Cost/Unit PoM, € cents** |
| **Central Admin System** | 1.6 | 0.1 | 1.6 | 0.1 | 1.6 | 0.1 |
| **Handling Fees** | 24.7 | 1.3 | 19.7 | 1.1 | 39.5 | 2.2 |
| **Transport Costs** | 8.1 | 0.4 | 8.9 | 0.5 | 9.0 | 0.5 |
| **Counting Centre and Sorting Costs** | 6.2 | 0.3 | 1.9 | 0.1 | 1.9 | 0.1 |
| **Materials Income** | -8.3 | -0.5 | -8.3 | -0.5 | -8.2 | -0.5 |
| **Unclaimed Deposits** | -7.7 | -0.4 | -7.7 | -0.4 | -7.7 | -0.4 |
| **Fraudulently Claimed Deposits** | 0.9 | 0.1 | 1.1 | 0.1 | 1.2 | 0.1 |
| **Net Cost** | **25.5** | **1.4** | **17.2** | **0.9** | **37.2** | **2.0** |
| **Funded by Producer Admin Fee** | **-25.5** | **-1.4** | **-13.5** | **-0.9** | **-30.9** | **-2.0** |

### Figure 5-2 Breakdown of system costs [green] and revenues [orange] in the Conventional scenario




### Figure 5-3 Breakdown of system costs [green] and revenues [orange] in the Smart-low scenario

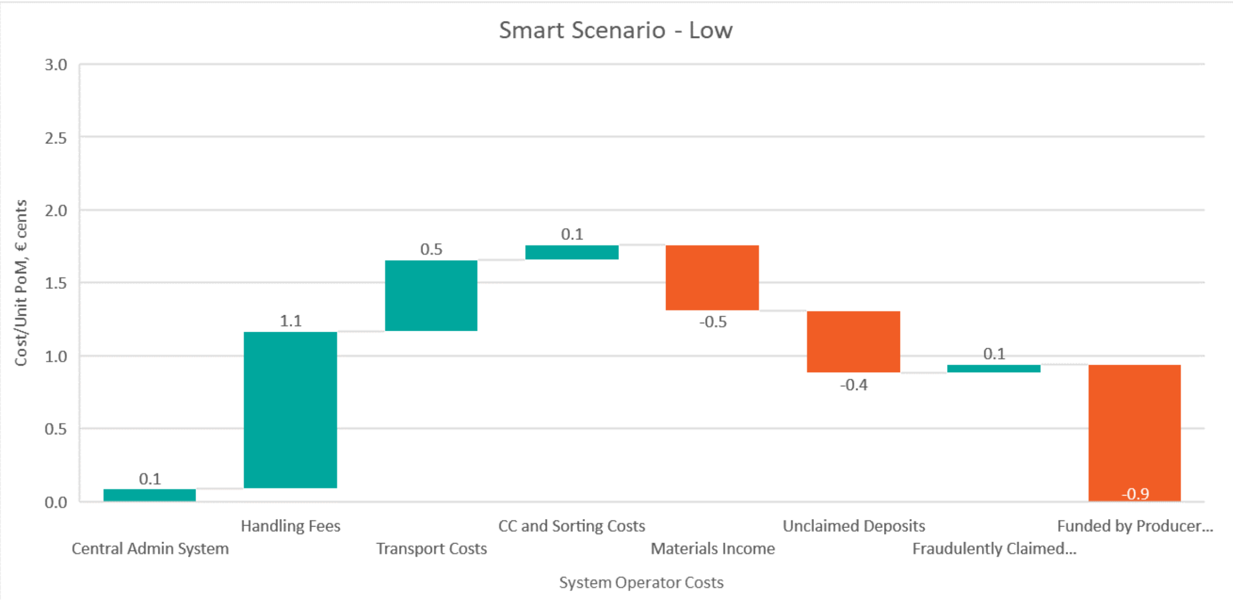
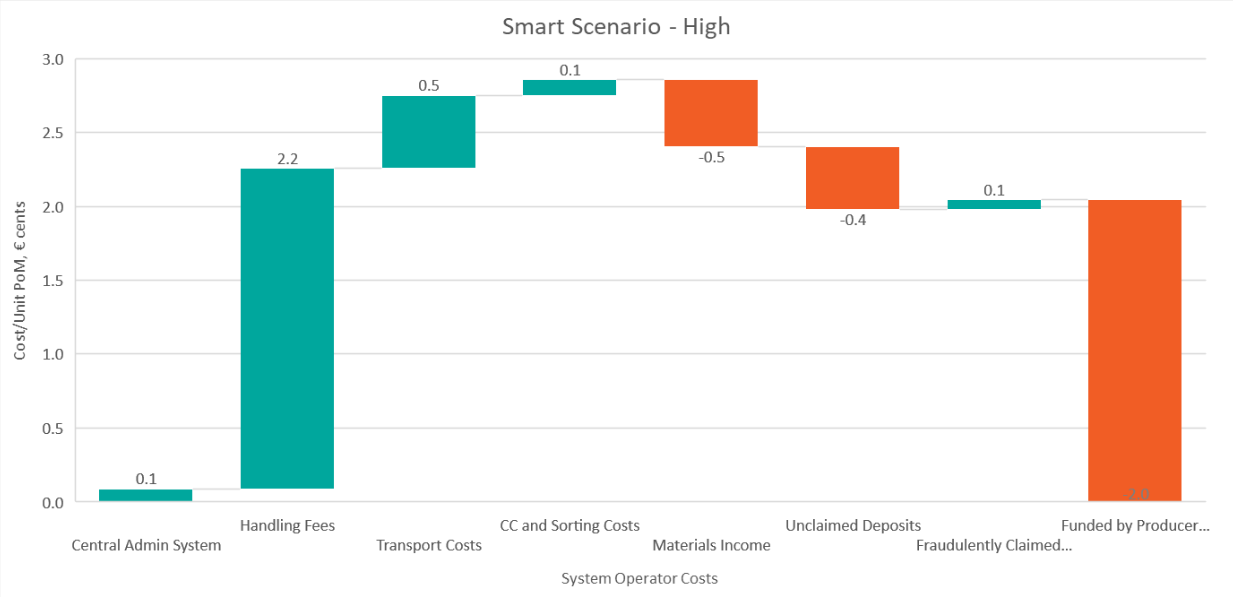


**Figure 5-4 Breakdown of system costs [green] and revenues [orange] in the Smart-high scenario**




The results indicate that a Smart system operates in a range that overlaps with the cost estimates for the Conventional system; thus, the Smart Low scenario appears much cheaper than the Conventional scenario and the Smart High appears more expensive. The range of costs for the Smart system are mainly due to differences in handling fees (see section 5.2). These are significantly higher in the Smart High scenario due to the use of more sophisticated (and therefore expensive) return infrastructure. Counting centre costs are higher in the conventional scenario due to the much greater use of manual returns (of uncompacted containers). In the smart scenario most material is compacted at the point of return, which does not require subsequent counting.

Table 5-3 provides more detailed system costs by material for the Conventional scenario and the same results are presented for the Smart scenario in Table 5-4. In both systems, the producer fee is approximately the same for each stream with the exception of metals which are considerably lower. This is affected mainly by the following:

- **Bulk density / volume** – material which is lower in volume per container (i.e. a larger number of containers can fit within a given volume) is cheaper to transport and handle on a per container basis. For example, trucks can hold more containers per trip, and less storage is required per container at return points etc.
- **Material income** – materials with a higher material income (on a per container basis) contributes to lower producer fees. This is particularly significant for metals, for which the material revenue per container is greater than 1 cent.

In the conventional scenario, the producer fee per unit PoM ranges from 0.46 cents for metal to 2.32 cents for glass.

### Table 5-3 Detailed system costs per material stream for Conventional scenario

| | Total Cost, € million | | | | Cost/Unit PoM, € cents | | | |
|---|---|---|---|---|---|---|---|---|
| **System Operator Costs** | **Glass** | **Plastic** | **Metal** | **Bev Cartons** | **Glass** | **Plastic** | **Metal** | **Bev Cartons** |
| **Central Admin System** | 0.14 | 0.95 | 0.21 | 0.32 | 0.09 | 0.09 | 0.09 | 0.09 |
| **Handling Fees** | 2.31 | 15.06 | 2.81 | 4.52 | 1.46 | 1.40 | 1.21 | 1.26 |
| **Transport Costs** | 0.88 | 5.33 | 0.66 | 1.22 | 0.56 | 0.50 | 0.28 | 0.34 |
| **Counting Centre and Sorting Costs** | 1.24 | 3.22 | 0.64 | 1.12 | 0.78 | 0.30 | 0.28 | 0.31 |
| **Materials Income** | -0.30 | -5.44 | -2.36 | -0.18 | -0.19 | -0.51 | -1.02 | -0.05 |
| **Unclaimed Deposits** | -0.67 | -4.56 | -0.99 | -1.52 | -0.43 | -0.43 | -0.43 | -0.43 |
| **Fraudulently Claimed Deposits** | 0.08 | 0.54 | 0.12 | 0.18 | 0.05 | 0.05 | 0.05 | 0.05 |
| **Net Cost** | **3.67** | **15.10** | **1.08** | **5.65** | **2.32** | **1.41** | **0.46** | **1.57** |
| **Funded by Producer Admin Fee** | **-3.67** | **-15.10** | **-1.08** | **-5.65** | **-2.32** | **-1.41** | **-0.46** | **-1.57** |

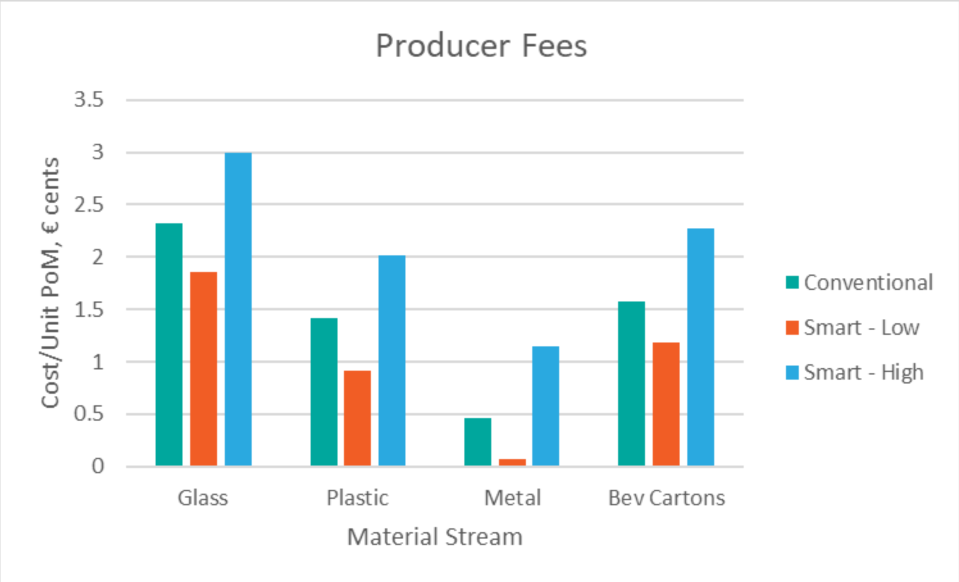
In Table 5-4, some values have a range, showing the difference between the Low and High scenario. In the smart scenarios, the producer fee per unit PoM ranges from -0.08 cents to 1.79 cents.

### Table 5-4 Detailed system costs per material stream for Smart scenario

| | Total Cost, € million | | | | Cost/Unit PoM, € cents | | | |
|---|---|---|---|---|---|---|---|---|
| **System Operator Costs** | **Glass** | **Plastic** | **Metal** | **Bev Cartons** | **Glass** | **Plastic** | **Metal** | **Bev Cartons** |
| **Central Admin System** | 0.14 | 0.95 | 0.21 | 0.32 | 0.09 | 0.09 | 0.09 | 0.09 |
| **Handling Fees** | 1.81 – 3.56 | 11.81 – 23.52 | 2.33 – 4.80 | 3.72 – 7.58 | 1.15 - 2.26 | 1.10 - 2.19 | 1.01 - 2.07 | 1.04 - 2.11 |
| **Transport Costs** | 1.01 – 1.03 | 5.75 - 5.81 | 0.74 - 0.75 | 1.40 – 1.45 | 0.64 - 0.65 | 0.54 - 0.54 | 0.32 - 0.33 | 0.39 – 0.40 |
| **Counting Centres & Sorting Costs** | 0.86 | 0.69 | 0.09 | 0.27 | 0.55 | 0.06 | 0.04 | 0.08 |
| **Materials Income** | -0.30 | -5.42 | -2.36 | -0.08 | -0.19 | -0.51 | -1.02 | -0.05 |
| **Unclaimed Deposits** | -0.67 | -4.56 | -0.99 | -1.52 | -0.43 | -0.43 | -0.43 | -0.43 |

| | Total Cost, € million | | | | Cost/Unit PoM, € cents | | | |
|---|---|---|---|---|---|---|---|---|
| **System Operator Costs** | **Glass** | **Plastic** | **Metal** | **Bev Cartons** | **Glass** | **Plastic** | **Metal** | **Bev Cartons** |
| **Fraudulently Claimed Deposits** | 0.09 - 0.10 | 0.63 - 0.69 | 0.14 - 0.15 | 0.21 - 0.23 | 0.06 | 0.06 | 0.06 | 0.06 |
| **Net Cost** | **2.94 – 4.73** | **9.85 – 21.69** | **0.16 – 2.66** | **4.22 – 8.14** | **1.86 – 2.99** | **0.92 - 2.02** | **0.07 – 1.15** | **1.18 - 2.27** |
| **Funded by Producer Admin Fee** | -2.94 - -4.73 | -9.85 - -21.69 | -0.16 - -2.66 | -4.22 - -8.14 | -1.86 - -2.99 | -0.92 - -2.02 | -0.07 - -1.15 | -1.18 - -2.27 |

Figure 5-5 Producer fees per material stream per scenario




## 5.2 Handling Fee

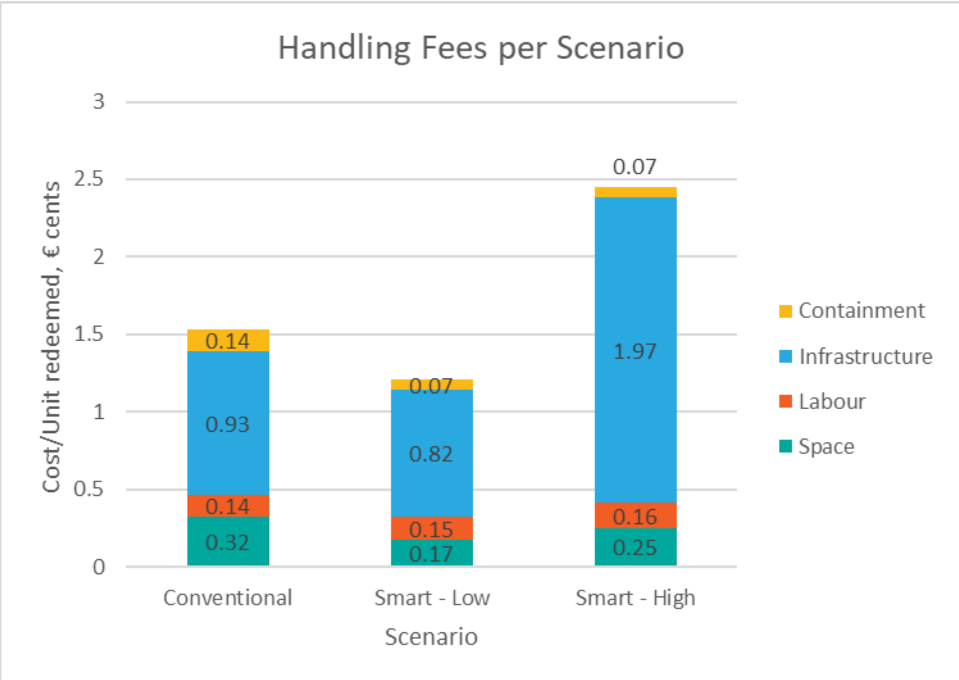
We assume that the handling fee is paid to the **owner of the return location**, who bears the associated costs. Handling fees would equally be paid to retailers, as well as a range of other return locations including business owners, local authorities, property managers etc. In reality, it may be that a different model of investment would be appropriate, for example, whereby some smart return technologies are funded directly by the central DRS system. However, for this study we have chosen to structure cost outputs in the standard ‘handling fee’ format. This financial mechanism is commonly used in DRSs and therefore provides results in a familiar format that are more easily comparable with existing systems.

The handling fee is one of the most sensitive results in determining overall system costs and is paid on a per unit redeemed basis. Table 5-5 below shows the breakdown of the handling fee in both scenarios, with the Smart scenario showing a range between the Low and High. The Conventional scenario has an average handling fee of 1.35 € cents per unit redeemed and the Smart scenarios have an average handling fee ranging from 0.96 € cents to 2.07 € cents per unit redeemed. The full details of the calculation can be found in section A.4.1 in the appendix.

### Table 5-5 Summary of Handling Fee per scenario

| | Conventional scenario | | | Smart scenario | | |
|---|---|---|---|---|---|---|
| | Total cost, € million | Average cost per unit redeemed, € cents | Cost/Unit PoM, € cents | Total cost, € million | Average cost per unit redeemed, € cents | Cost/Unit PoM, € cents |
| **Space** | 5.12 | 0.32 | 0.28 | 2.71 – 4.04 | 0.17 - 0.25 | 0.15 - 0.22 |
| **Labour** | 2.26 | 0.14 | 0.12 | 2.38 - 2.52 | 0.15 - 0.16 | 0.13 - 0.14 |
| **Infrastructure** | 15.11 | 0.93 | 0.83 | 13.37 – 31.84 | 0.82 - 1.97 | 0.73 - 1.75 |
| **Containment**[24] | 2.21 | 0.14 | 0.12 | 1.22 - 1.07 | 0.07 | 0.07 - 0.06 |
| **Net Handling Fee** | **22.05** | **1.36** | **1.21** | **19.68 – 39.47** | **1.21 – 2.45** | **1.08 – 2.17** |

### Figure 5-6 Breakdown of Handling fee per unit redeemed for 3 scenarios




**Infrastructure contributes to the greatest proportion** of the handling fee in either scenario, as does it most countries. Whilst there is a high proportion of containers being collected manually in the Conventional scenario, the infrastructure cost is still considerable due to the high capital cost for each conventional RVM. In any system, the RVM handling fee is higher than the manual handling fee but crucially, the use of an RVM reduces overall costs because of efficiency savings. For the Smart scenario, infrastructure units are generally much cheaper, but the number of infrastructure units included in the system can potentially make

[24] These are the boxes/bags that DRS materials are transported within.

the cost per container higher. This is because a conventional RVM has a much higher average throughput than other technologies. Table 5-6 and Table 5-7 give a further breakdown of the handling fees by material for each scenario.

### Table 5-6 Handling Fee by material in Conventional scenario [cost/unit redeemed, € cents]

| Cost/Unit PoM, € cents | Glass | Plastic | Metal | Bev Cartons |
|---|---|---|---|---|
| **Space** | 0.41 | 0.35 | 0.20 | 0.24 |
| **Labour** | 0.15 | 0.14 | 0.14 | 0.14 |
| **Infrastructure** | 0.97 | 0.92 | 0.95 | 0.92 |
| **Containment** | 0.18 | 0.15 | 0.09 | 0.10 |
| **Net Handling Fee** | **1.71** | **1.56** | **1.38** | **1.40** |

### Table 5-7 Handling Fee by material in Smart scenario [cost/unit redeemed, € cents]

| Cost/Unit PoM, € cents | Glass | Plastic | Metal | Bev Cartons |
|---|---|---|---|---|
| **Space** | 0.22 - 0.34 | 0.18 - 0.27 | 0.11 - 0.17 | 0.13 - 0.20 |
| **Labour** | 0.15 - 0.16 | 0.15 - 0.16 | 0.15 - 0.16 | 0.15 - 0.16 |
| **Infrastructure** | 0.84 – 2.01 | 0.82 - 1.97 | 0.83 - 1.99 | 0.82 - 1.96 |
| **Containment** | 0.10 – 0.09 | 0.08 - 0.07 | 0.05 - 0.04 | 0.06 – 0.05 |
| **Net Handling Fee** | **1.31 – 2.60** | **1.23 – 2.47** | **1.14 – 2.36** | **1.15 – 2.38** |

### Table 5-8 Handling Fee per return point, € cents

| | Conventional RVM (compacted) | Manual (with scanning) | Manual (no scanning | Simplified RVM | Smart Bin | RfID Enabled Container |
|---|---|---|---|---|---|---|
| **Space** | 0.30 - 0.36 | 0.21 - 0.28 | 0.29 | 0.10 - 0.20 | 0.00 | 0.00 |
| **Labour** | 0.11 - 0.12 | 0.23 - 0.24 | 0.15 | 0.17 - 0.33 | 0.02 | 0.01 - 0.01 |
| **Infrastructure** | 2.34 - 2.43 | 0.05 - 0.08 | 0.00 | 0.83 – 4.45 | 0.67 – 4.14 | 0.06 - 0.24 |
| **Containment** | 0.04 | 0.21 – 0.24 | 0.19 | 0.00 | 0.00 - 0.01 | 0.00 |
| **Net Handling Fee** | **2.75 - 2.95** | **0.71 - 0.84** | **0.64** | **1.10 – 4.99** | **0.69 - 4.17** | **0.07 - 0.25** |

*Note: Handling fees are expressed in terms of € cents per unit redeemed at each return location. High-low ranges are due to the range of capital expenditure costs assumed for the smart DRS scenario. In general, handling fees for smart and conventional are similar for each return location – the costs shown here are based on the smart DRS scenario for all return technologies with the exception of manual (no scanning), which is only used in the conventional scenario.*

## 5.3 Recycling Rates

Recycling rates are calculated on the basis of small loss rates applied to the modelled return rate. The advantage of a DRS means that only target material is generally collected, so loss occurs mainly through the transportation and sorting processes.

### Table 5-9 Recycling Rates in Conventional scenario

| | Glass | Plastic | Metal | Bev Cartons | Total |
|---|---|---|---|---|---|
| **Placed on Market, tonnes** | 33,496 | 26,811 | 3,654 | 4,303 | **68,263** |
| **Final recycling, tonnes** | 29,996 | 23,678 | 3,264 | 3,843 | **60,780** |
| **Overall Recycling Rate** | **89.6%** | **88.3%** | **89.3%** | **89.3%** | **89.0%** |

## 5.4 Sensitivity Analysis

This type of analysis tests how the model outputs are affected by variances in the model inputs. There are four types of sensitivities analysed, these are shown in Table 5-10 below and compared to the model assumptions used for the central scenario.

### Table 5-10: Overview of Sensitivity Analysis

| | Central Scenario | Sensitivities |
|---|---|---|
| **Materials included** | Plastic, cans, glass and cartons | 1) Plastic and cans only;<br>2) Plastic, cans and cartons;<br>3) Plastic, cans and glass |
| **Wines and Spirits** | Included | Excluded |
| **Deposit level** | 5 RSD | Multi-level |
| **Return Rate** | 90% | Low (88%) and High (92%) |

### 5.4.1 Materials Included in DRS

Sensitivities were run to understand the impact of the inclusion/exclusion of specific materials in the system. The mass flows under each of these sensitivities, and under the central scenario, are shown in Table 5-11.

### Table 5-11 Number of Containers Placed on Market for Material Sensitivities, Million

| | Glass | Plastic | Metal | Bev Cartons | Total |
|---|---|---|---|---|---|
| **Central (all materials)** | 158 | 1,072 | 232 | 358 | **1,821** |
| **Plastic and cans only** | 0 | 1,072 | 232 | 0 | **1,304** |
| **Plastic, cans and cartons** | 0 | 1,072 | 232 | 358 | **1,663** |
| **Plastic, cans and glass** | 158 | 1,072 | 232 | 0 | **1,462** |

The modelling outputs shown below have been calculated by re-dimensioning for each sensitivity; i.e. the system for plastic and cans has fewer return points than the central scenario (with the four material types). For example, the system for plastic and cans has fewer RVMs (and other types of return infrastructure under smart DRS) as the throughput requirements are lower.

**Table 5-12 Cost sensitivities for Conventional scenario [cost/unit POM, EUR cents]**

| Item | Central | Plastic and Cans | Plastic, Cans and Cartons | Plastic, Cans and Glass |
|---|---|---|---|---|
| Central Admin System | 0.09 | 0.11 | 0.09 | 0.10 |
| Handling Fees | 1.35 | 1.16 | 1.23 | 1.23 |
| Transport Costs | 0.44 | 0.48 | 0.43 | 0.47 |
| Counting Centre and Sorting Costs | 0.34 | 0.44 | 0.36 | 0.41 |
| Materials Income | -0.45 | -0.60 | -0.48 | -0.55 |
| Unclaimed Deposits | -0.43 | -0.43 | -0.43 | -0.43 |
| Fraudulently Claimed Deposits | 0.05 | 0.05 | 0.05 | 0.05 |
| **Net Cost** | **1.4** | **1.2** | **1.3** | **1.3** |
| **Funded by Producer Admin Fee** | **-1.4** | **-1.2** | **-1.3** | **-1.3** |

**Table 5-13 Cost sensitivities for Smart scenario [cost/unit POM, EUR cents]**

| Item | Central | Plastic and Cans | Plastic, Cans and Cartons | Plastic, Cans and Glass |
|---|---|---|---|---|
| Central Admin System | 0.09 | 0.11 | 0.09 | 0.10 |
| Handling Fees | 1.08 – 2.17 | 0.92 – 1.67 | 0.90 – 1.62 | 0.93 – 1.79 |
| Transport Costs | 0.49 | 0.58 – 0.68 | 0.49 – 0.50 | 0.53 – 0.55 |
| Counting Centre and Sorting Costs | 0.11 | 0.15 | 0.12 | 0.13 |
| Materials Income | -0.45 | -0.60 | -0.48 | -0.55 |
| Unclaimed Deposits | -0.43 | -0.43 | -0.43 | -0.43 |
| Fraudulently Claimed Deposits | 0.06 | 0.06 – 0.07 | 0.06 | 0.06 – 0.07 |
| **Net Cost** | **0.9 – 2.0** | **0.8 – 1.7** | **0.8 – 1.5** | **0.8 – 1.7** |
| **Funded by Producer Admin Fee** | **-0.9 - -2.0** | **-0.8 - -1.7** | **-0.8 – 1.5** | **-0.8 - -1.7** |

As we can see, the central scenario is more expensive than the other three sensitivities, where only two or three materials are included. This is mainly due to the different requirements in terms of return infrastructure.

In all cases, the number of return infrastructure units required is adjusted in response to throughput (i.e. lower throughput requires less RVMs), however, based on this factor alone there is little variance in costs on a per container basis.

The model also specifies the minimum number of return units required to collect the mix of materials modelled under each sensitivity, as shown in Table 5-14. These assumptions vary according to the capability of each return technology to sort multiple material streams. For example, in all cases it is assumed that one RVM can handle all material streams, however, with more material streams more sorting is required on the RVM. The central scenario requires a tri-sort RVM (which sorts into cartons / glass / plastic and cans – the latter stream is easily separated post-collection), whilst dual-sort and single (no sorting) RVMs are modelled for the material sensitivities. More sophisticated RVMs come at a higher cost, which accounts for the range of costs modelled for RVMs (see Table 4-9).

For return infrastructure which does not have a sorting capability, such as smart bins, multiple units are required to provide separate collection of material streams. Whilst plastic and cans can be collected together, glass and beverage cartons must be kept separate to avoid significant complications (and cost) to sort these material streams post-collection.

These variances are the main factor accounting for the difference in handling fees between sensitivities.

**Table 5-14: Minimum Number of Return Units per Location**

| | Conventional RVM (compacted) | Manual (with scanning) | Manual (no scanning | Simplified RVM | Smart Bin | RfID Enabled Container |
|---|---|---|---|---|---|---|
| **Central (all materials)** | 1 (Tri-sort) | 1 | N/A | 2 | 3 | 3 |
| **Plastic and cans only** | 1 (Single) | 1 | N/A | 1 | 1 | 1 |
| **Plastic, cans and cartons** | 1 (Dual-sort) | 1 | N/A | 1 | 2 | 2 |
| **Plastic, cans and glass** | 1 (Dual-sort) | 1 | N/A | 1 | 2 | 2 |

Other significant differences in cost between sensitivities include transport costs and material revenues. For transport costs there are two main factors which contribute to these results:

1) Larger numbers of containers in the scheme (i.e. in this case, more materials included) leads to greater efficiencies of scale and therefore lower cost – as seen in the central scenario; and
2) Systems with a greater proportion of high-volume containers (particularly glass) are associated with higher transport costs per container.

Material revenues are higher per container for systems with greater proportions of high value materials (particularly metal cans).

The producer fee for each material shows minor variance between sensitivities, as shown in Table 5-15. Consistent with the trends discussed, the producer fee is slightly higher for some materials in the central scenario.

**Table 5-15 Producer Fee, Total Cost/Unit PoM (€ cents)**

| | Glass | Plastic | Metal | Bev Cartons |
|---|---|---|---|---|
| **Central (all materials)** | 2.3 | 1.4 | 0.5 | 1.6 |
| **Plastic and cans only** | - | 1.4 | 0.4 | - |

| | Glass | Plastic | Metal | Bev Cartons |
|---|---|---|---|---|
| **Plastic, cans and cartons** | - | 1.4 | 0.4 | 1.5 |
| **Plastic, cans and glass** | 2.3 | 1.3 | 0.4 | - |

However, as discussed in the System Design document, there are other considerations besides cost when deciding the scope, such as the fairness of the approach, the reduction of litter, the contribution to the recycling targets and the availability of high-quality secondary materials.

### 5.4.2 Wines and Spirits

A sensitivity was also modelled to assess the impact of excluding wine and spirits from the scope of the DRS. The mass flows including (central scenario) and excluding wine and spirits are presented in Table 5-16. As shown, the exclusion of wine and spirits results in roughly a 20% reduction in the number of glass containers compared to the central scenario, and a minor reduction in metal containers.

**Table 5-16 Number of Containers PoM for Wine and Spirits Sensitivity, Million**

| | Glass | Plastic | Metal | Bev Cartons | Total |
|---|---|---|---|---|---|
| **Central** | 158 | 1,072 | 232 | 358 | **1,821** |
| **Excluding wine and spirits** | 131 | 1,072 | 231 | 358 | **1,792** |

System costs calculated in the DRS model for the exclusion of wine and spirits, compared to the central scenario are shown in Table 5-17. For both scenarios the handling fee is slightly higher when wine and spirits are excluded - 1.38 € cents per container PoM, compared to 1.35 € cents per container PoM for the central scenario. This is because, whilst the number of return infrastructure units required is adjusted in the model according to throughput, for many return locations the minimum number of return units (e.g. a single RVM) is specified in both cases (and thus cannot be varied). Therefore, whilst the total cost of return technologies is approximately the same, the cost per container is higher when the total number of containers is lower (i.e. when wine and spirits are excluded). This is the only significant cost variance for this sensitivity.

**Table 5-17 Producer Fee with Wines and Spirits Sensitivity, Total Cost/Unit PoM (€ cents)**

| | Conventional DRS | Smart DRS |
|---|---:|---:|
| **Central** | 1.40 | 0.94 – 2.04 |
| **Exc. Wines / Spirits** | 1.42 | 0.94 – 2.07 |
| **% difference** | +1.5% | 0.1% to 1.4% |

Section 1.5.1 of the DRS System Design Report discusses the pros and cons of the inclusion of wines and spirits, summarised here for convenience:

- Advantages: improved recycling rate and increased supply of recycled material for glassmaking.
- Disadvantages: lower financial incentive due to higher price of the product, longer consumption time leading to less likelihood of redemption and potentially more complicated accounting, higher import rate and use of international barcodes.

### 5.4.3 Deposit Level

The multi-level deposits, as opposed to a flat fee, have been defined in Table 5-18 below.

**Table 5-18 Multi-level deposit prices per beverage container size, RSD**

| Size | <500ml | 500ml – 1l | 1l> |
|---|---:|---:|---:|
| **Deposit Value, RSD** | 4 | 5 | 6 |
| **Number of containers, millions** | 552 | 220 | 272 |

As this table shows, there are more small (<500ml) containers than larger, and so the average deposit level per container under the multi-level scenario is lower than 5 RSD (4.73 RSD). This means that the revenue from unredeemed deposits is lower in the multi-level scenario, leading to a more expensive system:

- In the conventional scenario the costs increase to 1.55 € cents per container PoM relative to the central scenario (1.40 € cents per container PoM).
- In the case of Smart DRS the costs increase to a range of 1.1 – 2.2 € cents per container PoM compared with the range of 0.9 – 2.0 € cents per container PoM with the flat fee.

Although the same return rate is used, it is possible that a slightly lower 'average' deposit under the multi-level scenario could lead to marginally lower return rates, particularly for smaller containers. This would in turn decrease the total costs of the system because it has fewer containers to process, and it would also reduce the net costs (via increased revenues) due to the increase in unredeemed deposits.

Finally, as described in the System Design report, in the absence of any clear differences in performance it may make most sense to select a flat-rate deposit because it is the simplest approach. The deposit structure can – and should – be re-visited once the DRS is up and running (see section 7.2). If, for example, data indicates that the return rate is lower for larger containers, a multi-level deposit could then be considered.

### 5.4.4 Return Rates

As discussed in Section 4.1.1, the deposit value is the main determinant of return rates. However, there are many other factors affecting return rates, including the convenience of return locations, governance arrangements, specific demographic and socio-economic factors etc. Due to the potential variance in the final return rates, a sensitivity was run to determine the costs of a DRS for return rates both higher (92%) and lower (88%) than the central scenario (90%). It is important to investigate the impacts of return rates on the sustainability of the system, to ensure that it runs efficiently even when returns are very high.

Producer Fees calculated in the DRS model for these sensitivities are shown in Table 5-19, and we can observe that a variation of 2pp in the return rate leads to a 8% variation in the unit costs in the Conventional scenario and an even higher variation of the range of costs in the Smart scenario (11% variation of the lower end of the range and 5% variation of the high end of the range).

**Table 5-19 Producer Fee by Return Rate Sensitivity, Net Cost/Unit PoM (€ cents)**

| | Conventional DRS | Smart DRS |
|---|---|---|
| **90% return rate (central scenario)** | 1.4 | 0.9 - 2.0 |
| **88% return rate** | 1.3 | 0.8 - 2.0 |
| **92% return rate** | 1.5 | 1.0 - 2.1 |

Changes to return rate affect four key variables:

- Revenue from unredeemed deposits - a higher return rate leads to less revenue from unredeemed deposits;
- Material income – a higher return rate leads to higher material income;
- Handling fees – a higher return rates leads to higher handling fees; and
- Transport costs – a higher return rate leads to higher transport costs.

However, as seen in the table above, in a 92% return rate the increase of revenues from the material income does not compensate the additional costs of handling fees and transport, and the loss of revenue from unredeemed deposits.

# 6.0 Model Results – Environmental & Social impacts

There are impacts arising from DRS implementation specifically related to the environment and social groups. These benefits stem from:

- Recycling of additional beverage containers;
- Reduction in disposal of beverage containers;
- Additional collection and transportation of containers to recyclers; and
- A reduction in littering, reduced litter clean-up costs and the associated impact this has on personal well-being, businesses and sense of community .

More details on the inputs and assumptions for this part of the model can be found in section A.4.6 in the appendix.

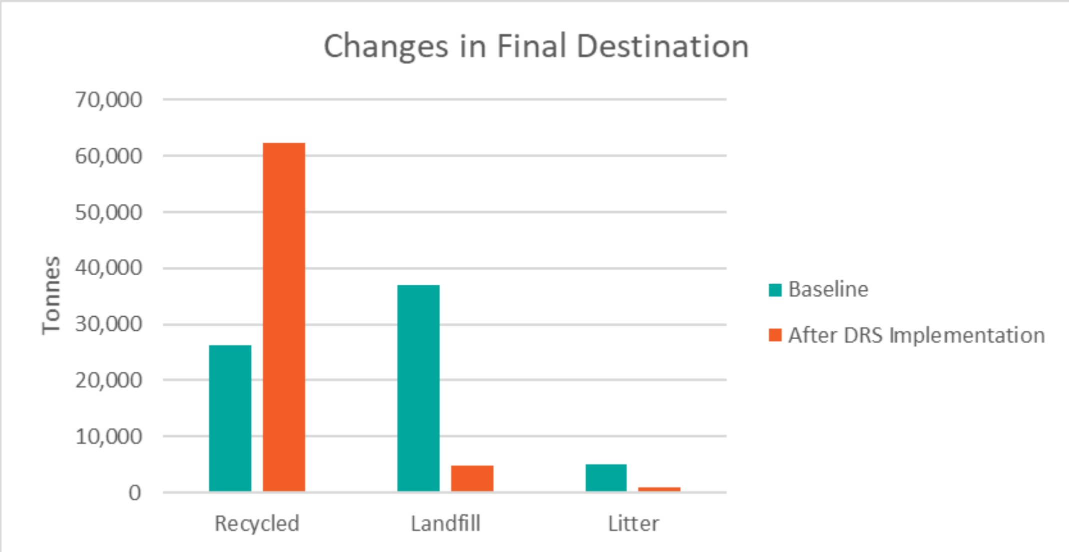
## 6.1 Final container destination

Table 6-1 shows the changes in the container destination comparing the baseline with the DRS implementation. The DRS more than doubles the quantities recycled and leads to significant reductions in landfill and littering.

**Table 6-1 Changes in final destination after DRS implementation, tonnes**

| | Baseline | After DRS implementation | Change | Change (%) |
|---|---|---|---|---|
| **Recycled** | 26,236 | 62,324 | +36,088 | +138% |
| **Landfill** | 36,945 | 4,923 | -32,022 | -87% |
| **Litter** | 5,082 | 1,016 | -4,066 | -80% |

**Figure 6-1 Final destination before and after DRS implementation, tonnes**



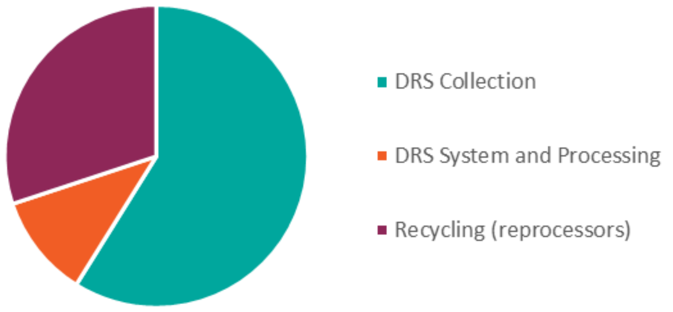

## 6.2 Creation of employment

Table 6-2 shows the incremental jobs in different areas: collection, system and processing, recycling and disposal. The model estimates a that **1,270 net jobs will be created** in these sectors.

**Table 6-2 Incremental jobs due to DRS implementation**

| Area | Type of job | Incremental jobs |
|---|---|---|
| **DRS Collection** | Receiving Containers by Retailers | 503.0 |
| | Collection | 184.0 |
| | Further Haulage | 60.0 |
| **DRS System and Processing** | Central System Administration | 13.0 |
| | Counting Centres | 127.0 |
| **Recycling (reprocessors)** | Plastic | 255.6 |
| | Glass | 86.8 |
| | Aluminium | 27.0 |
| | Steel | 4.9 |
| | Beverage Cartons | 7.6 |
| | Paper / Card | 0.0 |
| **Disposal** | Landfill | 0.5 |
| | **Total** | **1,270** |

Figure 6-1 Job creation per type of employment




## 6.3 Environmental impacts

The increased recycling rate will not only support attainment against EU and domestic recycling targets, but also reduce Serbia's greenhouse gas emissions (GHG) and other air pollutants. The reduced landfilling will also affect air quality.

Table 6-3 below shows the monetised environmental benefits, both in terms of greenhouse gas (GHG) emissions and air quality (AQ) savings. It is worth noting that the savings from recycling and disposal are higher than the additional transport emissions from collections.

Table 6-3 Monetised environmental benefits from DRS operations

| | | Monetised Benefits, €m | | |
|---|---|---|---|---|
| Area | GHGs, kt | GHG | AQ | Total |
| **Recycling** | -45 | -1.5 | -0.5 | -2.0 |
| **Disposal** | -3 | -0.1 | 0.0 | -0.1 |
| **Transport - Collections** | 14 | 0.7 | 0.0 | 0.7 |
| **Total** | **-35** | **-0.9** | **-0.5** | **-1.4** |

The **reduction in litter** has the potential to generate savings for municipalities in terms of street cleaning and litter bin collections. It is not, however, possible to quantify the impact of the DRS as it cannot be determined, for instance, whether streets would need to be swept less frequently or would take less time – because other items will still be littered. It does, however, seem clear that less waste would be collected and that municipalities could reduce their disposal costs.

In addition to the direct financial costs of collecting and processing litter, litter has indirect costs related to the impact on the aesthetic appearance of neighbourhoods, damage to belongings or injury to people as a result of broken (particularly glass) beverage containers, reduced property values, and links with reduced mental wellbeing and increased crime. Litter can, therefore, have a wider impact on the prosperity of a town or city and a DRS will help to address this. Eunomia has estimated the change in litter 'disamenity' as a result of the reduced litter in a DRS. Disamenity is a term used by economists to describe the negative perception of littering and the effect this has on people's sense of well-being, and is based on estimates of people's willingness to pay for a less littered local environment. This welfare loss is often referred to as the 'disamenity impact ' arising from litter – much of which is considered to be due to the 'visual disamenity impact' which is understandable given that litter can transform the look and feel of a place. Table 6-4 below shows the monetisation of litter disamenity.[25]

**Table 6-4 Monetised impacts of litter disamenity**

| | tonnes | Disamenity per tonne[26], € | Disamenity, €m |
|---|---|---|---|
| **Terrestrial Litter** | -3,049 | 92,848 | -283 |
| **Marine Litter** | -1,016 | 265,602 | -270 |
| **Total** | **-4,066** | **-** | **-553** |

The values attribute to marine litter result from an estimation of the litter from Serbia that can be transported to the marine environment via rivers. It is worth noting that the benefits in terms of marine litter may be perceived as global impacts.

# 7.0 Implementation

The implementation of a DRS can be achieved successfully within a 24 -30 month 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 planning and installation of infrastructure. Where countries have tried to implement a DRS in a much shorter time frame (e.g. Estonia – 16 months), they ran into "teething troubles" that created financial issues and took time to resolve. Lithuania delivered a successful scheme within 18 months, but it is a small country by European standards. A full description of the implementation phases can be found in appendix A.3.0.

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 DRS in line with their commercial interests.
- **Unfamiliarity with DRS** – stakeholders that are unfamiliar with a DRS, such as national retailers may need time to come on board with the project.
- **Population** – scaling up for this – This will greatly affect the practical implementation by increasing the numbers of counting centres and return locations required.
- **if several countries decided to implement a DRS in the same year,** sourcing the raw materials for RVM components could be problematic if a large number of RVMs are ordered in a short time frame.

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

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[25] Further considerations on the cost of litter can be found in Eunomia's blog article *Picking up the evidence: what is the cost of litter?* (2014) by Dr Chris Sherrington, available at https://www.isonomia.co.uk/picking-up-the-evidence-whats-the-cost-of-litter/

[26] Based on datapoints from a previous project, an impact assessment on the Single-Use Plastics Directive

- Simple legislation that sets the parameters for the CSO 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.
- Care in appointing the CSO CEO (and management) as this is a critical role requiring someone with management oversight and diplomatic tenacity.
- Coordinated dialogue with stakeholders to ensure a smooth implementation and facilitate an agreement on the handling fee.
- Early outlining of the obligations for producers and retailers to allow them maximum time for decision making and preparations.
- A clear tender process for external providers of infrastructure and transport facilities.

## 7.1 Legislation

The most common way to introduce deposit scheme into the legislation has so far been through Acts of Laws on Packaging and Packaging Waste. The list of the issues which are normally regulated at the level of Act of Law include the following:

1. Field of application
2. Scope of the packaging types and product types in the system
3. Definitions:
    - beverage packages
    - refillable beverage packaging
    - reuse
    - one-way packaging
    - filler
    - dealer
    - final consumer
    - deposit
4. Obligations related to the sales of the beverage with deposit (obligations concerning producers/fillers, dealers, distributors and retailers)
5. Obligations related to taking back of the beverage packaging (applying to retailers, defining exemptions, if any of them apply)
6. Approval/appointment of the deposit operator (Approval for the non-for-profit entity established by the producers/importers or appointment of another entity in case producers/importers fail to establish their own organization)
7. Obligations of the deposit system operator including:
    - Financial clearing
    - Collecting administration fees
    - Pay handling fees to retailers/service entities
    - Collecting the returned packaging from the collection points
    - Transferring the collected recyclables to recycling
    - Reporting recycling levels to the relevant authorities
8. Obligation of the producers/importers related to entering the contract with the deposit system operator, payment of the administration fees etc. (including due time)
9. Approval of the minimum deposit value (with recommendation of the deposit system operator)

10. Minimum collection levels to be achieved by the deposit system
11. Administrative offenses
12. Deposit marking requirements
13. Entry into force

It must be noted that although legislation is the most common approach, it is not the only option. For example, in Norway, the industry chose to introduce a DRS without government legislation. Instead, they have a Beverage Container Tax which reduces as the recycling rate increases, so the industry decided to introduce a DRS as it was the most cost-effective way to reduce their tax liability.

## 7.2 Changes after implementation

Finally, changes to the system design can be made after the system has been introduced, and elements should in any case be kept under review so that the system can be adapted as necessary to make it more efficient and/ or increase the return rate. Some key parameters are:

- **deposit structure and value** – as described in the System Design Report, the deposit structure and value should not be fixed in legislation, as it can be a time-consuming and difficult process to change, as well as subject to political lobbying (though, if desired, a minimum value could be fixed in legislation). It is important that the system operator has the flexibility to increase the deposit value if return rates are falling;
- **return infrastructure** – if the return rate targets are not being met, the CSO could decide to supplement the initial infrastructure setup, for example, by adding RVMs in other location;
- **retailer handling fees** – should be revised annually based on actual costs, to reflect wages and rental costs. Similar to the deposit value, prescribing fees in legislation could politicise the issue, subjecting the legislature to lobbying from retailers for a fee increase and from producers who will oppose a change that would increase their costs. It is recommended to have fees negotiated between the CSO and retailers and, as retailers and producers are represented on the board, all interests are taken into consideration; and
- **target return rates** – ambitious targets should be set in the legislation at the outset, with interim targets for the first couple of years. It is important that Governments and the CSO have a mechanism for monitoring the success of the DRS and holding it to account - government should provide oversight and auditing.

# 8.0 Conclusions

Firstly, the implementation of a well-designed DRS (be it smart or conventional) should increase recycling rates and support contributions to SUP targets. It is worth noting that the Smart DRS option reduces the certainty that the system will perform well, due to the untested nature of the system. One of the main aspects of uncertainty is the potentially increased rates of loss, fraud and contamination in Smart DRS, as the containers proposed are not as secure as a traditional RVM. Further investigation is recommended on the impacts of Smart DRS on a future closed loop system and the SUP directive, as the reduced material quality potentially created in the smart DRS scenario may not be compatible with these future policy changes.

Two main scenarios have been analysed in this report: a conventional DRS and a Smart DRS (with low and high estimates). The system net annual costs are €25.5 million and €17.25-37.2 million respectively, to be funded by producer fees.

- The conventional DRS would result in an average unit cost of 1.4 cents, the smart DRS would result in an average unit cost of 0.9-2.0 cents;
- The Smart DRS has inherent uncertainties around its application due to its novelty. The model has produced a range of costs that suggest that a well-designed Smart DRS could achieve the same results as the Conventional DRS with slightly lower costs.

Four different sensitivities have been analysed:

- With the regards to the **materials included**, the cheapest option would be only including plastic and cans, followed by the options of excluding glass or beverage cartons. Finally having the four material streams would be the most expensive option, but there are other factors to be considered, such as the fairness of the approach, the reduction of litter, the contribution to the recycling targets and the availability of high-quality secondary materials.
- The scenario that excludes **wines and spirits** leads to higher costs so the inclusion of wines and spirits is recommended.
- The model suggests that the multi-level deposit would lead to a higher producer fee in conventional DRS while a lower fee in Smart DRS; therefore, and in the absence of a strong case for a multi-level structure, the simpler system of a **flat fee** is recommended.
- The **return rate** is a key variable of the DRS and it has been modelled at 90%; however a variation of 2pp of the rate (88% or 92%) would lead to much higher variations of the producer fee, according to the interplay of key variables such as material income, unredeemed deposits and transport and handling fees.

The implementation of a DRS in Serbia would have **social and environmental impacts**, summarised as:

- Creation of 1,270 jobs;
- More than doubling of the recycled volumes and landfill and littering reduced to around a fifth of the volumes;
- Monetised savings from reduction of greenhouse gases and air quality improvements equivalent to €1.4 million; and
- Litter disamenity estimated at €553 million.

Overall, the introduction of DRS in Serbia would reach high collection targets, increased recycling rates, significant environmental benefits and job creation.

# APPENDICES

# A.1.0 Background and Objectives of DRS

## A.1.1 What is a DRS?

Packaging fulfils important functions: good packaging can make logistics efficient, improve the safety and the durability of products and serve purposes of communication and marketing. Eco-design initiatives help to provide all of these functions with a minimum of material consumption and waste generation, both in packaging and packaged products. However, while technological progress and eco-design allow packaging to become more efficient, packaging waste generation in Europe is still growing. A functioning waste collection and recycling system is the cornerstone of a material-efficient economy. In the context of the European Green Deal, high reuse rates of beverage packages and high recycling rates of packaging materials have been shown to contribute to lowering the carbon footprint and reducing other environmental impacts of packaging systems and increasing resource efficiency.[27]

A DRS for one-way packaging is a system that incentivises the return of the packaging (most commonly beverage cans and bottles) to collection points, using a refundable deposit (in current schemes within the EU, typically EUR ¢10–25 per item). Consumers pay the deposit when they purchase the beverage and receive it back when they return the container to one of the designated collection points. If a consumer chooses not to return the empty container, then they lose the deposit. Under a conventional DRS, collection points are located in retail outlets, for convenience, or centralised locations, where containers can be deposited in bulk. At retail outlets, consumers can return the 'empties' to the shop counter, or in larger shops to automated 'reverse vending machines' (RVMs). The containers collected can then be recycled into new containers for filling with new beverages or used for other manufacturing purposes.

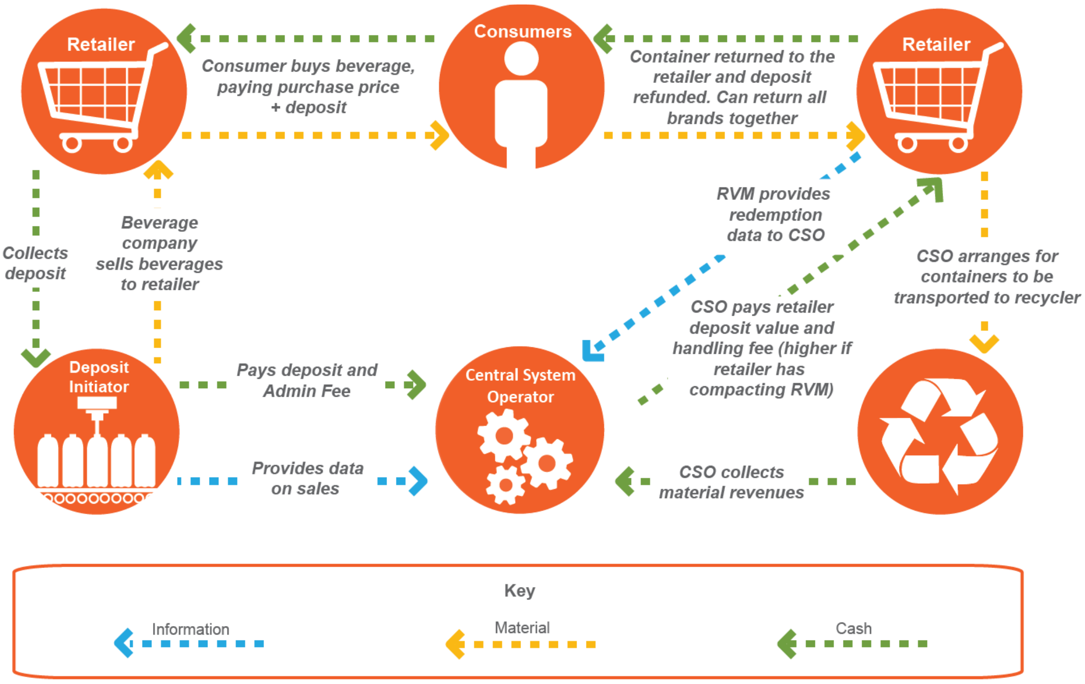
There are number of DRSs established in the EU or parts of countries elsewhere (e.g. several US States, provinces of Canada and Australia). The number of return options varies, from a high proportion of grocery and convenience stores to just a few big collection points, often at large shopping malls or other centralised locations. A DRS can apply to one-way (single use) containers and/or to refillable containers.

While in principle it is possible for a DRS to include a wide range of products, most scheme are limited to beverage containers, which are fast-moving and often found in litter. There is considerable variation in precise scope, but the vast majority include plastic bottles and metal cans, with many also including glass bottles. Most schemes are to some degree 'producer-led', and so although there is increasing interest in extending scope beyond beverage packaging, governance and ownership structures can make this a complex task.

[27] Radhakrishnan, S. (2015) Environmental Implications of Reuse and Recycling of Packaging, *Environmental Footprints of Packaging* (December 2015) Dr Subramanian Senthilkannan, p.pp.165-192

The 'return to retail' model around which traditional DRS systems are built is illustrated in Figure A-1.

**Figure A-1 Flow diagram for a conventional 'return-to-retail' DRS**




Generally, the system works as follows:

1) Beverage producers initiate the deposit by paying it into a deposit account;
2) Retailers pay the deposit to producers/ distributors at the wholesale stage;
3) Consumers pay the deposit to retailers, along with the price of the beverage;
4) Consumers claim a full refund on their deposit when they return the container to a designated return location;
5) The return location is reimbursed for the refunded deposit from the deposit account; and
6) The returned containers are transported for reprocessing and can then be used to manufacture new containers.

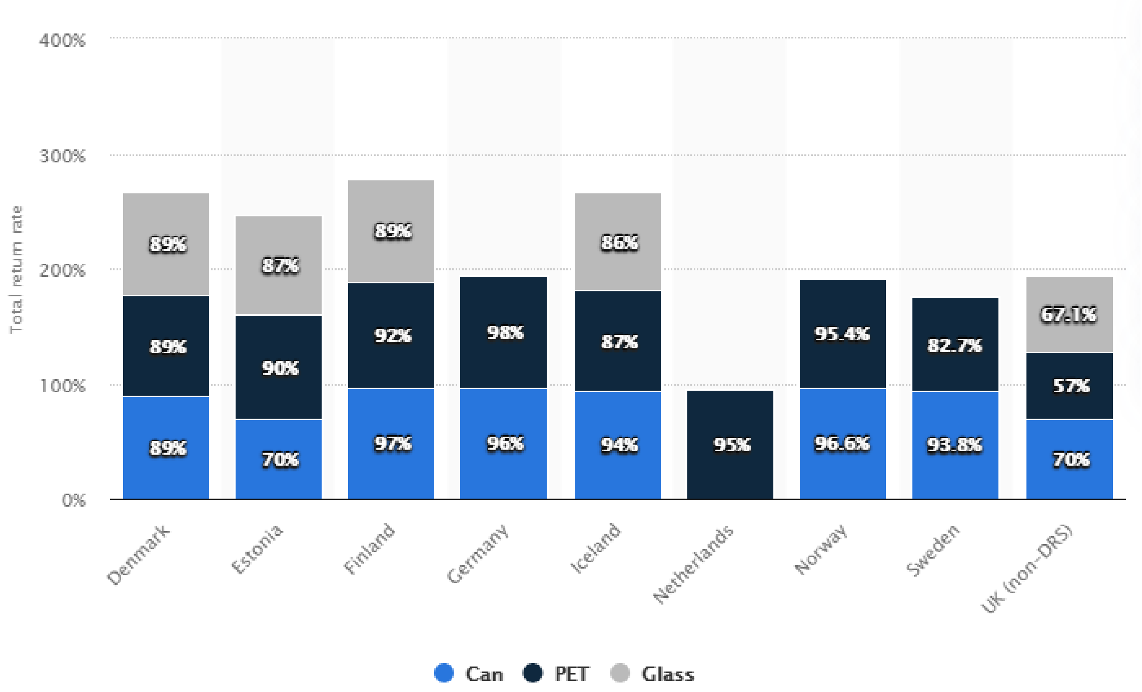
## A.1.2 Why Introduce a DRS?

A number of EU Member States are actively considering the introduction of DRS, driven by a range of generally accepted benefits of a well-designed DRS.

### A.1.2.1 Increased Recycling Rates

A key driver of interest since its adoption in 2019 has been the requirement in the EU's Single Use Plastics Directive for Member States to meet a target of 90% separate collection for plastic beverage bottles by 2030.[28] As illustrated in Figure A-2 several European DRSs achieve return rates above 90%, successfully diverting significant numbers of beverage containers from landfill and incineration. By contrast, evidence from across the EU suggests that the maximum recycling rate for plastic bottles in countries without a DRS is currently around 70%[29], with only Belgium achieving a collection rates above 80%.[30] The Single Use Plastic (SUP) Directive specifies DRS as a potential mechanism for securing the 90% plastic beverage bottle separate collection target, further increasing focus **on DRS as a proven means of delivering very high recycling rates**.[31] From what can be discerned so far, in their responses to this driver Member States seem likely to extend their DRS to include at least cans and plastic bottles and, in most cases, also glass bottles.

### Figure A-2 Return rates from existing EU DRS (2016)[32]




As described in the EPR Baseline Report, Serbia is currently not in track to meet EU recycling targets. Table A-1 is reproduced below for reference.

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[28] Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L:2019:155:TOC
[29] Eunomia and ICF for the European Commission, Directorate-General for the Environment (2018) *Plastics: reuse, recycling and marine litter: impact assessment of measures to reduce litter from single use plastics*
[30] Eunomia, EFWB, Petcore and Plastics Recyclers Europe (2020) *PET Market in Europe: State of Play*
[31] European Commission (2019) Directive (EU) 2019/904 on the reduction of the impact of certain plastic products on the environment
[32] Source: https://www.statista.com/statistics/990105/drs-performance-rates-in-europe-by-country/

**Table A-1 Current and future performance against EU packaging recycling targets if no improvements to the system are made**

| | Performance against National Targets | Performance against EU Targets | | |
|---|---|---|---|---|
| | 2019 | 2022 | 2025 | 2030 |
| **Paper/cardboard** | 10% | 4% | -5% | -15% |
| **Plastic** | 12% | 0% | -16% | -21% |
| **Glass** | -11% | -14% | -38% | -43% |
| **Metal** | 7% | 4% | 1% | -9% |
| **Wood** | 9% | 3% | -1% | -6% |

*Cells in green indicate that the target is projected to be met or exceeded; cells in red indicate that the target is projected not to be met*

#### A.1.2.2 Reduced Littering

Research indicates that a well-designed DRS could reduce the littering of beverage containers by 95%. On the basis that roughly 40% by volume of litter is comprised of beverage containers, the volume of all litter could be reduced by approximately a third.[33]

#### A.1.2.3 Reliable Supply of High-Quality Material

As a DRS provides a well-defined single stream collection, the material collected is generally of a higher quality and less contaminated than that obtained through other collection methods, such as kerbside or bring-banks. Of particular relevance to plastic bottles, this means the recycled material is of food-grade quality and can be used to manufacture new beverage containers, helping producers who have committed to increasing their use of recycled content.

#### A.1.2.4 Wider Environmental and Economic Benefits

A DRS increases recycling rates and reduces littering by increasing the beverage container capture rate, hence diverting material from landfill and incineration plants, which in turn can reduce greenhouse gas emissions (due to less use of virgin material for the manufacture of new beverage containers) and other air pollutants. A DRS has been shown to boost

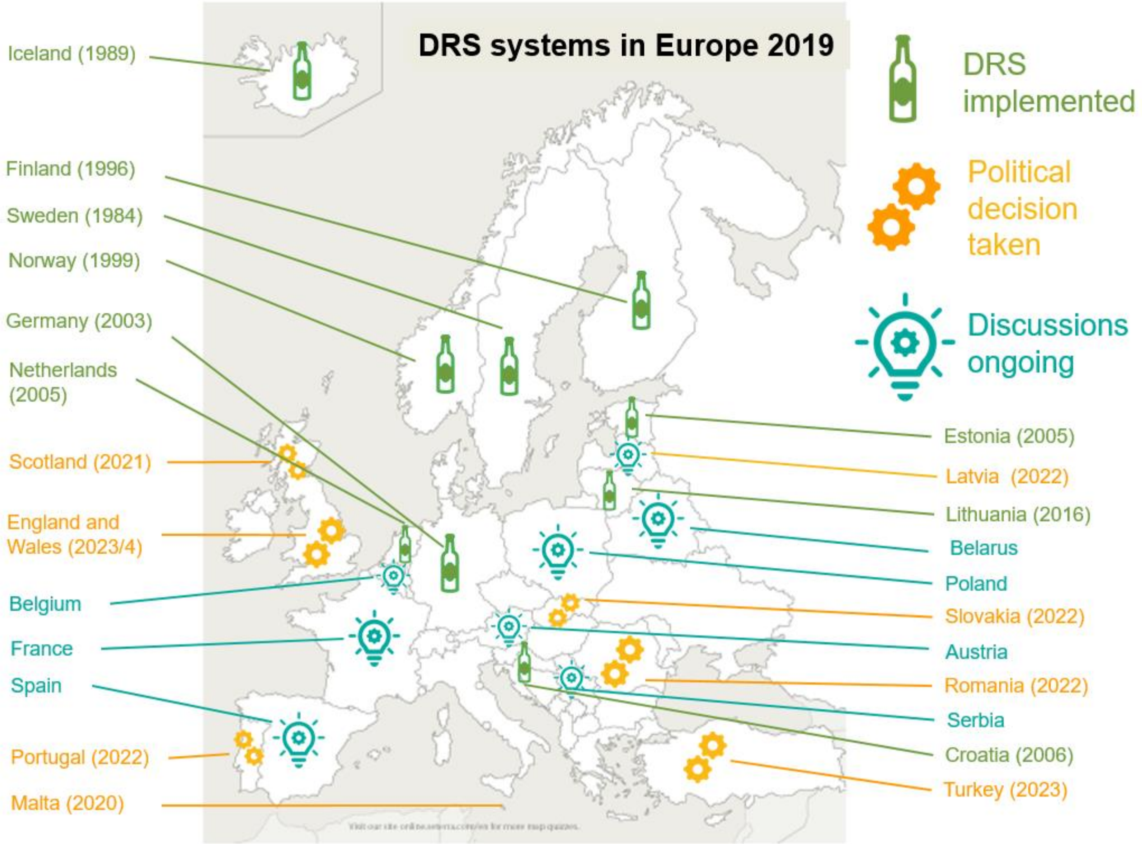
[33] Eunomia (2017) *Impacts of a Deposit Refund System for One-way Beverage Packaging on Local Authority Waste Services*, 2017

employment, with the potential to create jobs in administration, retail, transportation, processing and recycling.[34,35]

## A.1.3 Current DRS context in Europe

Figure A-3 shows the countries where there is an existing DRS in operation and the countries where a DRS is either in the process of being introduced or is a possibility being considered.

**Figure A-3 DRS systems in Europe 2019**

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[34] Eunomia (2019) *Employment and Economic Impact of Container Deposits*, 2019

[35] Eunomia (2011) *From Waste to Work: the Potential for a Deposit Refund System to Create Jobs in the UK*, Report for Campaign to Protect Rural England, 2011

# A.2.0 Smart DRS Approach

## A.2.1 Return Technologies

### A.2.1.1 Return Technology Specifications

We describe the current return technology options on the market as **'conventional RVMs'**. These include self-contained systems with internal storage, or larger units with a backroom system with conveyors that sort containers into their respective waste streams. The waste is compacted prior to emptying.

Costs for RVMs in our modelling are based on a small[36] sized RVM with a backroom system, as this provides a good proxy for the 'average' RVM (in terms of capacity, as used in a typical conventional DRS).

**'Manual return'** describes the process in conventional DRS whereby consumers hand over DRS containers to a member of staff at the return location, usually a small retail outlet, perhaps in a village in a rural area. The containers are manually counted and the consumer is issued with a refund for their deposit on these containers. DRS containers are then stored non-compacted at the return location prior to collection. The manual return location can also be equipped with a handheld scanner, which is used by the staff member to record the return of each DRS container. In both cases, regional 'counting centres' are required to ensure that deposits paid out tally with the material collected from manual returns.

A **simplified RVM** is a standalone system with internal storage. It differs from a traditional RVM in the following ways:

1) It does not use a conveyor to transport and sort containers into storage. Instead, packaging falls into internal storage.
2) It is single stream. As there is no conveyor, there is no means to sort the waste streams and therefore **one simplified RVM is required for each waste stream.**

A simplified RVM has the capacity to reject packaging if the barcode is not recognised, or if consumers try to deposit an item belonging to a different waste stream. Additionally, as with conventional RVMs, simplified RVMs can return physical coupons or vouchers should users wish to redeem their deposits for them. A simplified RVM also gives users the option to donate funds to charity.

**Smart bins** are containers with apertures protected by a hatch which opens if the returned container is applicable to that waste stream. As with systems already used in several countries in the EU, the hatch could open after communicating over Bluetooth or via RFID with a phone app (after the smartphone scans the container via the app) causing a powerful magnet to deactivate and the aperture to open, if the container is applicable. The smart bin is internet enabled to communicate with databases to authenticate whether the hatch

[36] See section A.4.1.3 for justification of selection of a small RVM

should open, based on customer ID, whether the bottle is redeemable and RFID geo-referencing.

In terms of power supply, there are three market options: battery power, mains powered, or battery and solar. Due to the requirement for regular communication with the database system, it is likely the smart bins will require a mains power source, although a solar power supply with a battery could be sufficient.

Additional functionalities include an in-built sensor which links to a Cloud system managed by the waste contractor. This system enhances the efficiency of collections as waste is emptied only when the bin is nearing full capacity.

Unlike the majority of traditional smart bins used for general waste, the smart bin would **not comprise a compactor**. This is because:

- In a combined plastic bottle and can waste stream, crushing the drinks containers would cause logistical problems as the containers needs to be separated at the re-processing stage, and;
- It is difficult to manufacture a smart bin with the mechanical power required to crush glass.

Figure A-4 An internet-enabled smart bin option

An **RFID enabled container** comprises a regular wheelie bin with an RFID nested on the outside in secure housing, allowing for accessible scanning. RFID enabled containers will be located in social housing, with Smart Bins, Conventional RVMs, Simplified RVMs and Bring Bank Collections providing for on-the-go disposals. Due to the location of RFID enabled containers, in fenced off areas of social housing, there is no requirement for further protective housing. The development of this option is straightforward, as the majority of the required storage units exists in-situ already – all that is required is the fitting of an inexpensive passive RFID chip.

This return technology is similar to the specification of an RFID Enabled Container, except the container is the recycling bin within a resident's household. Residents would fit their containers with an RFID chip for scanning when they deposit their recycling.

In France and Greece, is it is assumed that glass containers will be collected via bring banks rather than door to door – this matches the existing system in France and the most likely system for Greece if upgrades were made to waste collection services.

### A.2.1.2 Serialisation

With a serialised barcode, containers can be connected with only one redeemable deposit. Once scanned, the barcode reference number is deactivated on the system, stopping any frauds from repeatedly redeeming deposits. Serialisation also enables the journey of each container through the DRS system to be tracked and recorded. This capability has the potential to hasten circular economy principles and enable ethical sourcing for buyers.

### A.2.1.3 Traditional Databases

Traditional databases, in this context, are data stores which are managed by a centralised system administrator. A traditional database in a 21st Century DRS would be processed and audited by the central system operator. Traditional databases are 'centralised' data stores, managed and maintained by one organisation normally in one location. This does not necessarily mean that data is stored on servers on the organisation's premises as cloud-based databases are increasingly common.

Databases usually store data on one node, with back-up data stores, which means they have fewer points of failure and are more likely to crash, compared with a blockchain. In this event, there are mechanisms to restore the database – and therefore the system – to full functionality. Databases adjoin with back-up data stores, which periodically copies and stores the database's data, commonly referred to as hot and cold storage points. The 'heat' level depends on the accessibility and speed of transport protocols of the storage and therefore the ability of the system to reboot. Data in traditional databases is protected by firewalls, first developed in the late 1980s, which are a proficient means to protect commercially sensitive information. Databases can encrypt data so that organisations cannot access and view commercially sensitive data belonging to competitors.

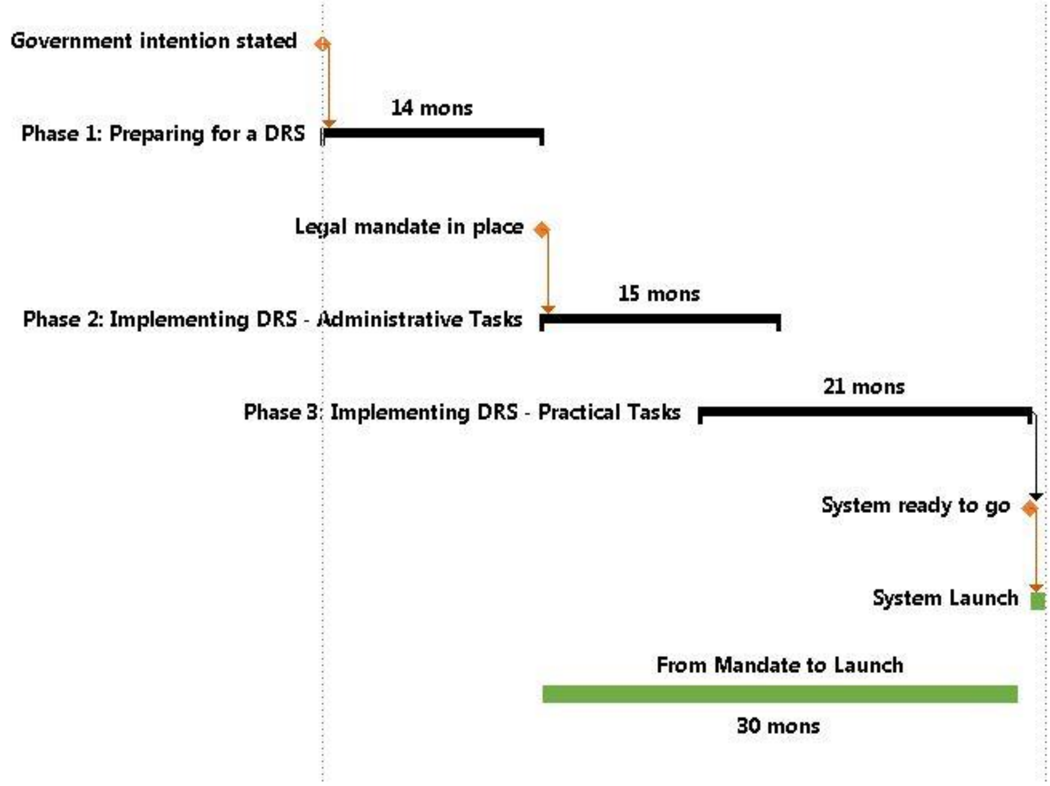
# A.3.0 Implementing a DRS

Three main phases are needed for setting up a DRS:

- a **preparatory phase**, culminating in the passing of a legal mandate that triggers the establishment of a DRS;
- and then the **implementation process** which can be broadly divided into
- an administrative phase; and
- a practical implementation phase.

These main phases are shown in Figure A-5. Following the legal mandate and the end of the preparatory phase, DRS implementation can typically be completed within 24 – 30 months, noting that the practical phase can only start at best around 6 months after the administrative phase has started. This is because the tasks within the practical phase (e.g. installing return infrastructure, organising transport logistics) are contingent on the CSO completing certain administrative tasks first (e.g. completing detail system design modelling, deciding how RVMs will be procured). Any delay in the administrative phase will therefore have knock on impacts for the entire implementation timeline.

**Figure A-5 DRS Idealised Timeline**




The introduction of a DRS is essentially an intervention in an economic system, which needs to be done with care. Rushing the implementation process is likely to have negative impacts – for example, if return infrastructure is not sufficiently developed by the time system launches, consumers may have a negative experience when attempting to return containers (i.e. long queues at manual collection points or customers in rural areas being without a convenient return point). This in turn will lead to negative publicity and could reduce consumer engagement with the system.

It should also be emphasized, that there is no one-size-fits all approach to the set-up of a DRS and no two implementation timelines are identical. The time required to implement a DRS varies depending on a number of factors including:

- **Size of the country (and beverage container market):** this influences the scale of return infrastructure required and lead times required by manufacturers of RVMs, counting centre technologies, and sorting and baling equipment. It also influences the scale of the training programme required for retail staff (processing returns) and producer staff (packaging registration process, sales report procedures).
- **Existing retail infrastructure:** for example, it may be more straightforward to develop collection points in a retail market dominated by supermarkets that absorb most of the beverage containers, versus a retail market with a high proportion of small, independent retailers. In the latter case, the CSO will need to spend more time engaging with retailers, ensuring they are aware of their obligations and sorting out contracts.
- **Existing DRS infrastructure:** for example, in Finland, a DRS for refillable glass bottles has been in existence since 1950. A one-way metal beverage cans system was introduced in 1996, which was expanded in to include one-way PET bottles in 2008,

and one-way glass bottles in 2011.[37] Each stage of expansion was streamlined given that a system of sorts was already in place and all stakeholders (consumers, retailers, producers) were already familiar with the concept of a DRS.

- **Extent of cross industry co-operation:** openness of industry (retailers and beverage producers) to co-operating.
- **System scope:** for example, a system including one-way glass containers requires more complex return infrastructure, which can increase implementation timelines compared to a system that accepts cans & PET only. Where key stakeholders disagree on the system scope this can cause delay in the early stages of the administrative phase where key decisions are being taken.
- **Stakeholder consultation timeline:** the extent to which stakeholders / 3rd parties are consulted on matters. The more input requested, the longer the implementation timescale.
- **HoReCa sector size –** the CSO must engage with the HoReCa (hotels, restaurants and cafes) sector, to engage them in the DRS. HoReCa participation in the system is not usually required by legislation, but it is beneficial to the CSO if the sector is involved (i.e. if HoReCa establishments retain the containers sold on premises until they are collected by the CSO, rather than the containers being returned via retail). This has two benefits: it reduces pressure on retail return points and also reduces the retail handling fees paid out by the CSO, because HoReCa establishments are not paid a handling fee. The larger / more complicated the HoReCa sector in a particular country, the more time the CSO must spend mapping out the sector, arranging meetings and providing training.
- **Extended Producer Responsibility (EPR) reform** – Recent amendments to the Packaging and Packaging Waste Directive (2018/852/EC) and the Waste Framework Directive (2018/851/EC) mean that many European countries will be changing their extended producer responsibility schemes for packaging. Note the timing of this is not entirely clear: Article 8a of the Waste Framework Directive states that Member States shall take measures to ensure that extended producer responsibility schemes that have been established before 4 July 2018, comply with this Article by 5 January 2023; under the Packaging and Packaging Waste Directive, Member States must ensure that, by 31 December of 2024, extended producer responsibility schemes are established for all packaging in accordance with Articles 8 and 8a of Directive 2008/98/EC. Governments and industry are unlikely to want two significant periods of upheaval with regards to waste management, and therefore, may choose to align the implementation of a DRS with changes to EPR systems.

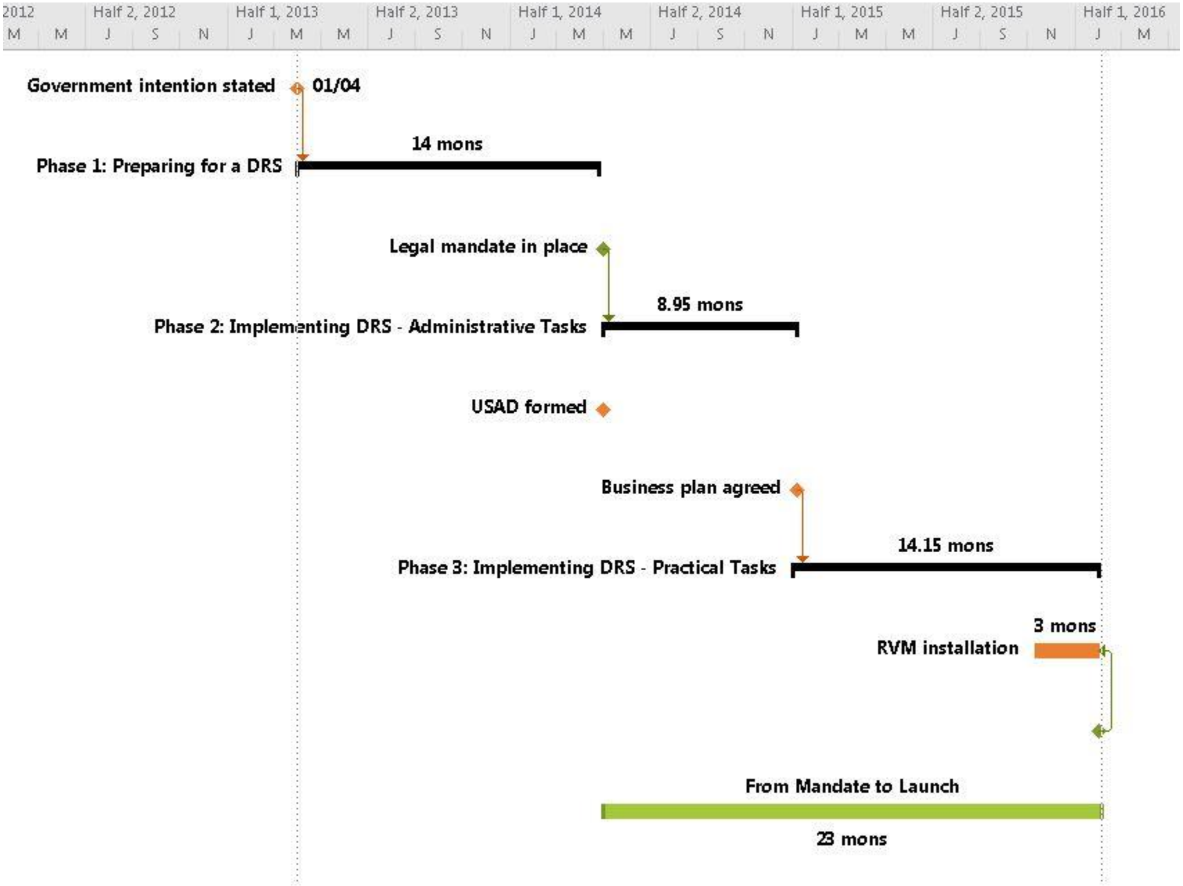
### A.3.1 Country Example: Lithuania

Lithuania is the most recent example of DRS implementation. With a population of 2.8 million it is a relatively small country by European terms. Legislation was passed in May

[37] Ettlinger, S. Deposit Refund System (and Packaging Tax) in Finlandi, p.9

2014, and the system launched 22 months later in February 2016 (see Figure A-6 for more detail).

**Figure A-6 Lithuania DRS Timeline**




## A.3.2 Administrative Phase

Once the mandate for a DRS is in place, the implementation process begins. The implementation process can be thought of as two phases: the **administrative phase** and the **practical implementation phase**. Certain administrative tasks must be completed before the practical implementation phase can begin (i.e. the detailed system design and business plan) though the administrative and practical phases do overlap and run in parallel to some extent. The core tasks within the administrative phase are:

1) the establishment of the CSO;
2) detailed system design – Business Plan;
3) set-up of data management tools; and
4) stakeholder engagement.

| Establishment of the Central System Operator | |
|---|---|
| **Optimal timeframe** | 4 months |
| **Key predecessors** | Legal mandate sets framework for CSO |
| **Key stakeholders** | Industry associations (producers and retailers) |
| **Key tasks** | • Appointing key individuals, CEO, CFO<br>• Other recruitment<br>• CSO infrastructure in place – buildings, admin systems,<br>• Securing initial set up loan |
| **Outcomes** | CSO can take forward implementation process |

| Detailed System Design – Business Plan | |
|---|---|
| **Optimal timeframe** | 4 – 6 months |
| **Key predecessors** | Establishment of CSO |
| **Key stakeholders** | CSO (Industry associations) |
| **Key Tasks** | • Detailed system design modelling<br>  ○ Return infrastructure (return points, counting centres, sorting and baling)<br>  ○ Transport and logistics<br>• Agree retail handling fee<br>• Agree RVM procurement method / specification<br>• Agree fraud prevention measures |
| **Outcomes** | Handling fee is set, practical implementation can begin |

| IT systems | |
|---|---|
| **Optimal timeframe** | 5 months (can be done in parallel with set up of physical infrastructure) |
| **Key predecessors** | Establishment of CSO |
| **Key stakeholders** | CSO (industry associations) |
| **Key tasks** | • Set up IT systems |
| **Outcomes** | Prerequisites for practical implementation complete |

| Stakeholder Engagement | |
|---|---|
| **Optimal timeframe** | 5 months |
| **Key predecessors** | Establishment of CSO |
| **Key stakeholders** | CSO (industry associations and other producers/importers) |
| **Key tasks** | • Clarification of obligations for producers and retailers<br>• Production of guidance (e.g. handbooks)<br>• Drafting and signing final contracts with producers, retailers |
| **Outcomes** | Producers and retailers are start preparations for DRS launch |

### A.3.3 Practical Phase

Once the CSO is up and running, has developed a detailed business plan, and has made the necessary key decisions (i.e. RVM specification and ownership model), the practical implementation phase can begin. This phase is the one most greatly affected by the size of a country, and can take between 18 and 30 months, depending on the country and its specifics, system scope, population size, number of stakeholders etc. The core tasks within the practical phase are:

1) establishing counting centres, sorting and baling facilities;
2) transport and logistic design;
3) develop return infrastructure; and
4) run a public communications campaign.

| Counting centres, Sorting and Baling facilities | |
|---|---|
| **Optimal timeframe** | 9-12 months |
| **Key predecessors** | Detailed business plan |
| **Key stakeholders** | CSO |
| **Key tasks** | • Acquire permits / licenses – e.g. for counting centres to be defined as waste management facilities.<br>• Run tender process for counting centres / baling and sorting equipment<br>• Building or refitting counting centres<br>• Production of sorting, counting and baling equipment<br>• Installation of sorting, counting and baling equipment |
| **Outcomes** | Back-end return infrastructure ready for system launch |

| Transport and Logistics | |
|---|---|
| **Optimal timeframe** | 9 months (in parallel with return infrastructure planning) |
| **Key predecessors** | • Location of retailers<br>• Location of counting centres agreed<br>• Predicted return volumes<br>• Retailers using RVMs vs manual collection<br>• Proportion of containers compacted vs uncompacted |
| **Key stakeholders** | Transport companies and CSO |
| **Key tasks** | Negotiation of contract with transport companies |
| **Outcomes** | Transport logistics ready for system launch |

| Return Infrastructure Developed | |
|---|---|
| **Optimal timeframe** | 12 – 15 months |
| **Key predecessors** | • CSO decided RVM specification and procurement model<br>• Retailers decided on type of return point |

| Return Infrastructure Developed | |
|---|---|
| **Key stakeholders** | Retailers, RVM manufacturers |
| **Key tasks** | • RVM tender process & selection of supplier (either by CSO or by retailers)<br>• Production of RVMs by selected RVM supplier(s)<br>• Installation of RVMs into retail locations and other locations<br>• Infrastructure for manual returns in place<br>• RVM testing |
| **Outcomes** | System ready for launch |

| Public Communications Campaign | |
|---|---|
| **Optimal timeframe** | 4 – 5 months |
| **Key predecessors** | CSO in operation |
| **Key stakeholders** | PR partners, Government department (e.g. Ministry of Environment) |
| **Aims of this stage** | Build public understanding of the DRS and encourage participation |
| **Key tasks** | • Run PR campaign |
| **Outcomes** | Consumers informed and ready to use DRS system. |

# A.4.0 DRS System Modelling

This section lists the input data and assumptions that have been used in the DRS model. The key variables have been described in section 4.0: return rates, loss rates, fraud, return locations, return points and data limitations.

## A.4.1 Retailer Costs

### A.4.1.1 Space Costs

#### Table A-2 Space Requirements per return technology, m2

| | Conventional RVM (compacted) | Manual (with scanning) | Manual (no scanning | Simplified RVM | Smart Bin | RfID Enabled Container |
|---|---|---|---|---|---|---|
| **Per unit infrastructure, m2** | 3.8 - 5.0 | 2.0 | 2.0 | 2.5 | 1.4 | 1.4 |
| ***Note: These include queuing space and backroom storage space*** | | | | | | |

#### Table A-3 Average monthly rent per type of location, EUR

| Location type | Rent price per m2, € |
|---|---|
| **Office** | 16 |
| **Retail** | 20 |
| **Industrial** | 5 |

### A.4.1.2 Labour Costs

#### Table A-4 Annual salaries per type of job, EUR

| Type of job | Annual salary, € |
|---|---|
| **Retailer Staff** | 4,800 |
| **Manual operator - Counting Centre** | 4,800 |
| **IT / Database staff - Central Admin (total salary per annum)** | 17,400 |
| **Customer services staff - Central Admin (total salary per annum)** | 11,400 |

### A.4.1.3 Return Technology Costs

#### Table A-5 Unit costs[38] per return technology

| | Cost per unit, € | Comments |
|---|---|---|
| **Conventional RVM (compacted)** | 15,000 – 28,000 | |
| **Manual (with scanning)** | 50 | |
| **Manual (no scanning)** | | |
| **Simplified RVM** | 7,500 | 5,000 for Low scenario<br>10,000 for High scenario |
| **Smart bin** | 3,500 | 1,676 for Low scenario<br>3,500 for High scenario |
| **RfID enabled container** | 210 | |

For the conventional RVM we modelled three types of RVM (tri-sort, dual-sort and single), depending on the number of materials included in the scheme. RVMs with low footprints (i.e. standalone RVMs rather than modular RVMs with a backroom unit) to account for the fact that Serbia has many small stores which may be limited in space.

[38] Sources: industry data, and most recent information from RLG (Reverse Logistics Group)

### A.4.1.4 Return Locations

**Table A-6 Number of return locations per type and data sources**

| Return location | # return locations | Notes |
|---|---|---|
| **Apartments / Flats** | 15,360 | http://sled.rec.org/documents/SLED_Serbia_BUILDING_ENG.pdf |
| **Large Retailers** | 968 | Provided by NALED |
| **Small Retailers** | 13,599 | Provided by NALED |
| **Petrol Stations** | 893 | Provided by NALED |
| **HORECA** | 14,275 | Provided by NALED |
| **Shopping Centres** | 49 | This was taken from a list of Shopping Malls within Serbia |
| **Workplaces** | 12,130 | Total of all businesses in Serbia excluding micro businesses |
| **Education** | 2,083 | Total number of schools, colleges and universities |
| **Sports and Leisure** | 110 | Total number of indoor arenas, swimming pools and ice rinks |
| **Religious Centres** | 3,410 | Based upon number of parishes within Serbia + 10% to represent other religions within Serbia |
| **Transport Hubs** | 690 | Based on train stations - no information on buses available |
| **Major Outdoor Events** | 800 | Based on total number of festivals within Serbia |
| **Parks and Open Spaces** | 350 | Based on total number of national parks within Serbia |
| **Town Halls** | 164 | Based on total number of notable urban areas |
| **Government Buildings** | 161 | Based on number of municipal areas |
| **Museums** | 100 | Based on number of museums in Serbia |
| **Recycling Centres** | 28 | Provided by NALED |

### A.4.1.5 Containment Costs[39]

**Table A-7 Containment costs, EUR, Conventional Scenario**

| Totals | RVM Bin (compact) | Manual bag | Total |
|---|---|---|---|
| Total Req'd, Thousand | 116 | 10,159 | **10,257** |
| Purchase Cost per Unit Containment | 12 | 0.25 | |

[39] Containment is the boxes/bags that DRS material is transported in.

| Totals | RVM Bin (compact) | Manual bag | Total |
|---|---|---|---|
| Beverage Container Lifetime (Years) | 3 | | |
| Annualised Cost per Unit Containment | 4.20 | 0.25 | |
| Total Cost, €M Annualised | 0.49 | 2.47 | **2.54** |
| Washing Cost per Container, € | 1 | | |
| Total Washing Costs, € | 115,911 | | **115,911** |
| **Total containment costs, €** | **0.60** | **2.54** | **3.36** |

**Table A-8 Containment costs, EUR, Smart scenarios**

| Totals | RVM Bin (compact) | Smart Bin | RfID Enabled Container | Manual Bag | Total |
|---|---|---|---|---|---|
| Total Req'd, Thousand | 1 | 5 - 55 | 0 - 12 | 6,388 - 4,264 | **6,394 - 4,332** |
| Purchase Cost per Unit Containment | 12 | | | 0.25 | |
| Beverage Container Lifetime (Years) | 3 | 3 | 3 | | |
| Annualised Cost per Unit Containment | 4.20 | | | 0.25 | |
| Total Purchasing Cost, €M Annualised | 0.002 | | | 1.60 - 1.07 | **1.60 - 1.07** |
| Washing Cost per Container, € | 1 | 0.50 | 0.50 | | |
| Total Washing Costs, € | 595 | 2,381 - 27,553 | 85 - 6,038 | | **3,061 - 34,187** |
| **Total containment costs, € M** | **0.003** | **0.002 - 0.03** | **0.000009 - 0.006** | **1.60 – 1.07** | **1.60 - 1.10** |

### A.4.1.6 Summary of retailer costs

As described in the System Design Report, the retailer handling fee should be based on an assessment of retailer costs, including staff time, retail space and infrastructure costs.

**Table A-9 Summary of retailer costs, EUR million, Conventional Scenario**

| | Conventional RVM (compacted) | Manual (no scanning) |
|---|---|---|
| **Pickup / Unload Costs** | 0.05 | 0.25 |
| **Labour Costs - Emptying Bins and Manual Returns** | 0.67 | 1.28 |
| **Return Infrastructure Costs** | 15.11 | 0.00 |
| **Space Costs** | 2.21 | 2.90 |
| **Total** | **18.04** | **4.44** |

**Table A-10 Summary of retailer costs, EUR million, Smart scenarios**

| | Conventional RVM (compacted) | Manual (with scanning) | Simplified RVM | Smart Bin | RfID Enabled Container |
|---|---|---|---|---|---|
| **Pickup / Unload Costs** | 0.03 - 0.03 | 0.15 - 0.11 | 0.04 - 0.06 | 0.01 - 0.03 | 0.01 - 0.04 |

| | Conventional RVM (compacted) | Manual (with scanning) | Simplified RVM | Smart Bin | RfID Enabled Container |
|---|---|---|---|---|---|
| **Labour Costs - Emptying Bins and Manual Returns** | 0.41 - 0.33 | 1.18 - 0.91 | 0.52 - 1.00 | 0.02 - 0.01 | 0.00 – 0.001 |
| **Return Infrastructure Costs** | 9.02 - 7.31 | 0.30 - 0.34 | 2.80 - 14.19 | 1.16 - 9.23 | 0.10 - 0.78 |
| **Space Costs** | 1.14 - 0.93 | 1.24 - 2.46 | 0.33 - 0.65 | 0.00 | 0.00 |
| **Total** | **10.60 - 8.59** | **2.87 - 3.82** | **3.69 - 15.89** | **1.19 - 9.27** | **0.10 - 0.82** |

## A.4.2 Transport Costs

### A.4.2.1 Pick-ups from return locations

Table A-11 shows the average number pickups per week, which are calculated based on expected throughout and maximum storage volume per return location.

**Table A-11 Average number of pickups per week per return location**

| Return location | Conventional scenario | Smart scenario - Low | Smart scenario - High |
|---|---|---|---|
| **Large Retailers** | 1.4 | 1.4 | 1.3 |
| **Small Retailers** | 3.0 | 3.7 | 1.4 |
| **Petrol Stations** | 0.5 | 2.2 | 1.0 |
| **HORECA** | 0.3 | 0.3 | 0.3 |
| **Shopping Centres** | | 5.2 | 4.5 |
| **Workplaces** | | - | 0.7 |
| **Education** | | - | 1.5 |
| **Sports and Leisure** | | 4.8 | 2.6 |
| **Religious Centres** | | - | 0.4 |
| **Transport Hubs** | | 4.5 | 2.1 |
| **Major Outdoor Events** | | 9.7 | 2.6 |
| **Parks and Open Spaces** | | 5.7 | 2.7 |
| **Town Halls** | | - | 3.2 |
| **Government Buildings** | | - | 4.4 |
| **Museums** | | - | 2.6 |
| **Recycling Centres** | | 3.2 | 3.2 |

### A.4.2.2 Onward Haulage to Counting Centres / Reprocessors

The model has considered the following datapoints:

- Assuming an 85% fill efficiency, each lorry can carry 78 m3 of uncompacted manual collected containers;
- The cost of haulage for a large truck is €0.80 per km;
- The fuel cost is €1.02 per litre;
- Based on Serbian geography, and a distribution of 5 counting centres across the country, the average haulage distance from drop off point to counting centre would be 79 km.

### A.4.2.3 Additional Consumer Journeys

The additional consumer journeys have been considered in the environmental modelling (see section A.4.6), not applicable for smart bins and RfID enabled containers.

**Table A-12 Additional consumer journeys to return the containers**

| Containers through… | Beverage Containers per customer | % of journeys that are in addition in passenger cars | Km Per Excess Journey |
|---|---|---|---|
| **Conventional RVM (compacted)** | 25 | 5% | 2 |
| **Manual (with scanning)** | 15 | 2% | 2 |
| **Simplified RVM** | 25 | 5% | 2 |
| **Smart Bin** | 5 | 0% | |
| **RfID Enabled Container** | 5 | 0% | |
| **TOTAL** | | | |

## A.4.3 Counting Centre and Sorting Costs

The locations of the 5 counting centres that have been modelled are denoted as CCL (counting centre location):

- CCL1: South Backa
- CCL2: Zlatibor
- CCL3: Podunavlje
- CCL4: Pcinja
- CCL5: Zajecar

Table A-13 shows the distance from each district to the individual counting centre locations. Counting centres are only included in the Conventional scenario, not in the Smart scenario.

**Table A-13 Average distances [km] from districts to each counting centre location (CCL)**

| District | Distance to CCL1 | Distance to CCL2 | Distance to CCL3 | Distance to CCL4 | Distance to CCL5 |
|---|---|---|---|---|---|
| **Bor** | 338 | 270 | 195 | 271 | 31 |
| **Branicevo** | 173 | 206 | 26 | 298 | 204 |
| **Belgrade** | 97 | 198 | 65 | 343 | 249 |
| **Jablanica** | 368 | 300 | 225 | 71 | 150 |
| **South Backa** | 0 | 270 | 156 | 434 | 340 |
| **South Banat** | 108 | 214 | 43 | 333 | 240 |
| **Kolubara** | 167 | 79 | 156 | 434 | 341 |

| District | Distance to CCL1 | Distance to CCL2 | Distance to CCL3 | Distance to CCL4 | Distance to CCL5 |
|---|---|---|---|---|---|
| **Macva** | 68 | 145 | 141 | 419 | 326 |
| **Moravica** | 215 | 56 | 145 | 310 | 217 |
| **Nisava** | 331 | 263 | 188 | 122 | 98 |
| **Pcinja** | 434 | 366 | 291 | 0 | 216 |
| **Pirot** | 397 | 329 | 254 | 188 | 106 |
| **Podunavlje** | 155 | 183 | 0 | 292 | 198 |
| **Pomoravlje** | 233 | 148 | 90 | 212 | 118 |
| **Rasina** | 289 | 151 | 147 | 180 | 127 |
| **Raska** | 241 | 95 | 141 | 250 | 180 |
| **North Backa** | 106 | 363 | 249 | 527 | 433 |
| **North Banat** | 102 | 340 | 177 | 476 | 382 |
| **Central Banat** | 52 | 273 | 120 | 419 | 325 |
| **Srem** | 55 | 248 | 133 | 411 | 318 |
| **Sumadija** | 232 | 111 | 89 | 255 | 161 |
| **Toplica** | 352 | 212 | 209 | 123 | 133 |
| **Zajecar** | 339 | 271 | 197 | 217 | 0 |
| **West Backa** | 99 | 356 | 241 | 520 | 426 |
| **Zlatibor** | 270 | 0 | 200 | 366 | 272 |
| **Average distance (not weighted)** | **209** | **218** | **155** | **299** | **224** |

Table A-14 shows the distance from each district to the counting centres if there is more than one implemented. If all five counting centre locations are implements, the average haulage distance from tipping point to counting centre is 79.2km.

### Table A-14 Average distance [km] from districts to multiple counting centre locations

| District | 2 Counting Centres | 3 Counting Centres | 4 Counting Centres | 5 Counting Centres |
|---|---|---|---|---|
| **Bor** | 270 | 195 | 195 | 31 |
| **Branicevo** | 173 | 26 | 26 | 26 |

| District | 2 Counting Centres | 3 Counting Centres | 4 Counting Centres | 5 Counting Centres |
|---|---|---|---|---|
| **Belgrade** | 97 | 65 | 65 | 65 |
| **Jablanica** | 300 | 225 | 71 | 71 |
| **South Backa** | | | | |
| **South Banat** | 108 | 43 | 43 | 43 |
| **Kolubara** | 79 | 79 | 79 | 79 |
| **Macva** | 68 | 68 | 68 | 68 |
| **Moravica** | 56 | 56 | 56 | 56 |
| **Nisava** | 263 | 188 | 122 | 98 |
| **Pcinja** | 366 | 291 | | |
| **Pirot** | 329 | 254 | 188 | 106 |
| **Podunavlje** | 155 | | | |
| **Pomoravlje** | 148 | 90 | 90 | 90 |
| **Rasina** | 151 | 147 | 147 | 127 |
| **Raska** | 95 | 95 | 95 | 95 |
| **North Backa** | 106 | 106 | 106 | 106 |
| **North Banat** | 102 | 102 | 102 | 102 |
| **Central Banat** | 52 | 52 | 52 | 52 |
| **Srem** | 55 | 55 | 55 | 55 |
| **Sumadija** | 111 | 89 | 89 | 89 |
| **Toplica** | 212 | 209 | 123 | 123 |
| **Zajecar** | 271 | 197 | 197 | |
| **West Backa** | 99 | 99 | 99 | 99 |
| **Zlatibor** | | | | |
| **Average distance (not weighted)** | **159** | **124** | **98** | **79** |

Table A-15 shows the annual operating costs for the Counting Centres (only in Conventional scenario), accounting for cleaning and maintenance, rent, energy, wages and other supplies such as servers and networks.

### Table A-15 Operating Costs for Counting Centres

| Cleaning and Maintenance | Conventional Scenario |
|---|---|
| Time required for daily cleaning and maintenance, hrs | 2 |
| Number of machines | 19.0 |
| Total time required for all machines per day, hrs | 38 |
| Total time required for all machines per annum, hrs | 13,490 |
| Total Salary Cost per annum, € | 37,356 |
| Additional cost per machine for maintenance contract (per annum), € | 2,000 |
| Total Maintenance Contract Costs per annum, € | 38,000 |
| **Total Costs for Cleaning and Maintenance per annum, €** | **75,356** |
| Rent | |
| Space required per machine, m2 | 100 |
| Rent, € per m2 | 60 |
| Rent space per machine | 705,516 |
| Total rent across all machines | 113,996 |
| Additional space required per counting centre, m2 | 7,000 |
| Additional space total rent, € | 2,099,929 |
| **Total Rent per annum, €** | **2,213,925** |
| Energy | |
| Power consumption under load (kW) - machine | 3 |
| Power consumption under load (kWh) - baler | 14 |
| Number of machines served by each baler | 2 |
| Consumption per day (kWh) per machine | 218 |
| Consumption per annum (kWh) per machine | 77,297 |
| Total Annual Consumption, kWh | 1,468,635 |
| Cost per kWh, €/kWh | 0.05 |
| **Total Cost per annum** | **74,937** |
| Wages | |
| Number of machines per centre | 3.8 |
| Number of staff per machine at any one time | 1.5 |
| Number of hours each machine to run per annum | 7,455 |
| Number of hours per counting centre per annum | 28,329 |
| Hours per centre per year - 1.5 operatives per machine | 42,494 |
| Hours per operative per year | 1,672 |
| Staff per centre per annum | 25 |
| Wage per staff member per annum, € | 3,858 |
| Total wages per annum per centre, € | 98,059 |
| **Total wages across all centres, €** | **490,293** |
| Other supplies - server, network etc | |
| per centre per annum, € | 2,000 |
| **Total across all centres** | **10,000** |
| | |
| **TOTAL OPERATING COST P.A., €** | **2,864,510** |

### Table A-16 Investment costs for Counting Centres

| | Conventional Scenario |
|---|---|
| Counting machine List price per machine, € | 185,000 |
| Compactor and Bailer per machine, € | 230,000 |
| Installation Costs per machine, € | 20,000 |
| Number of years to be annualised over | 5 |
| Cost of capital | 5% |
| List Price + installation - annnualised over 5 years, € | 75,310 |
| **Total annualised investment cost, €** | **1,430,889** |

## A.4.4 Material Revenue

### Table A-17 Material Revenue (per tonne of material), EUR

| Material | Revenue per tonne of material, € |
|---|---|
| **Glass** | 10.00 |
| **Plastic (PET, HDPE)** | 229.61 |
| **Cans (Fe.)** | 199.85 |
| **Cans (Al.)** | 901.44 |
| **Beverage Cartons** | 19.56 |

## A.4.5 Central System Operator (CSO) Administrative Costs

### Table A-18 CSO costs

| | Conventional Scenario | Smart Scenario - Low | Smart Scenario - High |
|---|---|---|---|
| Set up Costs, € | | | |
| IT - capital investment | 400,000 | 400,000 | 400,000 |
| Office - furniture and equipment | 20,000 | 20,000 | 20,000 |
| Project (setup) management | 100,000 | 100,000 | 100,000 |
| Communication | 300,000 | 300,000 | 300,000 |
| Annualised cost | 141,712 | 141,712 | 141,712 |
| **Total Annualised Set Up Costs** | **141,712** | **141,712** | **141,712** |
| Staff Costs, € | | | |
| Number of staff required | 13 | 13 | 13 |
| **Total On-going staff costs** | **233,992** | **233,992** | **233,992** |
| Office Space Costs, € | | | |
| Office Space required, m2 | 200 | 200 | 200 |
| Office Space | 38,399 | 38,399 | 38,399 |
| Ongoing costs, € | | | |
| Administration - IT, Staff Expenses, Legal, Utilities etc, din | 350,000 | 350,000 | 350,000 |
| Marketing, % of turnover | 1.00% | 1.00% | 1.00% |
| Marketing total | 856,075 | 855,918 | 855,763 |
| **Total annual on-going costs** | **1,206,075** | **1,205,918** | **1,205,763** |
| | | | |
| **Total central system admin cost per annum** | **1,620,178** | **1,620,021** | **1,619,866** |

The costs have been allocated to each material stream based on number of containers.

## A.4.6 Environmental aspects

Litter rates in Serbia have been modelled with the assumption that each person generates **4.6 kg of litter per year**[40]. With a population in Serbia of 6,959,552 inhabitants, this results in an estimate of 32,084 tonnes of litter per year.

Table A-19 shows the share of litter that can be attributed to each type of container, which results in an estimation of 5,647 tonnes per year of litter of beverage containers.

### Table A-19 Distribution of litter per beverage container material

| | % in Litter | Tonnes |
|---|---|---|
| **Plastic Bottles** | 4.2% | 1,348 |
| **Glass Bottles** | 9.2% | 2,952 |
| **Aluminium Cans** | 3.1% | 995 |
| **Non Ferrous Cans** | 0.8% | 257 |
| **Beverage Cartons** | 0.3% | 96 |
| **Total** | **17.6%** | **5,647** |

With regards to the monetisation of environmental impacts, the damage costs have been modelled at a rate of **€32.70 per ton of $CO_2$**.

Asides from the environmental benefits, the implementation of a DRS also brings negative environmental impacts, namely in terms of journeys. The modelled assumptions are described in Table A-20.

### Table A-20 Additional journeys and GHGs impact

| | | Km | GHGs, tonnes |
|---|---|---|---|
| **Additional consumer journeys to redeem DRS containers** | Passenger Car | 5,199,025 | 1,583 |
| **DRS Collection Vehicles** | Larger HGV | 6,766,748 | 8,177 |
| **DRS Collection Vehicles** | 12 Tonne | | |
| **Further Haulage - DRS** | Larger HGV | 3,475,558 | 4,200 |
| **TOTAL** | | **15,441,331** | **13,960** |

[40] ICF & Eunomia Research and Consulting Ltd (2018) *Plastics: Reuse, Recycling and Marine Litter*, Report for DG Environment