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Serialised Deposit Return Systems

An assessment of the feasibility and desirability of container serialisation and alternative DRS return pathways in Belgium

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Report For

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Summary

Overview

Classic Deposit Return Systems (DRS) for beverage containers are well established and proven to deliver positive environmental outcomes. DRS relies on charging a small sum of money (the deposit) alongside the price of a drink when a product is sold, and refunding it when the container is returned. Classic DRS in Europe is built around return to retail, enabling return to the same range of locations as containers can be purchased.

There is now increasing interest in serialised DRS, specifically for single use. This alternative system has two key differentiating components:

- One element is the use of serialised markers, meaning each container in the system is uniquely identifiable (by means of a unique 2-D code, such as a QR code).
- The other element is the prospect of using that technology to enable additional or alternative return pathways to those seen in a classic DRS, specifically the potential for consumers to scan single use containers themselves using a smartphone app, and then place them in existing recycling collection services.

This study considers the technical, operational, and behavioural challenges for serialised DRS, and assesses the current state of readiness of these approaches. While a general review, it focuses specifically on current developments in Belgium, where a proposal for a serialised DRS has been recently put forward.

Whereas classic DRS models, at least in Europe, are increasingly standardised, there is still significant diversity in approaches proposed for serialised DRS. This study therefore concludes by suggesting a set of criteria against which the desirability and feasibility of individual serialised DRS proposals can be judged.

In the case of the Belgian proposal, many challenges exist with the current proposal for a serialised DRS, including:

- The **feasibility and likely costs of resolving technical challenges**, in particular around printing serialised markers on all container formats without slowing production, and ensuring controls on locations where deposits can be claimed are secure, without inconveniencing legitimate use.
- **Concerns over the public's ability and willingness to utilise return pathways that are dependent on consumers being digitally enabled**. This may create both social justice and performance concerns. These are particularly acute in Belgium as the proposal is completely dependent on consumers being digitally enabled, in contrast to proposals elsewhere.
- **Uncertainty over the likely performance of a serialised DRS in terms of consumer behaviours**, given the potential for the act of deposit reclaim taking place without containers being correctly returned. This may be particularly problematic in on-the-go settings.
- **The need to resolve these uncertainties and technical challenges in ways that are cost-effective all supply chain actors and households and can be rolled out at scale to meet a 2025 target date for DRS launch in Belgium.**

Benchmarking against a Classic DRS

The performance of classic DRS are well understood and provide a powerful benchmark against which alternatives can be assessed. Key policy outcomes for single use DRS for beverage containers include:

- **An increase in return rates**. Return rates are typically at least 90% when an extensive return-to-retail network is provided. Only eligible material is accepted by the system.
- **Reductions in litter prevalence**. Beverage containers can make up 30-40% of the litter stream by volume, and reductions of 85% are achievable with the introduction of a DRS.
- **An improvement in material quality and consistency**. Only eligible material is accepted by a DRS, and it is consistent right across the network. The material quality received is high value and suitable for recycling back into food grade packaging.

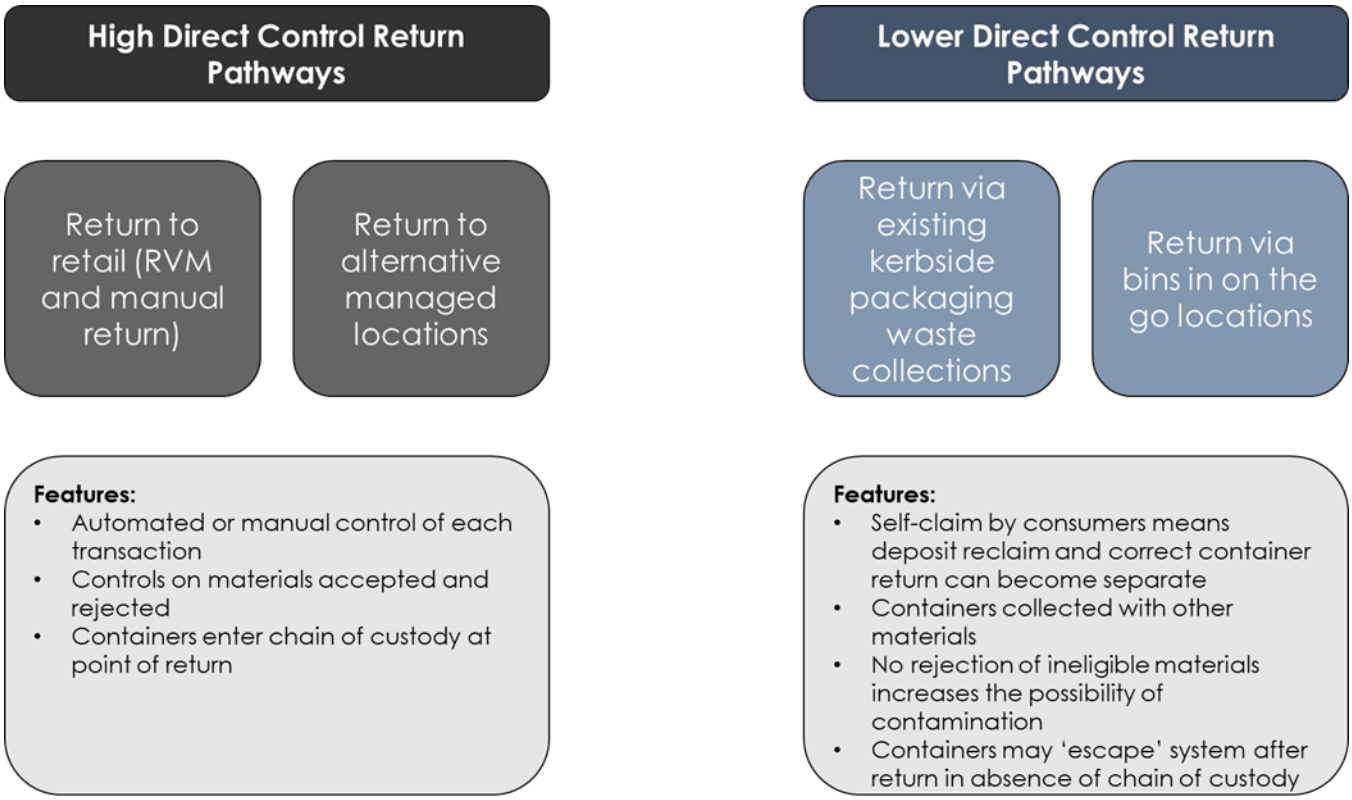
The above delivers higher levels of recycling, higher quality recycling, and greater material circularity.

Classic DRS designs can also give an identical consumer experience for both reuse and single use beverage containers, facilitating the consumer experience for both.

Return options for classic and serialised DRS

A classic DRS uses return pathways with high direct control, meaning that return and deposit refund takes place in a managed location, with verification of correct return undertaken automatically (via a Reverse Vending Machine (RVM)) or manually. Incorrect return is not accepted, and no refund occurs until containers have been physically returned. A serialised DRS can also use these pathways, but it can also use pathways with lower direct control. Consumers can use digital technology to reclaim their deposit, and are then assumed to correctly return their containers. These return pathways are summarised in Figure 1-1.

Figure 1-1 Available Return Pathways



Technical Considerations

The technical considerations for a serialised DRS can be split into three stages: pre-consumer, consumer, and post consumer. **Key considerations for each are outlined below.**

Pre-consumer Stage: Multiple supply chain adaptations are needed to enable a serialised marking system.

- **All eligible containers will need to be printed with serialised codes**, requiring IT and hardware changes to packaging printing processes. The cost of these changes is not yet fully understood, and there are concerns, especially where printing goes straight on the container rather than on to a separate label, that with current technology print and production speeds will be slower. **There will also need to be supply chain agreement about how codes are generated and IT systems to support this.** This will have technical, operational, and engagement challenges to ensure supply chain alignment. **Small businesses and importers will need extra consideration** to ensure they are not discriminated against and do not incur excessive costs, or end up excluded from the market.

- **A critical pre-consumer choice is 'deposit activation'.** Whereas in a classic DRS deposits are associated with container sales throughout the supply chain, they cannot be claimed early as reclaim depends on the return of an empty container to a designated return point. In principle a serialised container can be self-claimed, which would potentially enable 'virtual' theft of deposits, with containers scanned before sale, and before any deposit is paid. One solution is only to activate deposits at point of sale – but this requires additional technology at the point of sale, and this would need to be universal across all sales locations for the system to work. An alternative is to restrict the ability to claim a deposit earlier in the supply chain, however the technologies to do this, such as

geofencing, may complicate other elements of the system (such as ease of consumer participation for legitimate returns.

Consumer Stage: The additional technology needed to facilitate consumer return exists, but the IT requirements are exacting.

- Return pathways with high direct control do not change that much with the addition of serialisation. Ensuring RVMs can read the serialised codes is possible (depending where on the container they are located) and provision would also be needed for manual return (but could be smartphone or app based for the retailer as a minimal solution). **For kerbside collections, an authorisation code (confirming a user is close to a bin) and which is scanned alongside the container code may be required**, though alternatives such as geofencing are also options.

- **A key component in either case is a consumer facing smartphone app, and the database this is linked to.** This system will need to access a database with tens of millions of containers in it, contain personal data, link to payment systems, and work with exceptionally high accuracy and reliability in near real time. Workarounds may also need to be identified for situations where people do not have access to smartphones or internet.

- **Similar challenges exist for on-the-go return.** In these contexts there is scope for additional bin infrastructure, such as 'smart' bins. In practice however, smart bins are usually only offering an authorisation code and no guarantee that beverage containers are correctly returned, nor that unwanted waste is excluded. These fall far short of the levels of control seen in RVMs.

- **Unlike with a classic DRS, municipalities will be a key actor in return pathways that involve either kerbside collection or on-the-go bins**, with direct responsibility for providing and managing infrastructure and servicing. Understanding and reimbursing their true costs for these services will be essential to maintaining the principle of producer responsibility for financing the system.

Post-consumer Stage: The desirability of additional measurement to understand system performance is high.

- **Material sorting will be essential in determining material quality when beverage containers are collected via return pathways with lower direct control**. In a classic DRS, reclaimed deposits and returned containers match and provide high quality data on system performance. **A key limitation of return pathways that enable self-claim is the extent of any gap between the act of reclaim and that of actual return.** This can only be established with post-collection verification, but no technology exists that can verify serialised codes at the speed, scale, and accuracy needed after collection. Alternative means such as counts or weighing would however be essential, and there is a risk serialised DRS data at this stage would be weaker than classic DRS data**.**

- **Material quality and consistency from pathways with lower direct control will be worse than with a classic DRS.** Contaminants would not be physically excluded and target beverage containers would be deliberately collected alongside other recyclable materials. Both quality and consistency will suffer. Sorting is therefore an essential component of the system, and will determine whether materials can ultimately be directed to food grade recycling applications. **Material quality and consistency will not be improved by the addition of a deposit alone,** and are likely to match that experienced before the DRS is introduced.

Across all these areas, where technical and operational challenges exist, a key constraint for actual policymakers will be the timeline within which they can be proven to be resolved. There is high uncertainty on this point. No systems of this nature have been deployed at scale to date, and limited pilot settings have yet to test and demonstrate all aspects of delivery and performance in conjunction.

Behavioural Considerations

Classic DRS works well in behavioural terms. In addition to the incentive provided by the deposit, barriers to recycling should be minimised by the provision of a convenient and easy to use return network. Real world performance shows this solution works in terms of communication, opportunity, and capability of individuals to act. In the case of littering, the incentive works not just on the would-be litterer, but also provides a financial incentive for other members of the public who choose to pick up littered containers and return them. A serialised DRS would have little to no differential impact on behaviour if deployed only alongside return pathways with high direct control (e.g. Return-to-retail).

Return pathways with low direct control may have a range of impacts on system performance, which are not yet proven. On one hand, for some digitally enabled users these pathways may be more convenient than a classic DRS. However, the design of these routes may also create barriers to participation.

Firstly, the fact deposits are self-claimed may weaken the link between correct return and deposit reclaim, and thus the effectiveness of the incentive. Problems may occur through misunderstanding, oversight, and accident, as well as resulting from fraud and deliberate bad behaviour. While a range of mitigations can be proposed, none of them are foolproof and some (e.g. geofencing) significantly add to the complexity of the system, or create additional frictions for consumers using it.

Secondly, the fact that return pathways with lower direct control are mediated by technology makes them digitally dependent from a consumer perspective. The significance of this is particularly acute if non-digital alternatives are not also readily available.

- **Digital access and literacy** is therefore essential to enable participation in digitally dependent return routes, and is not universal. Even in a wealthy country like Belgium smartphone penetration is estimated at 90%, only around 75% of the population make an online purchase in a year, and levels of 'digital literacy' are judged to be lower still. Actual access may be further limited geographically by limited reception or internet access. Workarounds (such as provision of dedicated "home-scanners" for households lacking access) are ultimately also digital, and may prove challenging to roll out and support. No workarounds would be available in on-the-go contexts.

- **Digital banking access and literacy** is also essential as refunds will be made this way. This may prove difficult for those without this access or skills, whether permanently or temporarily. This would potentially impact those in financial difficulty, without bank account or transient populations like tourists.

- **System reliability and accuracy** over time is also critical, and delays in payment may also weaken the deposit incentive. Consumer will also need to be willing to use digital services, and **data security** and the perception of this will be critical.

Any shortfall in people's ability to participate in return creates a significant social justice concern. As participation in the DRS is not optional for consumers, an inability to reclaim deposits for certain groups would be both unfair and could cause genuine hardship.

Assessment criteria

Serialised DRS proposals are relatively unique in how they combine proposals for serialisation as a marking technology with combinations of return pathways. This is also a rapidly evolving area where technology continues to evolve and operational knowledge continues to be developed.

We therefore propose criteria against which serialised DRS proposals should be assessed, using classic DRS performance and convenience as a benchmark. These criteria can be summarised under three themes, outlined below:

Theme 1: Performance and wider policy alignment

1. **Litter:** Will the system deliver litter reductions on a similar scale to those seen in a classic DRS?

2. **Return Rate:** Will consumers return containers at similar or better rates than those seen in a classic DRS?

3. **High quality and consistency of material:** Will the material mix collected be suitable for sorting into different material streams with minimal material losses, and can these then be reprocessed into high quality food grade recycled material?

4. **Compatibility with Reuse:** Will return locations and infrastructure fit with longer term requirements to expand the provision of reusable containers, and normalise consumer behaviour for that future?

Theme 2: Access

5. **Accessibility of system for consumers:** Can all consumers easily reclaim their deposits and return their containers?

6. **Consumer Confidence and Safeguards:** Are measures to protect consumers personal and financial data sufficient to enable mass participation?

7. **Market Access for Producers:** Can all producers and importers access the market fairly and without excessive costs?

Theme 3: Technical Readiness

8. **Timescale:** Can everything below be resolved within the delivery timescales set by policymakers in a given country?

9. **Labelling With Serialised Markers:** Can all container formats, and all producers appropriately label their containers affordably and equitably?

10. **Integrated IT Systems:** Can all producers, retailers, and consumers access and operate appropriate hardware and software in real time?

11. **Easy and Controlled Deposit Activation:** Is the deposit activated in a way and at a time that minimizes risk, fits with retailer operations and technology, and does is not inconvenient for consumers?

12. **Easy and Controlled Reclaim and Deactivation Stage:** Can deposits be reclaimed quickly and easily by consumers, and in a way that maximises the likelihood that deposits are reclaimed only for containers returned correctly?

13. **Ability to Audit and Verify Performance:** Are opportunities for fraud minimised and can claimed return by consumers be checked against actual returns to the system?

The Belgian Example

The published Belgian proposal was written by PwC for Fost Plus in September 2022[1], and thinking will have continued to develop, not least as Flanders region has commenced on a series of pilots of serialised DRS. However, **three key areas are critical to test and prove**.

- **One key element of the published Belgian proposal is unique. It relies *exclusively* on return pathways with lower levels of direct control, which may create uniquely challenging access issues.** In contrast, discussion elsewhere (e.g. Wales) has assumed that return pathways with lower direct control would complement rather than replace return pathways making use of the retail network. This latter approach mitigates access concerns around dependence on digitally enabled and willing consumers. In contrast, digitally dependent return pathways alone will need to show they can match a classic DRS for both access and performance in Belgium, which is an exacting test.

- **The level of technical readiness of serialised DRS and the costs involved in realising those solutions are contested by stakeholders.** However, it is clear that this uncertainty represents significant risks, especially given that Belgian authorities are willing to launch a system in 2025.

- **Significant performance aspects of serialised DRS return pathways with low direct control remain to be proven.** Net effects on return behaviours, and the extent to which a lack of control may see deposits reclaimed, but containers not reclaimed, are unknown.

The performance and participation considerations resulting from the above are as follows:

- Especially as only return routes dependent on consumers being able and willing to participate digitally will be available in Belgium, any potential increases to the return rate resulting from the provision of a kerbside return option must be offset against the risk that some consumers who could and would access a return-to-retail network may be unable or unwilling to access a digitally dependent return pathway.

- These concerns are greatest in relation to people that may be digitally excluded due to either technology or financial issues. Cutting these people out of the system would have significant social justice implications as well as limiting performance potential for the system. However, other people may also find themselves temporarily cut off from the system (due to phone or internet coverage limitations or service disruptions). This will be disruptive to habit formation and could negatively impact views of the system. The proposed fall-back solution of handheld scanners for digitally excluded households is likely to be hard to administer, and may require significant support to households that are likely to be among the least digitally enabled. There is no alternative reclaim option of this type proposed in on the go locations.

- The system does not align with existing DRS provision for reusable beverage containers in Belgium, which are already returned to retail premises.

- Pathways with lower direct control in a serialised DRS may also suffer a performance gap between deposits reclaim, and actual correct container return, due to the weaker connection between these two actions compared to a classic DRS. This is not unique to the Belgian proposal. Finding a way to accurately measure and report on this gap will be essential to understanding actual performance in both pilot and operational contexts. This performance gap may be greatest in on-the-go contexts, which tend to see more challenging disposal behaviours to manage in any case. This will be exacerbated by the exclusion of anyone lacking the smartphone solution from this element of

[1] PwC, September 2022, Every Packaging Counts - DDRS Blueprint - Consolidated report. https://recyclingnetwerk.org/wp-content/uploads/2023/01/DDRS_Consolidated-report-1.pdf

provision, and the weaker incentives for other members of the public to pick up items that are littered.

- Material quality and consistency via existing collection routes is unlikely to change compared to existing collection arrangements at kerbside and on the go solely from the introduction of a deposit. While Belgium reports good kerbside collection results already by international standards, material from kerbside collections in Belgium will be lower quality and consistency than would be achieved with a classic DRS. Material from on-the-go locations is likely to remain relatively poor quality.

The technical uncertainties and risks of a serialised DRS contrast with the well understood and proven requirements associated with the launch of a classic DRS.

- The technology and operational requirements for a classic DRS are known, and largely utilise existing systems (such as 1D barcodes and point of sale technology). The detailed requirements, timelines, and costs for serialised DRS are not, and will require significant changes to software and hardware in the supply chain. One key issue for producers will be around label printing Even where this is technically possible, doubts persist about whether it will be possible at the speed and scale required for a national system, and whether this can be done without excessive transition costs, or impacts on production line speeds.

- Other features of the technical rollout (such as geofencing in the supply chain) may be possible in theory but hard to operationalise in practice. The final design solutions to challenges like the point of activation have yet to be confirmed. A 2025 launch date does not just require that technical challenges are resolvable but that they are resolved and socialised across all supply chain actors, large and small.

- Finally, the role of municipalities – and the associated funding requirement – needs to be better understood. They will be integral to the roll out of enhanced bin provision and may also find themselves as a public interface for other elements of system delivery, which would be a major departure from the classic DRS model.

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1.0 Introduction & Context

1.1 Introduction

Eunomia were commissioned by Fair Resource Foundation, formerly Recycling Netwerk Benelux, to conduct an assessment of the current state of knowledge and technical development relating to serialised Deposit Return Systems (DRS).

Classic DRSs are increasingly widespread in Europe and beyond, and involve consumers paying a small amount of money when they purchase a beverage in a container, which is then refunded when they return the empty container to a designated return point, most commonly a retail location. The high rates of return achieved deliver significant recycling and anti-litter benefits for single use containers. DRS with return-to-retail is also central to the design of national reuse systems for beverage containers in countries where these already exist, including Belgium.

Serialised DRS is an approach that does not yet exist in an operational context, but which would involve a different approach to container marking, whereby each individual container has a unique identifier. This approach to container marking might in turn enable different approaches to system management, and, from a consumer perspective, options to return containers via different pathways, most notably via pre-existing municipal collections for households. Both the feasibility of serialisation, and the feasibility and desirability of specific return pathways proposed, are features that must be assessed in any serialised DRS proposal.

The technical and practical challenges to realising a serialised DRS which can make use of alternative return pathways are significant at several critical stages, and its likely behavioural effectiveness is unproven. As these alternative return pathways are dependent on consumers being able and willing to interact with the system digitally, concerns have also been raised about the extent to which such a system could exclude individuals or certain demographic groups.

The aim of this assessment therefore is to review the options, readiness, and suitability of serialised DRS approaches, with technical, financial, performance and behavioural concerns identified. The study considers the state of knowledge and development in relation to serialised DRS internationally, and also how the specific plans in Belgium fit into that wider picture.

The structure of this report is as follows:

- Section 2.0: An introduction to serialised vs classic DRS, providing a summary of the current state of discussion and providing a framework for assessing different system components.

- Section 3.0: An analysis of the technical readiness of the hardware, software and associated implementation needed for the three stages of a serialised DRS (pre-consumer, consumer, and post-collection), and how long it might take to realistically deliver these in combination and at scale.

- Section 4.0: A discussion around how incentives and behaviours may combine in a proposed serialised DRS compared to a classic DRS, and an identification of the uncertainties this creates around serialised DRS performance.

- Section 5.0: An assessment of potential serialised DRS performance against litter prevalence, return rate (i.e. containers received by the system), recycling rate (i.e. proportion of collected material actually sent for recycling after sorting), and material quality (the value of the material collected, and its suitability for closed loop container-to-container recycling). The desirability of alignment of DRSs for single use and reuse from a consumer perspective is also discussed.

- Section 6.0: A conclusion that highlights criteria against which the viability and readiness of specific serialised DRS proposals can be judged.

1.2 Approach of this study

This study draws on Eunomia's extensive international experience working on classic DRSs around the world, at all stages of development. Eunomia also has extensive experience engaging with international stakeholders with a range of perspectives on serialised DRS and has closely followed debates around the feasibility of serialised DRS in countries where the debate has been most developed. For the purpose of the current study, additional analysis was undertaken of publicly available proposals for Belgium, as well as a series of in-depth interviews and engagement with a range of stakeholders in the Belgian system.

1.3 Glossary

Term	Definition
1D barcode	A visual method of representing data by using parallel lines that vary in widths, spacings and size.
2D barcode	A visual method of representing data by using both horizontal and vertical lines.
Authorisation code	An image that can be scanned, along with the container code, to self-claim a refund.
Classic DRS	A DRS that uses barcode-based system per product line to track the container through the system.
Counting centre	A large-scale centralised facility, which will also separate plastic bottles and cans where they are delivered together
Deposit Return System (DRS)	A system in which a fully refundable surcharge is applied to beverage containers at point of sale to encourage consumers to return the empty beverage container for recycling or reuse.
Digitally dependent	Based on the ability of consumers to use the proposed digital technology.
Extended Producer Responsibility (EPR)	An environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle. An EPR policy shifts the responsibility (physically and/or economically; fully or partially) upstream toward the producer and away from municipalities, providing an incentive to producers to take into account environmental considerations at end-of-life when designing their products.
Handling Fee	Fee paid by the System Operator to third party return points for each beverage container they take-back. Handling Fees are intended to cover the average costs

	of taking back containers in an efficient manner, and should be split by return method (RVM with compaction and manual take-back) to reflect the differential costs. As containers are expected to be returned primarily to retail locations, handling fees can also be referred to as "retailer handling fees". However, any non-retail return locations (e.g. any run by municipalities) would also receive equivalent handling fees.
Kerbside collections	The municipal household sack collection system.
Manual return point	A customer hands the used (empty) beverage containers over the counter to redeem their deposit. A manual return point does not use a machine such as a RVM to return the deposit to the customer.
Producer Fee	A producer fee in this report refers to a fee paid in a DRS. A fee per container is paid by the producer or importer that first places the beverage container on the market. Fees are set by the System Operator to cover the net costs of managing and recycling the beverage containers, after material revenues and unredeemed deposits are accounted for. It should be noted that the producer fee is paid by unit of packaging and not by weight as is the case with the existing EPR scheme in Italy.
Packaging and Packaging Waste Regulation (PPWR)	As part of the European Green Deal and the new circular economy action plan, the Commission put forward a revision of the PPWD in November 2022. The initiative's objective is to ensure that all packaging is reusable or recyclable in an economically feasible way by 2030. The aim is to reinforce the essential requirements for packaging to ensure its reuse and recycling, boost the uptake of recycled content, and improve the requirements' enforceability. Measures are also envisaged to tackle over-packaging and reduce packaging waste
Return Pathway (high or low direct control)	A specific approach to taking back UBCs and refunding deposits.
Return Points	Official locations to which used beverage containers can be returned for a deposit refund. These are typically beverage retailers, and/or a dedicated depot. The latter could include facilities operated by municipalities if desired.
Reverse vending machine (RVM)	A machine that accepts used (empty) beverage containers so that the consumer can redeem their deposit. The majority of RVMs for single use containers compact the container which creates an efficient system in terms of logistics and helps prevent fraud.

Selective collection	Within this report, the term "selective collection" is used to refer to a collection method in which single use bottles are separately collected for recycling from any other waste.
Self-claim	The act of a consumer registering the return and obtaining the claim independently of a third party.
Serialised DRS	The use of a unique identifier for each container, including the requirement for a unique identifier to be marked on the container.
Smart bins	In the context of a serialised DRS, the addition of an authorisation code, enabling self-claim by consumers. Further developments may involve the bin only opening when an eligible container is scanned.
Stock Keeping Unit (SKU)	A unique code that identifies the identifies the characteristics of each product.
System Operator (SO)	The body that manages the DRS and is key to setting fees and payments, establishing the IT needed for reporting and financial transactions, managing the logistics, and ensuring payments and transfers are made.
Used Beverage Container (UBC)	An end-of-life beverage containers to be returned to the System Operator.

2.0 Introduction to Classic and Serialised Deposit Return Systems

2.1 What is a DRS?

A Deposit Return System (DRS) for beverage containers charges the consumer a small, refundable sum of money (the deposit) in addition to the product price when the product is sold. The deposit is refunded when the empty container is returned after use, providing an incentive to consumers to do so. Consumers pay the deposit when they purchase the product, and are refunded when they return the used beverage container ("UBC").

A deposit mechanism encourages consumer return behaviour and can be applied to single use containers (where return enables recycling and helps reduce litter), or reusable containers (where return is also key to ensuring containers achieve a high number of rotations, maximising the environmental benefit of reuse). Much of the discussion in this report focuses on DRS for single use containers, given the current predominance of single use. However, one feature of this report is the potential transferability of behaviours and infrastructure developed for single use towards reuse systems.

DRSs are now common in Europe (with 13 systems now operational, and more in development[2]) and beyond. A well designed DRS for single use containers that ensures high return rates is proven to deliver several key environmental benefits. These are detailed in Section 5.0 but include:

- **Increased collection of consistent high quality material**, resulting from higher return rates (90% or higher is typically achieved), and the effectiveness of these systems in collecting only target materials.
- **Reduced litter prevalence**, resulting from consumers facing a higher cost (the lost deposit) if they litter, and also the higher likelihood that other people will pick up littered items in order to claim the deposit for themselves.
- **Increased recycling and greater material circularity**, resulting from minimal sorting losses, and the fact the high quality and consistency of material going into reprocessing operations produces high quality recycled material, suitable for container-to-container recycling, at the end.
- **Reductions in virgin material use and carbon emissions** resulting from the above outcomes.

These DRSs also serve as building blocks for a more circular material economy. Collecting and circulating high value material can create jobs and investment opportunities[3]. These wider benefits are not a feature of the current report, but the extent to which they can be realised is dependent on high DRS performance in terms of both material quantity and quality[4].

2.2 How does DRS work?

A DRS places obligations on both producers and retailers, both of whom are required to make a system work.

Requirements for producers

DRS is a form of Extended Producer Responsibility, with beverage producers taking direct operational responsibility for running the system. Producers guarantee to cover the full costs of the system, and this contribution is charged on a per container basis for items placed onto the market. However, the system

[2] May 2023, Investigate Europe, Deposit & return: the plastic recycling success opposed by southern Europe, https://www.investigate-europe.eu/posts/deposit-return-the-plastic-recycling-success-opposed-by-southern-europe

[3] Reloop, Deposit Return Systems Create More Jobs, https://www.reloopplatform.org/resources/deposit-return-systems-create-more-jobs/, accessed 29/08/2023

[4] Coca-Cola Europe, How Coca-Cola Germany is working towards a world without waste, https://www.coca-cola.eu/news/supporting-environment/how-coca-cola-germany-is-working-towards-a-world-without-waste, accessed 29/08/2023

also receives income from other sources (material sales and any unredeemed deposits) and the producer contribution is calculated only *after* these have been accounted for. Producers pay via a 'producer fee' which is levied per container. In the case of imported products, importers are treated as the producer by the national system.

Unlike some forms of EPR (where producers can sometimes choose to fulfil obligations individually), participation in a shared DRS is mandatory for all producers. **A System Operator (SO), usually a non-profit industry-led body, manages the system** and is key to setting fees and payments, establishing the IT needed for reporting and financial transactions, managing the logistics, and ensuring payments and transfers are made.

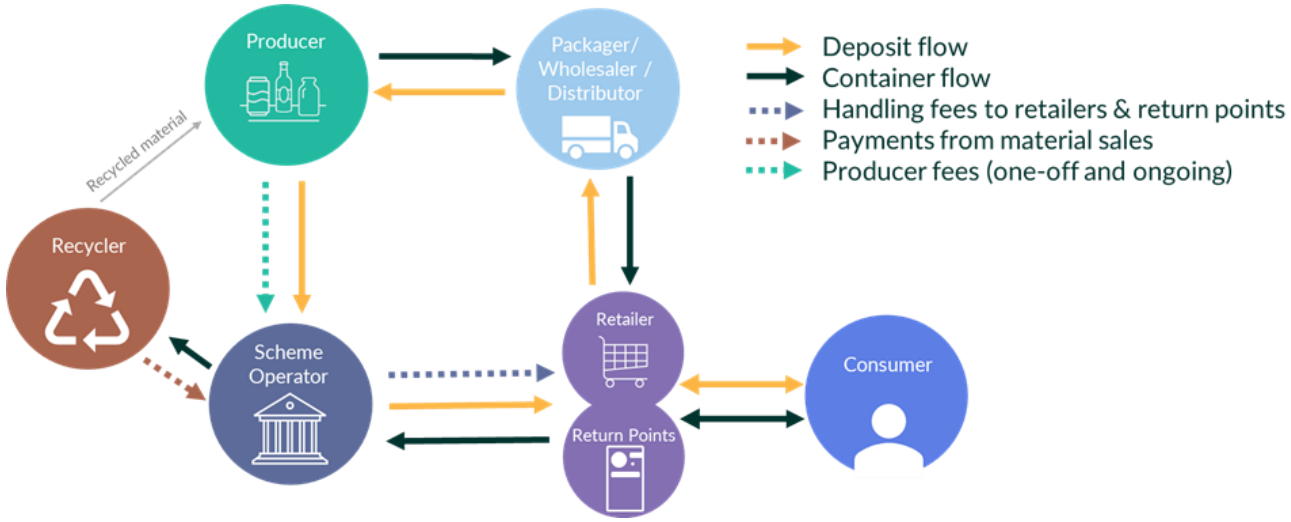
Requirements for retailers

Unlike other EPR systems, the deposit means that the consumer is directly incentivised to return items. To enable deposits to be charged, retailer participation is essential. They must levy and communicate the deposit at point of sale, and in all European schemes (except Iceland) retailers are also the main provider of return locations, meaning packaging return takes place at points of sale. This guarantees an extensive return network that matches to locations consumers already use. This 'take-back' and refund obligation for retailers is usually explicit in national legislation, alongside the requirement to charge the deposit.

A circular system

Containers, deposits, and payments flow around the system in a circular fashion, with the SO acting on behalf of the producers to manage and coordinate the system, see Figure 2-1.

Figure 2-1 Internal Relationships and Transactions in a DRS



2.3 Data is at the heart of existing DRSs

Data is essential to enabling any DRS to work. Producers, retailers, and the System Operator track and report the beverage containers sold into a national market at each step in the supply chain with absolute accuracy, as the deposit means each one has real financial value to every actor in the DRS. That value relates both to the deposit itself, as well as any per container producer or handling fees to be charged or refunded. Financial flows fund and balance the different actors in the DRS, and every return point is able to recognise every eligible container in the system to be able to verify it and authorise refunds. All current DRSs are already digital systems.

Existing DRSs in Europe identify products primarily by their barcode for operational purposes, with a visual (national) logo demonstrating eligibility visible to customers. The barcode is the same for all containers making up a product line, known in industry as a Stock Keeping Unit (or SKU). Each SKU represents a product and container combination that is identical (i.e. the same packaging format, product, and labelling combination, from the same producer). A national DRS will track tens of thousands of SKUs. Automated return locations may also conduct additional container verification (based on shape, weight, and material), but system traceability overall is built around the barcode identifier.

Producers register their products with the System Operator, providing barcode information and other details on the container specification as required. The additional information enables further checks when a UBC is returned to a Reverse Vending Machine (RVM), as well as enabling the system to see what amounts of materials are in circulation. Automated RVMs account for the majority of returns in most European systems, automatically verifying containers are eligible at point of return, which both controls the quality of material accepted, and authorises refunds only for eligible UBCs. Where there is no RVM (usually in smaller retailers) the barcode alone can be scanned to verify eligibility, prior to refunding the deposit. This uses existing point of sale technology, where barcode readers are already ubiquitous. A national DRS will track millions of individual container sales and returns in a day.

The data driving the system can be collected and updated in real time, but this is not always necessary with an existing DRS, and updates between locations can happen more periodically (e.g. hourly) if this is more efficient. RVMs store verification information in their internal memory, and do not need to do an internet-enabled verification lookup for every transaction. These features reduce the IT and data demands of a system, and also make it more resilient to outages.

Once a single use UBC enters an RVM it is often crushed (eliminating any risk of it being extracted and claimed again, as well as enabling more efficient logistics). Where such compaction does not take place (where return is manual, or where an RVM does not compact) the return point places UBCs in a dedicated receptacle (e.g. bag or bin) which is sealed with information on the number of UBCs included (a process known as 'tagging and bagging'). This creates a chain of custody from the return point onwards. These UBCs are then collected and verified at a counting centre (a large-scale centralised facility, which will also separate plastic bottles and cans where they are delivered together), to ensure reporting has been accurate. This non-compaction approach is also used for reusable containers.

In summary, while largely invisible to the consumer, all existing DRS are already highly data-driven. Data on products placed on the market, accurate recording of returns and refunds, chain of custody controls, verification of reported returns, and the financial flows associated with many of these stages are already essential components of running an effective, efficient, and fraudproof DRS.

2.4 Serialisation and alternative DRS 'return pathways'

Serialised DRS proposals usually consist of two elements. A change to the way containers are marked for the purposes of system management (serialisation) and a proposal for the ways in which consumers will be able to return their UBCs and reclaim their deposit. Describing a DRS proposal as 'serialised' only tells half the story.

2.4.1 Serialisation as an alternative form of container identification

An alternative to a barcode-based system to track beverage containers through a DRS would be a 'serialised DRS'. In a serialised system, instead of a barcode per product line (SKU), each individual container would have a unique identifier – both a reference number in the system records and a unique

marker on the container. The container marker could take several forms but is likely to be a 2D code such as a data matrix or QR code, as shown in Figure 2-2.

Figure 2-2 Types of Unique Identifiers

One Dimensional Marker	Two Dimensional Marker	
	QR Code	Data Matrix
		

Serialisation of containers poses technical and operational challenges, which are assessed in more detail in this report (see Section 3.0). There are however two main reasons for considering it. One reason is if there is a significant demand for significantly greater detail in the tracking and auditing of individual packaging units within a system. A second reason is if serialisation could enable new or alternative 'return pathways' for a DRS.

2.4.2 What 'return pathways' are available with barcode and serialised DRS respectively?

By return pathway we mean a specific approach to taking back UBCs and refunding deposits. Exploring the viability of alternative pathways is a key focus of this report, and two broad categories have been identified: those with high direct control, and those with lower direct control. Both are described below.

Return pathways with high direct control

Current barcode-based DRS provide two potential return pathways (return-to-retail or return to alternative managed locations). These return pathways are non-exclusive, and the mix pursued is a design decision for the DRS. Both are set out in Table 2-1below.

Existing DRSs have a tight link between the act of returning the container, container verification, and the refund of the deposit. This maintains tight control over material entering the system, and in behavioural terms means that the act of reclaiming the deposit cannot be separated from the act of correctly returning a UBC. If verification and correct return do not happen, then the refund is not enabled. It should be noted that RVMs can be programmed to accept suitable material even if it is not from a registered SKU, but no deposit is refunded in this case. From the point of return onwards, UBCs are part of the System Operator's chain of custody (which sometimes has subsequent audit points, such as counting centres), meaning all returned UBCs will reach the system.

Return pathways with lower direct control

In principle, a serialised DRS would also work via those same return pathways.

In addition a serialised DRS might also enable two additional return pathways, which are also presented in Table 2-1. **These additional return pathways do not necessarily have the same tight linkage between the act of returning the container, container verification, and the refund of the deposit**.

These routes could therefore allow for refund to occur independently of the act of return, whether deliberately or by accident. While countermeasures have been proposed in serialised DRS proposals, they introduce additional complexity to the system and may not be fail-proof. Similarly, there may be scope for UBCs to escape the system after they have been returned and refunded. Any audit of the system after return is likely to be challenging. These risks are discussed in greater detail in the rest of this report.

An overview of return pathways

Table 2-1 shows return pathways categorised by the above typology.

All current DRSs use return pathways with high direct control. Almost all existing European DRSs rely on 'return-to-retail' (pathway 1a below), supplemented to a greater or lesser extent by 'return to alternative managed locations' (pathway 1b below). DRSs outside of Europe tend to rely much more heavily on alternative routes, with fewer more centralised return locations being made available. European systems with return-to-retail typically perform better[5].

Serialised DRS proposals typically assume these routes would still be available, but envisage consumers would additionally be enabled to self-scan containers using a smart phone application to reclaim deposits. This is dependent from a performance point of view on consumers then doing the correct return behaviour. It also makes these routes 'digitally dependent' from a consumer point of view – it is not simply the system that is digital (as it is in all DRS designs) but the consumer must also be digitally enabled to participate.

Belgium is an extreme outlier in suggesting a system (as per the initial proposal in September 2022[6]) that would only offer return pathways with lower direct control. Apart from the performance uncertainties for these pathways in general terms, an *exclusive* reliance on these pathways also imposes a far higher test in terms of consumer access and acceptability, in comparison to proposals where alternative routes are also available.

[5] Eunomia, 2021, Deposit Return in the Netherlands, Section 3.2

[6] PwC, September 2022, Every Packaging Counts - DDRS Blueprint - Consolidated report

Table 2-1 Return Pathways

Level of control	Return Pathway	Features & Risks
1. High Direct Control *Possible for barcode or serialised containers*	**1a. Return-to-retail** (whether via RVM or manual return).	Automated or manual control of each full transaction means tight linkage of verification, return, and refund. Tight control over materials accepted and rejected. UBCs enter chain of custody at point of return.
	1b. Return to alternative managed locations (typically RVM based). This may include RVMs in shared spaces such as transport hubs or shopping malls, or at dedicated 'depots' such as existing recycling centres.	
2. Lower Direct Control *Possible for serialised containers only.* *Note that the inclusion of lower direct control return pathways alongside return pathways with higher direct control may impact performance in both, depending how they combine.*	**2a. Return via existing kerbside packaging waste collections for households** (e.g. Belgium's Blue Bag system). Consumers would primarily use an app to match the marker on a UBC to a marker associated with their waste receptacle to remotely claim their deposit.	Potential for verification and refund to become separated from the act of return. Potential for non-target material be returned, increasing contamination risk. Expectation UBCs will be collected as part of a broader mixed recycling stream, with potential for material quality issues and sorting losses. Potential for UBCs to escape between return and receipt by the system, with challenges for audit.
	2b. Return via public bins in on-the-go locations, ideally dedicated to recycling collections. Consumers would use an app to match the marker on a UBC to a marker on the public bin to remotely claim their deposit. Additional bins might be deployed, this is dependent on specific national proposals. 'Smart' bins might be deployed, and some of these can be enabled to only open when triggered, however the	

Level of control	Return Pathway	Features & Risks
	level of control is still significantly more limited than via an RVM (see Section 2.0 for a detailed discussion).	

2.5 Both serialisation *and* return pathways must be considered to assess the potential of a serialised DRS proposal

Serialised DRS is always a core feature of 'digital' or 'smart' DRS proposals. However, it is only half the story. Adding serialisation to a DRS proposal in itself tells us nothing about how the overall system is expected to work, and in practice, proposals typically make very different assumptions about return pathways.

These systems are most commonly proposed in countries with established kerbside collections, and these are a feature of the proposal. However, the combination of return routes offered can still vary, with significant implications. For example:

- Discussion in **Wales** has been based on a DRS using serialisation to offer an *additional* return route via household/municipal recycling collections (pathway 2a). Routes 1a and 1b are still assumed to be available to consumers[7].
- Discussion in **Belgium** is focused on using serialisation to provide return routes *only* via household/municipal recycling collections (pathway 2a) and public litter/recycling bins (pathway 2b)[8].

Discussion in some other markets without existing kerbside packaging collections has been based on primarily providing only routes 1a and 1b, but using serialisation as an additional anti-fraud measure to make the chain of custody even more secure in a system assumed to have high levels of manual return.

The potential risks and benefits of different combinations of serialisation and return route, mean that both elements, and how they come together, must be considered to assess any specific DRS proposal that includes serialisation. These considerations are at the core of this report.

Return pathways 1a and 1b are well understood, and have been proven to work in current DRS around the world. They would work with either barcode data or serialised data, if other challenges to serialisation were solved. The performance and costs of barcode-based DRS using combinations of these return pathways are proven. Section **Error! Reference source not found.** looks at typical performance levels a cross existing DRSs. Multiple studies exist on the overall costs and expected performance of introducing DRS in different countries and regions, including Flanders and the Netherlands[9].

[7] Resource Futures for Welsh Government, 2022, Digital DRS Feasibility Study Phase 1: Stakeholder perceptions of DDRS design and feasibility, and Digital DRS Feasibility Study Phase 2: End-to-end system design

[8] PwC, September 2023, Every Packaging Counts - DDRS Blueprint - Consolidated report

[9] CE Delft, 2017, Kosten en effecten van statiegeld op kleine flesjes en blikjes

In contrast, serialisation poses new technical challenges even within these established return pathways, relating to labelling, how individualised deposits would be activated at point of sale, and the higher IT and data demands of tracking every transaction in real time (see Section 3.0). RVMs can be made to recognise serialised codes, though existing RVMs are typically designed to read labels on the side of containers, with possible implications for printing (see section 2). **However, if those challenges were resolved, serialisation deployed solely as an alternative labelling tool would not be expected to impact performance or consumer experience for these return pathways in isolation.**

In contrast, return pathways 2a and 2b add additional technical, operational, and behavioural complexity. All of these create significant uncertainty around how a system would actually perform. One key element of the challenge posed is the need to find substitutes for the lower level of direct control inherent in consumers self-scanning to claim a refund, and the lack of a direct link between this and the act of correct return. A second key challenge is the uncertainty around the impact such a gap might have on overall performance. A final challenge is the level of dependency on the ability and willingness of consumers to engage digitally with the system for both claims and refunds, and provision for any that cannot do so.

2.6 Where does Belgium fit in terms of serialised DRS and proposals for return pathways?

There is currently a consensus across regional and Federal government in Belgium that a DRS for single use beverage containers is necessary, with anti-litter impacts as one of the key drivers. No decision has been taken as yet on the final system approach, though Wallonia has commissioned an extensive review of delivery option and is pursuing a 2025 launch dates[10]. Flanders will make its final decision on a preferred system by the end of 2023[11].

Fost Plus, the PRO responsible for packaging in Belgium currently, have proposed a serialised DRSs with takeback via existing municipal collections for households, and via a public bin network in on-the-go contexts[12]. The published document relies entirely on these return routes, though ideas and plans are still being developed[13], with elements of this approach are being piloted in Flanders in 2023[14]. In contrast, Wallonia has expressed an initial preference for a classic DRS.[15]

Some challenges of both serialisation and the provision of return pathways with lower direct control are common to all contexts. However, in Belgium, the fact that an *exclusive* reliance is placed on novel return routes places additional pressure on the proposal to show that it can work. As the only route for returning UBCs will be dependent on digital participation, the ability and willingness of consumers to access and use the system is a critical dependency. Getting this right is socio-economically essential, as

[10] Gouvernement Wallon, July 2023, Consigne sur les canettes et bouteilles en plastique : le Gouvernement s'oriente à ce stade vers le système manuel, https://tellier.wallonie.be/home/presse--actualites/communiques-de-presse/presses/consigne-sur-les-canettes-et-bouteilles-en-plastique--le-gouvernement-soriente-a-ce-stade-vers-le-systeme-manuel.html

[11] Vlaamse Regering, December 2022, CONCEPTNOTA AAN DE VLAAMSE REGERING - De invoering van een statiegeldsysteem in Vlaanderen, https://beslissingenvlaamseregering.vlaanderen.be/document-view/63A4300FDBF1CAE811022815

[12] PwC, September 2023, Every Packaging Counts - DDRS Blueprint - Consolidated report

[13] Project interviews with Fost Plus and industry representatives.

[14] OVAM, July 2023, Kwartaalrapport 2: Stand van zaken eerste pilootprojecten digitaal statiegeld,, https://ovam.vlaanderen.be/nl/w/kwartaalrapport-2-stand-van-zaken-eerste-pilootprojecten-digitaal-statiegeld?redirect=%2F

[15] Wallonie, July 2023, Deposit on plastic cans and bottles: the Government is moving towards the manual system at this stage. https://tellier.wallonie.be/home/presse--actualites/communiques-de-presse/presses/consigne-sur-les-canettes-et-bouteilles-en-plastique--le-gouvernement-soriente-a-ce-stade-vers-le-systeme-manuel.html

well as critical to system performance. Specific features of the Belgian proposal, including the extent to which the mitigations proposed for some of these challenges are likely to work, are discussed throughout the subsequent sections of this report.

3.0 Technical Feasibility

3.1 Overview

This section considers the technical challenges that need to be overcome in delivering a serialised DRS. This covers both the technical challenges to introducing serialization as a form of container identification, regardless of which return pathways are preferred, and specific issues arising around particular return pathways in a serialised DRS.

We consider three phases of the DRS cycle. The 'pre-consumer' stage covers the entire supply chain from production to the retailer. The 'consumer' stage covers activities between the purchase of a beverage product and disposal of the UBC by the consumer. The 'post-consumer' stage covers subsequent management of returned UBCs, including any additional verification of returns.

For each technical component we consider feasibility, or, where feasibility is not yet proven, how long it might take to establish what is possible. We also seek to identify any indications of costs, available information on implementation timeline, and any technical risks identified.

A number of technical interviews were undertaken specifically for this project, and the insight here also reflects wider conversations Eunomia have had within the packaging industry around serialization in recent years. For several key aspects however, evidence is limited, with several actors keen to maintain commercial confidentiality. Unlike with a classic DRS, there is no system working at scale against which to compare.

3.2 Pre-consumer stage: Producers & Retailers

This discussion of implications for this stage is relevant to any DRS proposal involving serialization, regardless of return pathways chosen. This section first describes the difference between 1D markers (as currently used by the beverage industry in existing barcodes) and 2D serialised markers. It then highlights the challenges and application decisions that must be made to integrate 2D serialised markers into the supply chain, before discussing the issues raised in more detail.

3.2.1 Creating serialised labels

The entire concept of serialised DRS is predicated on the fact that in scope packages are identifiable by a serialised marker. This means every single piece of packaging in scope for the system has a unique identifier. The existing beverage supply chain is not enabled for this at present.

The difference between '1D' barcodes and '2D' serialised codes

Currently almost all beverage packaging on the market will be marked with a one dimensional (1D) barcode which will contain sufficient information on the item to identify data down to a stock keeping unit (SKU), which describes an entire product line. This is the basis of stock management and point of sale transactions.

A classic DRS does not change the nature of this labelling system, it simply requires that existing barcodes are registered with the DRS, and then makes use of the same identifier for DRS purposes as is used for other supply chain purposes. The only products without 1D barcodes prior to DRS introduction might be those belonging to the very smallest micro-producers, if they are retailing directly, but this is rare.

A 1D barcode marking system means every piece of packaging for that product line shares the *same* barcode, and the code printing process can be identical for every package in the product line. Barcode printing is therefore integrated in other elements of the printing process that do not require variation from product to product.

Marking conventions are well established for marking packaging with 1D barcodes[16]. Data within a 1D barcode will be able to identify the brand/producer of the packaging and the product line of that packaging. Additional information can potentially be associated with the barcode (such as product weight) but it is not possible to store information unique to a specific product or packaging item – the information is the same for all products sharing the barcode.

To implement a serialised DRS each and every package in scope would need to be marked with a unique marker. Generally, this is assumed to be a two dimensional (2D) marker. QR codes are a familiar format for 2D markers, but alternatives are available, and Belgium's serialised DRS pilots are using dot matrix codes[17].

2D codes are used in many applications. Outside the scope of a serialised DRS they do not necessarily have to be unique serialised codes, depending on the function being served, and the same QR code for example can be used in multiple places. Where 2D QR codes are seen on packaging currently (e.g. to provide a link to additional product information for consumers) these are highly unlikely to be unique serialised codes.

However, in a serialised DRS a unique 2D code would need to be created and placed on every eligible container going into the system. No two labels would be alike, though the difference between QR codes on individual packages would not be noticeable to the human eye. This is a significant change from current practice in the beverage industry, and on beverage container packaging formats. Among over things, requiring serialised 2D codes means that the printing process for every package in a product line can no longer be wholly identical.

Serialisation is possible in principle. It is already used in a sector like **pharmaceuticals**, but this is a very different sector and use case to that required for a serialised DRS for beverage containers[18]. With pharmaceuticals, the requirements is common to the whole of the EU, use is restricted to within the supply and retail chain, the packaging materials are different in nature to beverage containers, and no deposit is associated with the code. For beverage containers in a DRS these conditions would not currently apply, nor is the sector currently enabled to print in this fashion. Set up and ongoing costs of serialization have been judged worthwhile in pharmaceuticals – it is not at all clear this is the case for beverage containers.

[16] GS1, Recent GS1 standards & guidelines postings, https://www.gs1.org/standards/log, accessed 18/09/2023

[17] Project interview with Fost Plus

[18] PharmOut, March 2023, Serialisation Requirements in the Pharmaceutical Industry, https://www.pharmout.net/serialisation-labelling-for-pharmaceutical-products/, accessed 18/09/2023

Table 3-1 Comparing 1D and 2D Markers

One Dimensional Marker	Two Dimensional Marker
	
GS1 Standard on 1 code and widely adopted	GS1 has proposed a standard for 2D barcodes. However, there is currently no adoption in European markets for beverage. (Where 2D codes are currently seen, they are not typically serialised).

3.2.2 How would 2D serialised codes apply to beverage containers

Switching to serialised markers in the beverage supply chain requires several key questions to be resolved.

These questions include:

1. A decision on **whether the serialised DRS is applied**:
    a. ***In addition* to the barcode system**, with the barcode used for the commercial sales transaction and stockkeeping (as at present) and the serialised code used only for the DRS,

    or

    b. ***As a substitute* for the barcode**, which would provide both DRS and other commercial purposes.

2. **Agreement on the adoption of a standardized marker system** across the relevant supply chain, including ensuring that it did not create a barrier within the EU Single Market.

3. **The reconfiguration of beverage packaging printing systems** to produce a serialised 2D code on every packaging item. This will involve one-off costs (e.g. installing new software and hardware) and may involve ongoing costs (e.g. if printing is slowed down by the additional requirements)

4. **A decision on what point of the supply chain a deposit is 'associated' with a specific serialised code.** If this happens at point of sale (i.e. when the consumer pays their deposit in) this poses additional technical challenges for the retailer. However, if it happens earlier, safeguards may be needed to prevent people from scanning and claiming deposits on unsold containers, for which no deposit has been paid into the system.

5. If a 2D barcode is chosen as a substitute to 1D barcodes for all supply chain functions, this imposes **additional supply chain compatibility issues**.

Whilst all of these challenges can be overcome from a technical point of view there are significant challenges in getting a given market to enact legislation or the DRS supply chain agreeing to and implementing all the necessary components in serialization for a given market. Currently existing DRSs work with tens of thousands of SKUs. A serialised DRS will need to work with billions of serialised codes which must be generated, printed, activated, recorded as sold and recorded as returned across multiple supply chain and retail actors, as well as millions of consumers.

3.2.3 Standardisation and 2D label formats

At present, there is no systematic move towards 2D serialised codes in place of barcodes in the food and drink supply chain. This means that there is no established practice for this, and, for example, that all supply chain systems are designed to scan and record only barcode level data.

Therefore, **it is certain that for the time being any DRS looking to introduce serialisation will be doing so for beverage packaging only. This means that it is highly likely that 2D labels are *additional* to 1D labels on beverage products.**

This does not simply mean that both codes would need to be scanned for a sale and DRS transaction to occur if activation is at point of sale (which poses scope for error and omission in the retail environment, as well as being less efficient than a single scan system). In addition, the financial transaction is directly relevant to the DRS, as the deposit payment by the consumer must be charged as part of their shopping bill, so it is likely that 1D and 2D information would *both* be needed in some way at point of sale to enable a transaction.

In the long term, greater serialisation may be seen in the fast-moving consumer goods sector, or, less ambitiously, 2D codes may become more widespread at SKU level (effectively replacing 1D codes in functionality, but meaning that scanners that could read 2D codes, including serialised ones, would become widespread). Either would lower the technical barriers around standardisation posed by a serialised DRS, but neither change is imminent.

A market adopting serialisation for DRS will therefore need to agree how standardisation will work. The Belgium proposal assumes both 1D and 2D markers will be on containers, the latter to be used for the serialised DRS only. The details of how this will be standardised have not been agreed.

3.2.4 Printing 2D serialised labels

Once a serialization convention is agreed upon, producers will need to ensure that their production lines can adapt to printing unique 2D serialised codes on every individual item.

Transition costs

For many beverage bottle product lines this would mean reconfiguring the label printing technology to add a unique code. Cost implications may include upgrades to printers, printer resolution, and the hardware and software involved in the printing process which would need to look up and retrieve an individual code for every single printing operation. Every actor producing or importing products for the serialised market, regardless of location, would need to be able to accommodate these changes. These challenges are likely to be technically resolvable for packaging formats with labels that are attached to the container, provided there are sufficient timescales and money to implement.

Focus on Belgium: *The PwC study for Belgium[19] suggested transition costs could be between €1 million and €11 million per producer. This was based on a small number of interviews, with several interviewees unable or unwilling to put a figure on the cost. PwC suggested a minimum timeline of 2-3 years. However, the final calculation of total DRS operational costs in the study explicitly excludes producer adaptations[20].*

The current study also found producers unable or unwilling to share transition costs. One large industry interviewee for this project expressed confidence solutions could be found by late 2025. However, concerns have been raised by several actors that the ability to print at speed and scale in way that would avoid an increase in ongoing costs (due to a slower printing process) are not yet solved. Even the PwC assessment of timelines for technical readiness would be likely to miss a 2025 launch date. Our assessment is that significant uncertainty remains in relation to both costs and timelines.

Ongoing costs

In addition to the one-off transition costs above, if the newer technology slows the printing process per container, this can potentially slow a product production line, with significant cost implications. Delays can be caused either by a longer time being taken to physically print each container or label, or if there are lags in the printing system accessing individual codes to issue print instructions. The speed of product production lines, and even more so print production lines is extremely high, so even split second delays per container will accumulate. The implications are likely to be distinct for cases where printing is done directly to the container (e.g. cans) and cases where pre-printed labels are affixed to containers (e.g. plastic bottles).

For plastic bottles, therefore, while label printing might be impacted, this would not impact the speed of the product production line directly, where bottle blowing, filling, and the attachment of labels could continue as before. The same would apply to glass, where labels are printed separately and then attached to the product.

Greater challenges are associated with printing serialised markers on beverage cans as the package is not typically treated with a pre-printed label, but the can is directly printed upon. Eunomia's assessment is that the can manufacturing supply chain are not close to being able to directly mark cans on the main body of the can. It is complex to print unique markers on the can body and it could currently only be achieved by an overall slowdown in the can production line.

It would potentially be more cost effective to mark the can on one of the ends, as this can enable faster printing. We understand that for pilot purposes in Belgium this is what has been done[21]. However, the implications of this for costs and speed on a full-scale production line are not known. Concerns were also raised by producers on the reliability and readability of can-top printing at scale[22]. In addition, printing on the top of the can would not be compatible with most current RVM technology (where the sides of containers are scanned). This means this solution would be incompatible with the main return pathway used in a classic DRS, or require dedicated RVM technology. As no RVM return pathway is currently proposed in Belgium, this might not be considered a problem, but this printing choice could limit options for return pathways if changes are needed. For markets considering a serialised DRS with a combination of return pathways, this would be an important consideration.

[19] PwC, September 2023, Every Packaging Counts - DDRS Blueprint - Consolidated report, p15

[20] PwC, September 2023, Every Packaging Counts - DDRS Blueprint - Consolidated report, p66

[21] Project interview with Fost Plus

[22] Project correspondence with a producer organisation

One response received for this project, representing can producers, suggested reliable solutions which did not slow production speeds were out of reach for the foreseeable future, and also expressed concerns that the investments required might be prohibitive for smaller producers. They further highlighted that even if technical solutions were found, this would need to be made available to all producers at a competitive price, and highlighted factors such as intellectual property rights could be a further barrier to adoption by the whole supply chain.

Focus on Belgium: *The PwC study for Belgium did not assign any costs to slower production lines. The current study also found Belgian producers unable or unwilling to share estimates for ongoing costs, but technical challenges have not all been resolved, and any slowing of production line processes would have real world cost implications. Our assessment is that while significant uncertainty remains, it is highly likely there will be additional ongoing costs that have not yet been quantified for at least some producers in the event of a 2025 launch requirement for a serialised DRS.*

Producer and importer access challenges

Specific challenges could arise for smaller producers or importers. All DRSs impose labelling requirements on containers entering the market, but those relating to serialization are particularly onerous, relating to both changes in design, and technological set-up for printing.

One suggested solution is for imported beverages, or for formats that prove hard to print directly with serialised codes, is 'stickering' where an additional label is added on to the container. This is however typically slow and inefficient. It is also unsuitable for some sales formats, such as multipacks, which must be labelled at container level before being grouped.

From an importer perspective, all in scope beverage packaging destined for a given jurisdiction would need to be marked with a serialised marker even if filled and labelled outside that jurisdiction and imported in. The practical challenges of this may discourage producers from importing to a system that is incompatible with their existing labelling technology. The legal issues that might arise in relation to the EU Single Market are discussed further in Section 3.2.6.

Focus on Belgium: *There is no question that risks are higher for smaller producers, who will have both less capital and knowledge to convert their operations to an entirely new labelling format. Belgium is also a highly interconnected market with high levels of import. Smaller producers importing to Belgium may however choose to avoid costly compliance in any case by removing products from the market. The challenges around technology and cost may be even more acute for producers that only sell a limited proportion of their product into Belgium*[23].

3.2.5 The challenge of deposit activation

In a classic DRS, the deposit is charged at each stage in the supply chain all the way to the consumer. The only way to claim a deposit from the system on one of these products without paying the deposit is by physically stealing the product, emptying the contents, and returning the container to the DRS. Supply chains already have safeguards in place to control for product theft, as part of their normal business models.

In a serialised DRS the points in the supply chain where serialised codes are generated and placed on a container may differ to the point in the supply chain where a deposit is formally associated with that code. For example, the serialised marker exists as an image from the point where the packaging (or the

[23] Project correspondence with a producer organisation

label for the packaging) is printed. If the deposit refund functionality is also considered 'active' at this point, there is a risk that someone could scan the code before sale (in a warehouse or on a shelf in the shop) and claim a deposit that neither they nor anyone else had ever paid in.

Delaying 'activation' of the deposit in the central database until the point of sale could avoid this risk, but this approach would in turn require all point of sale equipment in every single location, including less formal sales locations (e.g. kiosks, fetes, community events), to be capable of identifying the serialised code and communicating that a deposit has been paid to the central system. This communication needs to be in real time as the gap between purchase and return in an on-the-go setting may be very short. These requirements significantly increase the technical demand for the retail stage of the chain. It may also increase operational challenges as each retail transaction would require both the 1D code (for the sale) and the 2D code (for deposit activation) to be scanned, with scope for user error as a result, whether at staffed points of sale, or by consumers with self-checkout systems. Such errors would only become apparent later when return and refund was attempted in the system, and might not be attributed by the consumer to the actual cause.

There is therefore a trade-off to be made around activation. Point of sale activation is more logical and avoids supply chain risks, but places a burden on the retail stage of the supply chain in particular. Conversely, activation earlier in the supply chain simplifies the requirements at point of sale, but creates a risk of 'virtual theft' of deposits, where someone with access to the product before sale can claim the deposit without making a purchase (or physically consuming the product).

Not only is this a fraud risk for the system, it would also undermine consumer confidence in the system if they subsequently pay a deposit at point of sale which they are unable to get refunded because a container has already been deactivated by a prior claim. As they will have no idea why the container is not refunded, this could rapidly undermine the perceived reliability of the system. Virtual deposit theft may be a greatest risk in less formal retail settings, where items are more likely to be left unattended and unmonitored.

The counter-measure usually suggested for this problem is geofencing. This means specific geographic locations either *prevent* the scanning of UBCs and reclaiming of deposits (e.g. retail and supply chain premises) or *enable* the scanning of UBCs and reclaiming of deposits (e.g. designated return locations at home or at public bins). Both require the public to be willing to accept geo-tracking as part of the consumer app (see Section 4.2.2.2). The technical challenges are also high. A very large number of locations would be involved, and geolocation accuracy is not always available or precise, especially indoors or when connected to Wi-Fi rather than the phone network. Residential and supply chain locations (especially smaller retail) may be located literally on top of each other. Some parts of the supply chain may lack phone reception – though the implications of this for deposit reclaim more generally also need consideration.

A final point should be made around hospitality and catering. In most classic DRS, hospitality (I.e HoReCa) venues may choose not to charge deposits to customers for on-site consumption, where the venue maintains ownership of the container throughout use. The venue does however still have to pay a deposit when it purchases stock, and has a direct interest in ensuring it is also redeeming container deposit. Neither supply chain nor point of sale activation in a serialised DRS fits neatly with this model.

Focus on Belgium: *While the initial Belgian proposal appeared to favour point of sale activation[24], this topic is still under consideration as pilots continue[25]. This choice has created debate in all serialised DRS design discussions of which we are aware, as neither solution is fail-proof. In smaller pilots geofencing, and dealing with conflicts that may arise (e.g. fenced areas and legitimate return being in close*

[24] PwC, September 2023, Every Packaging Counts - DDRS Blueprint - Consolidated report, p55

[25] Project interview with Fost Plus

proximity), is likely to be far easier to manage than in a national system, so the challenge of scale, and location changes over time, needs careful consideration.

3.2.6 Cross-boundary challenges

European DRSs are currently all national in scope. Sub-national systems exist elsewhere in the world but are specific to a given regional jurisdiction.

Countries in Europe need to have the ability to mandate suitable beverage container labelling for DRS (both for consumers, and to facilitate operations), notwithstanding the expectation no barriers are created to the functioning of the European Single Market. This power is explicitly recognised in the EU's draft Packaging and Packaging Waste Regulation (PPWR) in relation to consumer labelling[26]. Existing DRSs can also require eligible 1D barcodes are *shared* with the system, but this is not a meaningful barrier, given this labelling technology is ubiquitous. Similarly, some existing systems (e.g. Germany) incorporate features like anti-fraud inks as part of their consumer labelling. **However, the status of a national serialisation requirement in relation to EU law is unclear. A serialised DRS without return-to-retail provision would not meet the proposed 'minimum requirements' for a DRS in the original Commission draft of the PPWR, though discussions in Brussels may see changed wording in the final text.**

In a DRS using 1D barcodes, producers will usually opt to provide a unique barcode per product line, giving a unique SKU, for each national DRS jurisdiction they sell into. This means that when a DRS is introduced, a producer often splits any product line that was previously sold into more than one national market. There is a small production inefficiency involved in running the additional product line, however, this inefficiency would be encountered with a unique serialisation requirement for a specific market too, and would potentially be far greater as the two production runs would have very different printing requirements (with serialised printing potentially requiring more complex equipment).

The separate SKU makes most elements of compliance easier, but systems often also allow a producer to continue use a SKU (and associated barcode) in multiple jurisdictions to avoid the need to run a separate product line. This option is more common for smaller producers or smaller product lines. This usually implies a higher per container producer fee is payable to the national DRS. This is done to reflect the potential risk a UBC is imported after purchase, and a deposit is claimed in the jurisdiction of import, despite no deposit having been paid into the system. The option of continuing to use an existing 'international' SKU would not be available with a serialised system, as the two marking technologies are wholly incompatible. 'Stickering' (see section 3.2.4) is unlikely to be a credible solution at scale to this problem and is wholly incompatible with formats like multi-packs.

The draft PPWR encourages Member States in cross-border situations to seek ways to make DRSs more compatible[27]. Currently there is little experience of this with either classic or serialised DRS. International barcodes, as described above are one facilitating action that can be taken. However, greater alignment between systems in terms of scope and deposit levels might allow for more alignment in the future. In that scenario it is clear that compatibility will be much easier between systems using the same underlying marking systems.

Although in a future scenario where serialised container labelling becomes widespread, serialisation itself could aid cross-border DRS compatibility, this is unlikely in the next decade. This would be possible especially if there would be an activation of the deposit at the point of sale . It would then be possible to

[26] European Commission, November 2022, Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on packaging and packaging waste, amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and repealing Directive 94/62/EC, article 11

[27] European Commission, November 2022, Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on packaging and packaging waste, amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and repealing Directive 94/62/EC, annex X

track where individual containers from a batch had been sold and apply a DRS regime accordingly. Until then, all the technical challenges above - from standardisation of labels to geofencing protections - need to be accessible to the entire supply chain, not simply the domestic market.

Focus on Belgium: *The current Belgian proposal appears to assume that the Belgian system will be compatible with the PPWR. While importers are mentioned, no specific concerns are raised. Our assessment is that producers outside of Belgium will be unlikely to invest in serialization technology solely for the Belgian market unless it represents a significant portion of their sales. Experience elsewhere suggests that stickering is not a feasible large-scale solution. Given Belgium's neighbours already have barcode-based systems (Netherlands, Germany) or are only likely to consider barcode-based systems (France[28]), this might be a specific consideration in the Belgian market.*

3.3 The consumer stage: Technical implications of different return pathways

The issues to be resolved by serialisation for return pathways with high levels of control (e.g. return-to-retail or to "depots") are relatively small. This section touches on this briefly and then considers the technical challenges for a DRS proposed for other return pathways.

3.3.1 Return-to-retail and return to alternative managed return points

Serialisation does not pose overwhelming challenges within return pathways with high levels of direct control. These pathways are the only ones deployed in existing DRSs. Their defining features are the direct link between the act of performing the correct return behaviour and reclaiming the deposit, and the fact that the UBC enters the DRS's chain of custody at the same time due to the design and location of the return points.

As discussed above (section 3.2.5), if a decision is made to place the serialised code somewhere other than the sides of a container, this will be a problem for many RVMs, though either the decision on code placement, or changes in RVM design over time, might resolve this.

In a manual return the location of the serialised code does not matter. **Serialisation may actually improve system security for manual return as it provides an additional level of security to eliminate the scope for a container to be illegally claimed a second time.** In the absence of serialisation, in a classic DRS, strict chain of custody controls and additional verification of container counts from manual collection centres are instituted to safeguard against this. These extra controls could become less necessary from a deposit fraud point of view if manual return points were also 'deactivating' deposits on an individual container basis. In markets with specific concerns about chain of custody therefore, serialisation is one potential mitigation.

Even with return pathways with high direct control, any weaknesses in the code activation process in a serialised DRS that enable a deposit to be claimed before the point of sale (see section 3.2.5) might create problems for genuine consumers at point of return. For example, if a container had its deposit fraudulently claimed before sale, it will not be able to claim the deposit later regardless of return route selected. **However, the activation problem may be simplified if *only* return pathways with high direct control are available.** Scanning and claiming deposits on containers while 'on the shelf' would be

[28] ADEME, June 2023, Faisibilité de la consigne dématerialisée pour les emballages de boisson en france

impossible in this scenario as self-claim would not be a feature of the system, making the activation point less critical to reliability.

It is sometimes suggested that serialisation might allow for less sophisticated (and therefore cheaper) RVM technology at return locations. However, without strong controls over what is accepted and rejected, and a tight link between the act of correct return and the authorisation of the deposit refund, there is a risk that return points would cease to be high direct control pathways, creating performance risks (see Section 3.3.3 below).

There may therefore be *some* elements of fraud prevention currently deployed in RVMs that would be unnecessary in a serialised system. If serialised codes are harder to fake than barcodes, then secondary checks on container eligibility such as container weighing could be avoided. The use of compaction as a means to reduce fraud could also be avoided, though compaction also delivers logistics efficiencies. .

However, a RVM that would read serialised codes would need to access a far larger database of valid serialised codes in real time and upload all redemptions to the same database in real time. In contrast, currently RVMs can store the database of valid barcodes locally. This enhanced data functionality would require more processing power and connectivity than is involved in existing classic DRS RVMs.

In total, serialization might slightly reduce individual RVM requirements and costs where it is combined with return to highly controlled pathways. The overall number of RVMs required in a system which mixes return pathways with high and lower direct control would depend on the extent to which UBCs were also returned via alternative pathways.

3.3.2 Municipal packaging waste collections for households in a serialised DRS

There are various implications for using municipal packaging collections for the return of beverage packaging. Behavioural responses and potential avenues for fraud are discussed in Section 4.0, while those relating to material quality are discussed at the post-consumer stage below, and in Section 5.0.

A key feature of the discussion is that collection quality via this route is not *changed* by the addition of a DRS. More *targeted* material should be captured, but any underlying issues with provision, including contamination with non-target materials, as well as the fact DRS material will still need to be additionally sorted from other mixed recycling material, will remain. One of the key benefits of a classic DRS is the consistency and quality of material, so this is an important consideration.

It is possible to imagine a kerbside collection more tailored to a DRS – for example with a dedicated bag or bin for DRS materials, which might reduce though not eradicate these issues. However, as a major rationale for considering serialised DRS with kerbside return via existing packaging waste collections is to avoid changes to pre-existing services, this is unlikely to be a common response.

3.3.3 Public bins in on-the-go locations in a serialised DRS

Public bins for a serialised DRS are sometimes suggested as an additional return route, and this is a core feature of the Belgian proposal. The level of sophistication assumed for these bins can vary, both between proposals, and potential within a system of provision.

General litter bins vs dedicated recycling bins

Firstly, two options are available for what the system intends to collect in a given receptacle:

- **General litter bins** could be provided with an 'authorisation code' (an image on the bin that can be scanned, along with the container code, to self-claim a refund). This authorisation code would only

be an extra step to enable this self-claim, but it would not prevent the disposal of other materials. While UBCs going into a mixed waste bin are unlikely to be sorted and recycled as high quality material, this could still give an anti-litter benefit, even if other circular economy objectives are missed.

- **Designated bins for UBCs (or dry mixed recycling more generally)** – the intention would be that these bins collect targeted UBCs only, or potentially a wider mix of recyclables. An authorisation code would be used as described above. However, there is nothing to stop other waste material being left in these bins, and experience with 'recycle on-the-go' bins in public locations suggests that the risks of contamination with untargeted waste would be very high[29].

'Smart' bins and their limitations

The level of sophistication assumed for designated collection bins varies. 'Smart' bins are sometimes identified as a feature of proposed serialized systems but the description of such bins can relate to different features. In the Belgian proposal a range of bin options are described.

It is useful to distinguish 'smart' bins from RVMs, in order to ensure shared expectations of what different technologies will provide. This comparison is in Table 3-2.

The terminology surrounding smart bins is inexact at present and is typically used to describe a range of possible solutions, of greater or lesser sophistication:

- 'Smart' may describe bins with **compaction abilities** or that **are internet enabled to notify operators when they are full** – this may be efficient for servicing but does not directly impact user behaviour.
- In the context of a serialised DRS, **'smart' bins may simply refer to the addition of an authorisation code, enabling self-claim by consumers**[30]. The deposit redemption is dealt with on smart phones by reading the code on the UBC and associating it with a code on the bin. There is no guarantee that correct use of the bin then ensues. Additionally, any other item can be placed in the bin at any time.
- Alternatively, **it may be possible to have bins that only open when the authorisation code on the bin and an eligible container are scanned together[31].** The cost and operational resilience of such a system are unclear[32], and while it might reduce contamination from other waste it does not eliminate it, as anyone with an eligible container can still dispose of other material once the bin is open. Similarly, there is no guarantee that a claimed container is correctly returned.

A level of sophistication beyond these options - i.e. a bin that can selectively accept only eligible UBCs - moves closer to an RVM and would be more similar to a high direct control return pathway. However, in on-the-go locations, especially outdoors, maintaining and servicing an RVM would be challenging[33]. The cost per unit would also be much higher than for a smart bin, limiting the number that would be deployed. It is however useful to distinguish what separates a 'smart' bin from an RVM to avoid confusion, and the approach in this report is summarised in Table 3-2. **The 'smart' bins under consideration in the Belgian proposal for example, fall significantly short of the level of control offered by an RVM.** There may still be merit in deploying smart bins, but expectations around performance and material quality must be realistic.

[29] Zero Waste Scotland, 2014 (unpublished), Evaluation of recycle on the go infrastructure provision

[30] PwC, September 2023, Every Packaging Counts - DDRS Blueprint - Consolidated report, p31

[31] PwC, September 2023, Every Packaging Counts - DDRS Blueprint - Consolidated report, p32-33

[32] Project interview with VVSG and discussion with Waste Services team at Eunomia

[33] Eunomia, 2021, Deposit Return in the Netherlands, p37

Table 3-2 Comparison of RVMs and 'Smart' Bins

Feature	Reverse Vending Machine	'Smart' Bin
Identifies that a deposit is redeemable and completes the transaction	Yes	In some but not all cases
Secures the item for a deposit is redeemed	Yes	No – A smart bin will have a return method but will not directly secure the item when the deposit is redeemed
Exclude non-deposit-bearing items	Yes	No – A smart bin may have a feature such as an aperture or door that is triggered at deposit redemption but there are unlikely to be any other technology to eject or exclude unwanted items.

Focus on Belgium: *The Belgian proposal discusses a wide range of bin options across the spectrum of smart bins identified above, but none would reach this studies definition for an RVM, as all lack the ability to reject ineligible material, or ensure correct return actually occurs after self-claim. A large number of bin locations are assumed (around 135,000 bins are suggested for the initial addition of an authorization code). A similar number are budgeted for in the cost analysis with a gradual transition from using existing bin infrastructure to dedicated dry mixed recycling bins. However, only 138 smart bins are budgeted for in the cost analysis, with the majority assumed to be basic bin designs[34].*

The proposal acknowledges operational discussion is needed with municipalities[35]. Unlike with a classic DRS, municipalities are key to return provision and servicing with both kerbside and on-the-go return pathways.

Municipalities in Belgium are keen to ensure that they are involved in any discussions on planning for the provision of on-the-go bins, that funding for their involvement is proportionate to their efforts, and that they enjoy reasonable discretion over how funding is spent[36].

[34] PwC, September 2023, Every Packaging Counts - DDRS Blueprint - Consolidated report, p68

[35] PwC, September 2023, Every Packaging Counts - DDRS Blueprint - Consolidated report, p32-33

[36] Project interview with VVSG

3.3.4 Requirement to involve Municipalities

One feature of DRS that is important to consider is the underlying notion of producer responsibility. In a classic DRS producers are fully responsible for the costs of setting up and running the system. Retailers are also legally obligated to share responsibility for charging and refunding deposits and accepting returns.

In contrast, the return pathways with lower direct control (i.e. kerbside packaging waste collections and bins in on-the-go locations) will require very close collaboration with existing municipal services, with associated operational costs. While integration into existing kerbside collections might not represent a significant change, any requirements for municipalities to be involved in ensuring access to the DRS (e.g. through distribution of scanning alternatives such as handheld scanners, distribution of authorisation codes, or geographic mapping of kerbside bins) would be an additional burden and a potential shift of the producer responsibility towards public authorities' responsibility

These challenges are greater for bin provision in on-the-go locations, which might require an additional element of separate collection (for residual waste and recyclable material), an upgrading of infrastructure (more and higher-specification bins), and potential ongoing maintenance requirements (e.g. ensuring authorisation codes on bins remain legible over time). In the Belgium case, VVSG stressed the importance of ensuring a sufficient and fair distribution of funds for any additional burdens that had to be undertaken, and the importance of enabling municipalities to calculate likely costs.

Municipalities may also find themselves as the public face of the system with these return pathways, and thus be contacted for wider consumer support or complaints about more technical system elements, though project interviewees differed on how likely this was and how much of a service challenge this might present.

3.3.5 Enabling technology for consumer return

In principle, provision of an app to facilitate consumer return is achievable. However, the complexity, accuracy, and reliability challenges should not be underestimated.

Consumer apps, including for purchases and financing are now widespread around the world. However, **this app will see high frequency low value transactions, and the database being accessed each time is very large with tens of millions and potentially hundreds of millions of containers within it at any given time**.

Down time or time lags in transactions will be particularly problematic for consumers in on-the-go locations. This is not just a question of app reliability, but also wider smartphone and internet coverage. Any problems with performance will impact consumers financially. It is generally assumed a single service provider will offer an app for this purpose, and this appears to be the case in the Belgium context too. This offers design advantages for the System Operator, but means consumers will have no choice but to use this single service for deposit reclaim. **Some anti-fraud measures, such as geofencing, or, even more challenging, the use of image recognition to validate if containers have been opened (see Section 4.0), will significantly add to the complexity of the system required and the probability of errors recurring.**

The database will also hold significant amounts of personal data, including potentially detailed geolocation data if features like geofencing are required. It will also be linked to personal financial information, though Fost Plus emphasized in interview that in the Belgian case these features will rely on existing proven banking and financial services. **Both system security and consumer trust will be essential to success.**

Overall, however**, the likely impacts of problems in this regard are more subject to manifest on consumer behaviour** and are dealt with in detail in Section 4.0.

One cost element that is worth noting is the cost of multiple micropayments through the banking system. The efficiency of a country's financial architecture and the extent to which payments are grouped will significantly impact the extent of this cost line. For Belgium we assume that system will be streamlined.

3.3.6 Fraud prevention and cyber security

Safeguards against fraud are integral to all DRSs. This relates to both consumer fraud (based around the point of claim) and operational fraud (relating either to registration or non-registration of products, or to the risk of returned containers exiting the system and being reclaimed).

Serialisation is traditionally seen as reducing fraud risk. For example, it should make it impossible to claim the same container twice (as the deposit relating to that specific container is deactivated at point of return). This is one rationale for DRS in markets with high numbers of manual return points, and concerns over chain of custody after take-back at retail points. **However, some forms of more casual consumer 'fraud' (in so far as consumers can reclaim deposits without always returning UBCs) is probably easier in a serialised DRS context** and is covered in section 4 where we focus on behaviours. Fraud at this level would not pose a financial risk to the system but it would reduce performance.

Additional forms of fraud specific to a serialised system have also been identified, such as the ability for people to purchase a product, reclaim the deposit, and then return the product to the retailers unopened and demand a product and deposit refund[37].

The question of when to activate the deposit (see Section 3.2.5) is largely one of fraud prevention – if it is possible for a deposit to be 'reclaimed' prior to purchase (either in store, or in transit) then this is a serious system risk. Activation at point of sale, or geofencing to restrict the location of claims is one possible solution.

The risk of larger scale fraud opportunities, such as accessing QR code data via cyber-attack and claiming deposits remotely is hard to quantify. The system will be able to monitor reclaim data for suspicious activity (e.g. very large reclaim volumes for specific accounts), but given the technical barriers is unlikely to have an explicit post-collection verification process for returned UBCs, matching them to claimed UBCs.

All DRSs are digital (see Section 2.3). Cyber-attack is therefore a risk. Particular risks for a serialised system would include:

- The inclusion of personal and financial information related to consumers. Fost Plus highlighted in interview that they intend for financial information and payments to make use of existing banking and financial architecture, not to be unique to the DRS.
- Extraction or injection of serialised codes to the system. Whereas in a classic DRS attempted fraud based on false reclaim requires a physical element (e.g. fake UBCs), in a serialised DRS, it could be attempted entirely remotely.

Fundamentally, all DRSs have to demonstrate that they are robust to both fraud and cyber-attack, and have to assume that both will be attempted, given the value of the transactions flowing through a system. Serialised DRS is not unique in this regard – but nor should be assumed to have any automatic advantages.

[37] PwC, September 2023, Every Packaging Counts - DDRS Blueprint - Consolidated report, p56

3.4 Post-consumer stage

Two key concerns arise in relation to post-consumer management of a serialised DRS with return pathways with lower direct control. These relate to verifying system performance in terms of collection, the likely quantity and quality of container recycling that is enabled by the DRS, and the extent to which container-to-container circularity is maximised.

3.4.1 Post-collection verification

In a classic DRS the identification of an eligible container, the authorization of the deposit refund, and the act of correct container return are tightly connected. In a serialised DRS with return pathways with lower direct control this connection is likely to be much looser. The opportunities for a gap to open up between the number of containers scanned and for which a deposit is paid out, and the number of UBCs correctly returned by consumers and actually captured by the system is discussed in more detail in section 4.

However, the scope to verify this gap is limited in most serialised DRS proposals. Post-collection verification is not a feature of most proposals. This includes the Belgian proposal, where the focus is on closing the behavioural gap at point of return.

While it would be clearly desirable to scan and authenticate all UBCs after receipt by the system, this is not technically feasible from a mixed recycling collection at the speed and scale needed in a DRS, even for a container count. There will losses in the collection and sorting system too, so this count would always diverge from claimed returns, even if all consumers did in fact behave correctly. While a count is challenging, it would be prohibitively difficult to additionally attempt to read the unique serialised container identifiers in such a context.

However, without this information, confidence in the true performance of a DRS accepting UBCs via these return routes is not readily possible. In a European context, some form of post-collection verification will be needed to meet European rereporting requirements on collection rates in both the Single Use Plastics Directive, and, if passed, the draft PPWR, as well as to provide confidence that national targets, whether for collection, recycling, or litter are being met.

3.4.2 Material sorting and material quality

There are potential further supply chain issues for metal and plastic beverage packaging.

A classic DRS collects very specific material streams, and keeps food contact plastics and metals from beverage containers away from other types of packaging and free from other contamination until the material reaches the recyclers. This clearly provides high quality feedstock and in the case of plastics a very clean stream of food contact material that facilitates circularity in plastics. The losses of material between collection and the gate of the recycler are very low.

In contrast, in a kerbside packaging waste collection the DRS material would be collected with other packaging materials, as well as non-target items ('contaminants') that should not be in the packaging collection at all. The collected material will then go to sorting plants to sort into grades of PET, HDPE metals etc. Even in the best cases there will be some losses of UBCs. During sorting, some materials may be miscategorized, and others will be missed and end up in sorting plant residues. Although in modern well-run plants these losses can be relatively low, they are always likely to be higher than in a classic DRS.

The debates around qualities of recyclates derived from the two different forms of collection (high and low levels of controls) are complex and nuanced. Good qualities of municipal collected materials are clearly possible in some contexts, and currently PET beverage bottles are recycled back to food grade rPET in cases where they are not collected via a DRS in several locations around the world. However, one

advantage of a classic DRS is the consistency of material from all return locations, while a feature of municipal collections is often variance by geography, even within a single municipality, and certainly at regional or national level. These routes are unlikely to reach the same quality levels as a classic DRS.

This difference in quality may increase in importance over time as recycled plastic makes up a greater and greater proportion of packaging material. Currently the circularity of the PET feedstock itself is low because the average recycled content of the collected bottles is relatively low. PET circularity will need to increase over time. As the amount of recycled content in PET bottles goes up, the need to rigorously control contamination may also increase, to prevent contaminants accumulating over multiple recycling cycles. Previous Eunomia work[38] concluded that an average 75% average recycled content material looked achievable from classic DRS PET feedstock. There is far from any certainty that similar levels could be achieved if the material was collected in a different manner.

We do not believe that limitations to circularity in aluminium UBCs in relation to collection systems has been explored in any detail. The extent to which cans are separated from other aluminium during sorting may be a factor (as specific alloys are required for drinks cans) in some markets.

3.4.3 Maximising circularity

In addition to *quality*, drinks producers are also increasingly concerned about *access* to recycled material, to ensure that they can meet both legal and voluntary recycled content targets. Container-to-container recycling requires both that material is collected *and* that it is obtainable after reprocessing for inclusion in new containers.

Packaging material collected in mixed systems is sold to the market for any purpose. Even where material is suitable for use in food contact recycled materials, this may not actually occur. In the case of PET in particular, this can often mean material is diverted to applications, like textiles, where it will not be recycled again[39]. Currently this is often the case with DRS too, but **beverage producers can, through the DRS operator, seek to ensure that those who have made their packaging recycled, and paid for high quality collection services, can also get the first option to access the material.** This is a position increasingly strongly supported by producers, who may be unable to reach legally mandated recycled content targets, and their own voluntary commitments, over time without it[40]. The approach is being explored in the Slovenian DRS currently. The case that producers who have invested in making their containers recyclable, and in the effort to collect them via a DRS, should enjoy the benefits of their investment in terms of improved access to the recycled content that results, in contrast to industries that have not, is strong. This approach can also ensure fairer access to recycled content for producers of all sizes.

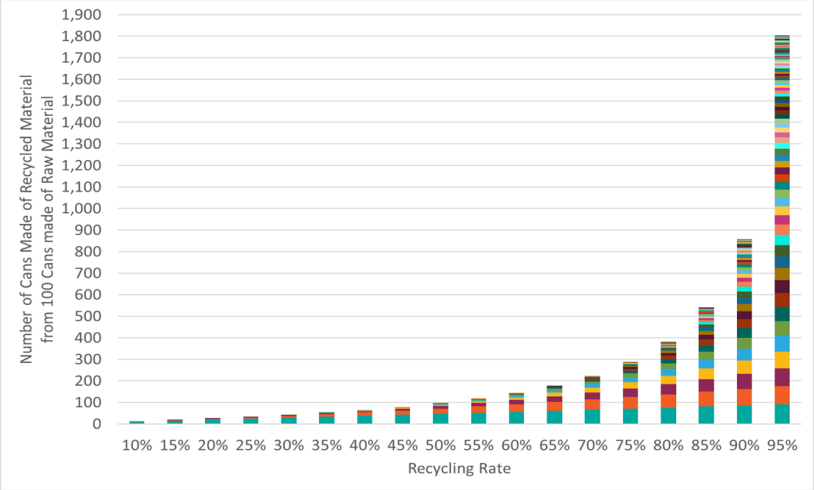
Figure 3-1 demonstrates the savings in raw material use that can be realized by progressively higher return rates and container-to-container recycling. To achieve this, captured material must be both of sufficient quality, and actually diverted to container-to-container recycling.

[38] https://zerowasteeurope.eu/library/how-circular-is-pet/

[39] https://zerowasteeurope.eu/library/how-circular-is-pet/

[40] Unesda, Zero Waste Europe, and Natural Mineral Waters Europe, 06/10/22, It's time to acknowledge the role of Deposit Refund Systems (DRS) in achieving a Circular Economy for beverage packaging in the EU, https://www.unesda.eu/its-time-to-acknowledge-the-role-of-deposit-refund-systems-drs-in-achieving-a-circulareconomy-for-beverage-packaging-in-the-eu/

Figure 3-1 Cumulative Impact of Higher Recycling Rate on Availability of Recycled Material



- Starting with 100 cans made of raw material
  - 10% recycling rate 11 cans
  - 90% recycling rate 850 cans
- Dramatically reducing the reliance on energy-intensive virgin metal

4.0 Citizen Experience and Behaviours

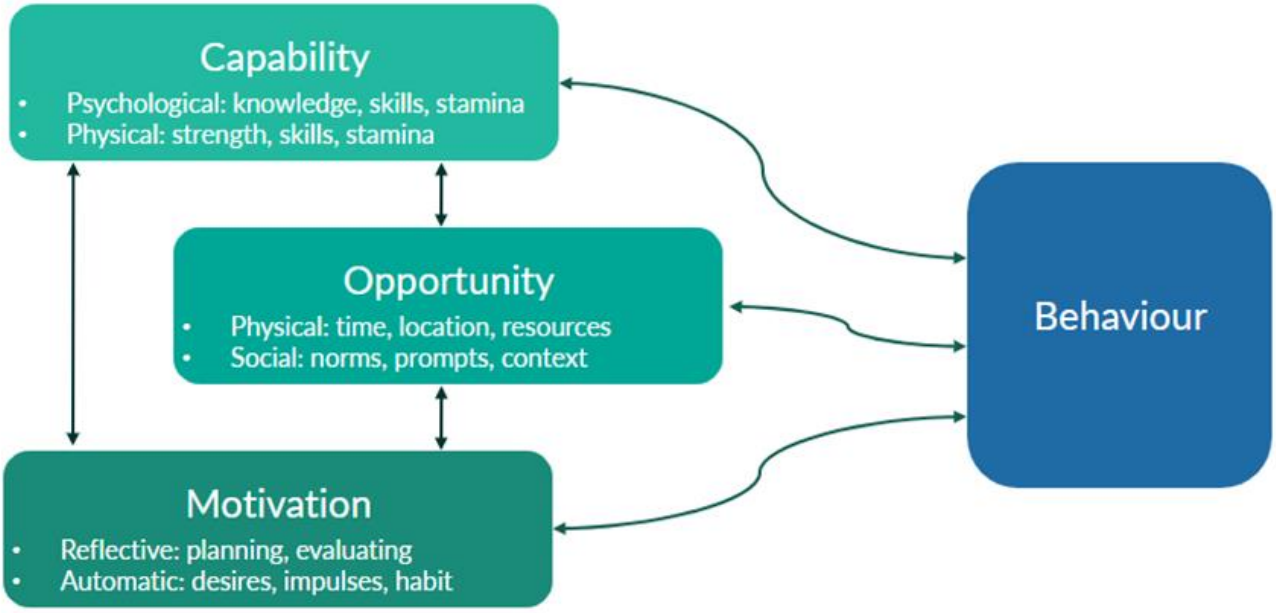
4.1 Thinking systematically about behaviour change

The "COM-B" behaviour change model (see Figure 4-1) is widely used around the world to assess how policies can change behaviour[41]. We can apply it to the current case: **pro-environmental behaviour is dependent on people's capacity to act, their opportunities to do so, and their motivation to do the right thing. To deliver change in the behaviour, all three drivers need to be sufficiently addressed.** Additionally, in a good intervention, these drivers will tend to mutually reinforce each other.

In a DRS, we are trying to change container return and littering outcomes, and this is done by incentivising return behaviour. This logic is the same for both single use and reusable containers. The overall convenience of the system, public understanding and support, as well as the deposit itself (which can be seen as either rewarding return behaviour, or imposing a cost on non-return) are all factors in how successful this will be. For DRS, the performance of existing systems shows that these factors are already well understood for the return pathways with high direct control as outlined in Section 2.4 (return-to-retail, or return to alternative managed returns locations).

This section therefore focuses primarily on how capacity, opportunity, and motivation to act might interact differently with a serialised DRS, in particular where alternative return pathways with lower direct control are offered as either additions or substitutes to high direct control pathways.

Figure 4-1 COM-B Behaviour Change Model



Source: Adapted by Eunomia[42]

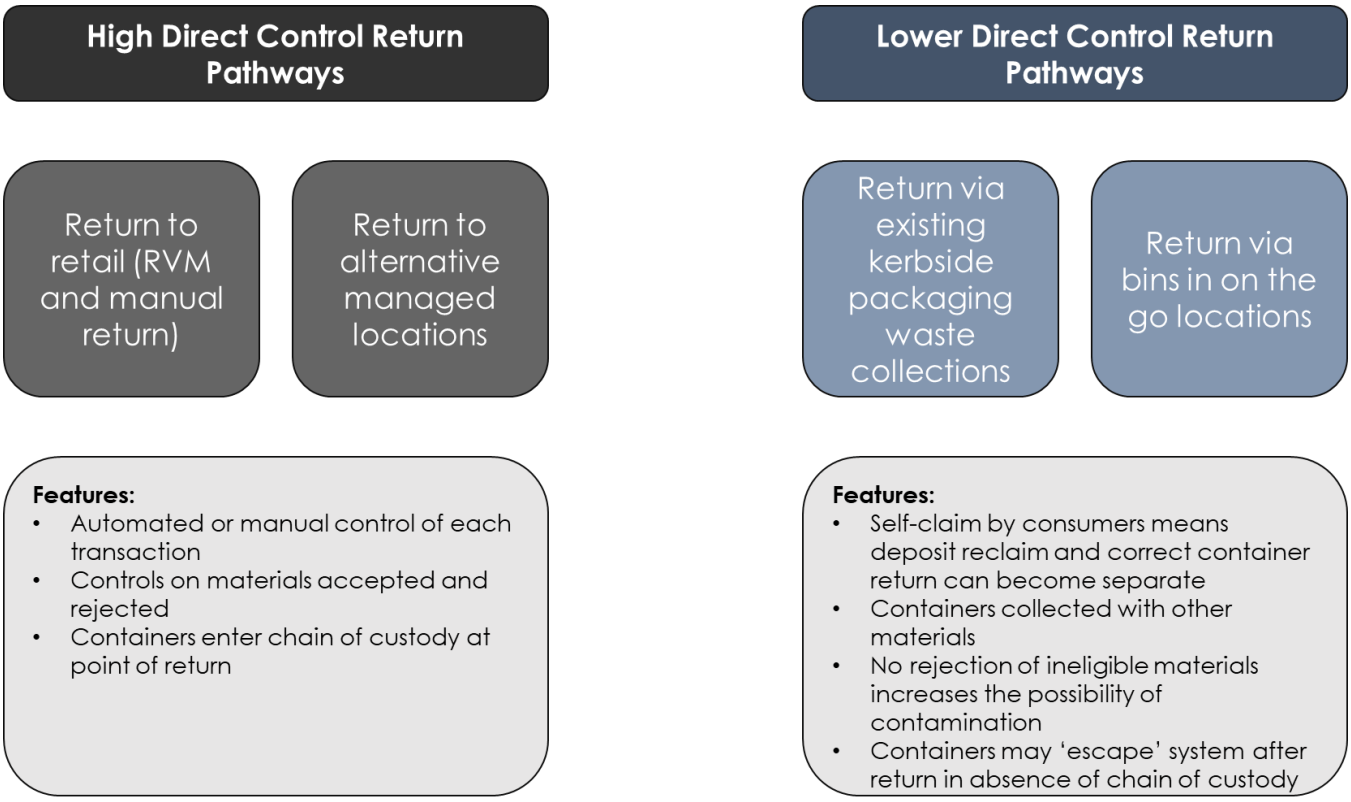
[41] See, for example, Michie, S, et al. (2020), *Achieving Behaviour Change: A Guide for National Government*, Public Health England, Available at: link. Accessed: 20/02/2022

[42] This is our preferred portrayal for the case of DRS. For more general presentations, see, for example, Decision Lab, *The COM-B Model for Behavior Change*, Available at: link. Accessed 20/02/2022

4.2 Behavioural considerations for different DRS return pathways

This section considers first the pathways with high direct control identified in Section 2.4. Whether manual or automated, these routes are managed in ways that ensure that container verification and refund are tightly linked to the act of return, and the system takes custody of UBCs thereafter. The section then considers the return pathways that could be enabled by serialisation, but which have lower direct control. See Figure 4-2. These pathways may pose behavioural challenges, and these are assessed alongside potential technical or operational mitigation for these challenges.

Figure 4-2 Summary of return pathways with high and lower direct control



4.2.1 Established return pathways with high direct control: Return-to-retail, and return to alternative managed locations

Whether a DRS uses barcodes or a unique serialised 2D code on containers makes little difference to consumers in a DRS that provides return pathways via managed locations. With barcodes, the behavioural impacts of these approach are demonstrated in existing DRSs around the world. Provided the challenges of labelling and activating serialised containers were solved, these containers would be expected to elicit similar consumer behaviour if they are routed through these same return pathways. From a consumer perspective, nothing changes – the act of return and redemption remains the same. There is no extra action needed from consumers than returning their empty packaging. Behavioural drivers for return via these pathways are outlined in relation to the COM-B framework in Table 4-1.

Table 4-1 Return behavioural drivers for return pathways with high direct control

Capacity to Return	Opportunity to Return	Motivation to Return
Minimises the cognitive burden for consumers by clearly and consistently identifying what can be returned, where, and when. Attempts to return ineligible items will be rejected (something that does not occur via other return routes, including Lower Direct Control pathways suggested for use with serialised DRS). This will help to educate consumers over time.	Return opportunities are accessible and easy to use. Return locations match retail locations, to fit existing habits and routines. This also ensures accessibility across demographics and geography – retail locations are already located to cater to the whole population.	Provides an economic incentive to return UBCs to get the deposit back. Provides a social signal that returning UBCs (to be recycled) is normal and desirable through DRS provision, design, communications, and the creation of a social norm. Supports desire to do the right thing to help the environment.

For both capacity and opportunity, which are closely linked, the connection to the retail network is powerful – not only do market forces dictate an extensive network of retail points, consumers of the in-scope containers must already visit the retail premises where this packaging is sold.

Some of these features might be achieved in other ways, but crucially, there is no need to speculate on the likely performance delivered by a DRS built around an extensive network of return points centred on retail locations. While not the only success factor for DRS delivery[43], this is the proven model in Europe, and return rates of 90% or higher are consistently achieved across a range of contexts and container formats (see Section 5.0). Standards for good DRS design are well established from analysis of current system design and performance, and the provision of return locations is a key element of this[44]. This approach is reflected in the EU's draft Packaging and Packaging Waste Regulation[45].

For littering, the primary benefit of DRS is delivered by changes to motivation. Specifically:

- **Potential litterers will lose their deposit if they choose to litter**, effectively imposing a charge on the behaviour, which follows the principle of 'polluter-pays'.
- **Other members of the public will be rewarded if they pick up eligible littered items**, meaning that even when littering occurs, the likelihood that items will remain in the environment is reduced.

[43] Eunomia, 2021, Deposit Return in the Netherlands

[44] TOMRA, Rewarding Recycling: Lessons from the world's highest-performing deposit return systems, https://www.tomra.com/en/collection/reverse-vending/deposit-return-DRSDRS's/white-paper

[45] European Commission, November 2022, Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on packaging and packaging waste, amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and repealing Directive 94/62/EC, annex X

Behavioural implications of serialisation with highly controlled return routes only

If containers were identified via unique serialised 2D codes rather than by barcodes at the SKU level, a return-to-retail model for return, with a mix of RVMs and manual return provision, could deliver the same behavioural motivations as above. Provided technical challenges around serialisation were resolved, nothing would change from a consumer perspective. Behaviour would reflect the return pathway experience – which would be the same – not the underlying container identification technology.

For a country considering the introduction of serialisation as an additional control measure for a classic DRS design, this conclusion is sufficient to understand likely behaviours. **However, where additional or substitute return pathways are also proposed both the behavioural drivers for the new pathways, and the interaction between those new pathways and the pathways with high direct control discussed here need to be considered.**

4.2.2 Proposed return pathways with lower direct control: Integration in kerbside packaging waste collections and return via public bins in on-the-go locations

Two novel DRS return pathways could be enabled via serialisation. These might be provided as additional return pathways (as discussed in Wales) or as substitute return pathways (as proposed in Belgium). The issues raised are slightly different in both cases. Unlike in the case of return pathways with high direct control (where behaviours and performance have been proven) no serialised DRS yet exists. Pilots around the world to date have not been full operational pilots, but have been somewhat artificial in scope, testing limited aspects of system technology, and potential behaviours with very small groups, or with 'rewards' rather than deposits[46]. The current pilots in Flanders will add to this body of knowledge, and will increase in scope and scale. However, the first pilot undertaken was more of a proof of concept in a tightly controlled environment[47], and care must always be taken in interpreting DRS pilots (classic or serialised) to national operating contexts.

None of these pilots have demonstrated participation at population scale, nor rates of return for *all* UBCs used by the target population approaching 90% - however, this has not been their aim to date, reflecting the relatively early stage of this technology.

This section therefore focuses on the challenges that would need to be overcome to enable high participation and thus performance via return pathways with lower direct control. It also highlights the importance of inclusion, not just for system performance, but as a central requirement for a deposit-based incentive structure. It is essential to the deposit principle that all consumers can in fact easily and promptly recover their money.

4.2.2.1 Return via these pathways is 'Digitally Dependent'

Container return via a DRS requires three steps to be successful in reaching the system objectives:

- Eligible containers must be identified.
- The refund to the consumer must be authorised and paid.

[46] Reloop, January 2022, Digital Deposit Return Systems: What You Need to Know

[47] Corda Campus, May 2023, EERSTE PILOOTPROJECTEN DIGITAAL STATIEGELD VAN START, https://www.cordacampus.com/nieuws/eerste-pilootprojecten-digitaal-statiegeld-van-start/

- The container must be correctly placed into the desired return pathway (in the case of return pathways with lower direct control, either a household packaging waste collection or a designated public bin).

Return pathways with high direct control in a classic DRS tightly link all three of these stages, and do so in RVM or human mediated return location. In contrast, in pathways with lower direct control this all has to take place remotely, with 'self-claim' by consumers, and scope for that claim to become separated from correct return behaviour. In addition, this makes the interaction with the system 'digitally dependent' from the *consumer* perspective. While all DRSs are digital on the system side, classic DRS does not require consumers to engage digitally.

The default requirement for digital consumer participation would be a smart phone with a QR reader and dedicated app, and for the consumer to have registered their bank details with the DRS to enable refund. However, additional complexity is likely to be needed to reduce unintended consumer behaviour. This is because, in the absence of direct control, the system must find other ways to try and ensure that the crucial step of "correct container return" does effectively occur after the deposit is claimed.

In Belgium, it has been acknowledged that not all consumers may have access to a smartphone, and the distribution of handheld scanners has been proposed to support households that cannot or do not wish to use the app-based system. Some of the potential operational and behavioural challenges with this approach are discussed below. However, the requirement of consumers is similar whether a handheld scanner or smartphone app is used to undertake self-claim and container return.

4.2.2.2 Unintended behavioural interactions are a key challenge for these return pathways

A key challenge for return pathways with lower direct control is the risk consumers claim the deposit, but do not perform the correct return behaviour. This might mean claimed containers do not reach the system. But it can also mean that non-target material enters the collection stream (something that is prevented in return pathways with high levels of control). Such problems may be caused by consumer mistakes, carelessness, or deliberate bad behaviour.

Challenge 1: Misunderstanding

Misunderstanding is a feature of both kerbside collections, and recycling bins in on-the-go locations, in almost all countries. Consumers can easily put the wrong items in the wrong container, whether that means recyclable items going into a residual waste bin, or non-recyclable items going into a recycling bin[48]. As no feedback to consumers is offered with these collection routes, mistakes are likely to be made repeatedly over time.

While a deposit might be expected to increase return of UBCs in kerbside packaging collections and recycling bins in on-the-go locations, **it is not guaranteed that all UBCs claimed for will in fact be correctly returned to these pathways even with good intent. Additionally, any pre-existing contamination issues in**

[48] WRAP, 2021, Recycling Tracker Report 2021: Behaviours, attitudes and awareness around recycling, https://wrap.org.uk/resources/report/recycling-tracker-report-2021-behaviours-attitudes-and-awareness-around-recycling. This report is the most recent in over ten years of behavioural tracking and insight by WRAP and Zero Waste Scotland.

these routes will continue. The extent of these will depend on the existing system, but high variability is typically seen between individual households and different areas within countries[49].

In contrast, DRS return pathways with a high degree of control, as used in classic DRS, both ensure the act of return is performed correctly before refunding a deposit and will not take ineligible material. This final factor is a key reason for the material quality achieved, and is a potential long-term educator of the public in how the system works.

Challenge 2: Oversight and accident

Oversight and accident relate to situations where consumers do understand what should happen, and genuinely intend for this to be the case at the point they reclaim the deposit, but the container still does not reach the custody of the DRS.

From a behavioural perspective **consumers will wish to reclaim their deposit in the way that is most convenient for them, and other 'points of claim' than the point of disposal may prove more convenient**. We assume that the system will impose technical controls preventing a form of fraud where codes can be scanned and claimed before purchase (see Section 3.3.6). However, after that point, consumers could scan containers and claim a refund in locations or stages in the product journey that are not intended by the system but are more convenient for the consumer.

The most likely example is while unpacking shopping at home in the kitchen – a location that is highly likely to have a waste receptacle with an authorisation code enabling the deposit to be claimed. Batch processing a claim for clean, dry product containers when a smartphone is available may seem easier and cleaner than doing so when dealing with used containers. This would also mean deposits could be refunded sooner, meaning a financial incentive also exists for this behaviour. Such behaviour may not be malicious – consumers may make the digital claim at a time that is more convenient to them, with the genuine intention of returning the container later. However, once the link between the deposit value and the container is broken, the incentive to actually follow through on that intention to return the container is no stronger than it is without a DRS. Additionally, scanned containers may not then even be consumed at home, but on-the-go, in contexts where we know litter already arises. Not all UBCs would be lost to the system, but the high capture rates seen in a classic DRS would be unlikely.

Independently of the consumer, because the DRS does not take custody of UBCs as soon as they are returned, there is an opportunity for even correctly returned UBCs to 'escape' the system between the point the consumer returns the container and the point it is actually collected. This could occur through spillages from collection systems or overflowing bins in on-the-go locations – events that not only lose UBCs from the system but also generate litter. The tight chain of custody in a classic DRS eliminates this risk.

Challenge 3: Fraud and deliberate bad behaviour

Fraud or active bad behaviour would involve the deliberate exploitation of the potential loopholes above, for example reclaiming the deposit early with no intention to return the container, or before deliberately placing it in the wrong collection route or simply littering it. Fraud may be more likely at home (due to the volumes of containers available) while deliberate bad behaviour is more likely in on-the-go environments (given the fact littering behaviour already reflects bad behaviour) and is discussed in Section **Error! Reference source not found.** below.

Additionally, a new and unique form of consumer fraud is also potentially possible with a serialised DRS. A consumer can purchase a product, reclaim the deposit, and then take advantage of product return

[49] Zero Waste Scotland, 2017, The composition of household waste at the kerbside in 2014-15. This published study shows variation by municipality, but the underlying dataset showed very significant variation within areas with identical collection systems as well.

policies to additionally get their original purchase refunded. While checks could be made to see if the deposit was still activated, it would pose additional complexity for retailers.

Potential mitigations to these challenges

Given the relatively high risk that the link between container identification, refund, and the act of returning the container correctly can be broken with these low direct control return pathways, several mitigations have been proposed to seek to ensure correct behaviour occurs. These include:

- **Authorisation codes on waste receptacles:** Authorisation codes that can be matched to the unique 2D codes on containers to authenticate return are a common feature of proposals for these return routes, but the choice of where to locate them (on bins, on designated bags for recyclable waste such as blue bags in Belgium, or as moveable signs or stickers for households to deploy for themselves) may make it more or less likely that the act of scanning a container happens in close proximity to an authorised return route.
- **Geofencing:** This is typically proposed in relation to litter bins and would mean that scanning of containers for return could only be made in close proximity to the bin. However, there is a risk that poorly defined geofences could prohibit correct behaviour where households are located near to excluded areas. This may be a particular risk if geofenced areas around public bins or retail locations overlaps with valid disposal locations for nearby households.

  In Belgium the wC proposal also suggests geofencing could be linked to households, with home return allowed within a designated distance of the home address.

  All geofencing solutions would be dependent on consumers being willing to share location data. And these solutions check *where* a person is, but do not limit *what* they are doing, and would not control many of the behaviours above (such as claim before disposal, or use of the wrong waste receptacle).

  Geofencing may also create specific challenges in terms of smartphone and internet coverage, discussed further below.
- **Validation that scanned containers have been opened at point of consumer claim:** In this case proof would be sought that a container had been opened (restricting the option to scan and claim unused products). In theory this might involve sending a photo of the opened container, which might also have implications for where the QR code had to be displayed on a container. It would also rely on a significant amount of processing per transaction for an algorithm to validate the image, and with current technology it is highly unlikely this could be achieved at high rates of accuracy. This would also add significantly to the reporting requirement on consumers.
- **Refund delays:** These are proposed specifically to prevent the purchase refund fraud mentioned above in the Belgian proposal[50]. This would delay payment by a defined period of time so that a rapid version of this fraud would be impossible. However, this would mean a gap between claim and refund for everyone, with any resulting impacts on motivation, or personal finances. It would also eliminate the incentive for on-the-go return with any recently purchased container (which is a common scenario in on-the-go contexts especially).
- **Post-collection validation:** Scanning UBCs within the system after collection could confirm that UBCs scanned by consumers had in fact been returned and received. However, this is not currently technically possible at a speed, scale, and accuracy that is economically viable (see Section 3.4). Additionally, while codes might be readable at the point of consumer return, they may no longer be so by the point of validation (I.e. in most kerbside collection systems, packaging are crushed). Finally, an absent container would not prove consumer error – it might reflect UBCs that went missing after a valid return but before the system took custody or a 2D code that became unreadable. Post-collection validation seems unlikely to provide a credible way to validate or authorise consumer

[50] PwC, September 2023, Every Packaging Counts - DDRS Blueprint - Consolidated report, p53

refunds. This may also pose problems for the system in validating its overall return rate for performance reporting.

Handheld scanners have been proposed in the Belgian case as a key performance mitigation, but they are primarily designed to solve potential access challenges, rather than the potential for unintended behaviours discussed here.

Without a direct validation point within the system, identification of eligible UBCs and the act of scanning the container to reclaim the deposit by consumers is delinked from the actual act of return. There is then no explicit motivation for consumers to ensure claim and return really do match up, other than the desire to do the right thing.

This creates a much weaker incentive system than in the return pathways deployed in a classic DRS. While the majority of users are still likely to wish to use the system correctly, and some of the controls above may additionally nudge consumers to interact with the system as intended, a gap between scanned containers and actually returned UBCs is likely. The scale of that gap is currently unknown. In addition, the more controls are imposed to try and close this gap, the more risk is created in terms of the convenience of consumer experience.

4.2.2.3 Return via existing or modified kerbside collections for households

In countries with established household collection services, a key driver for considering serialisation as part of a DRS design is typically to enable UBCs to continue to be placed in existing collection infrastructure. The deposit is assumed to provide additional motivation for people that do not currently participate, or participate fully. But no changes to the *desired* consumer return behaviour are targeted. Two rationales for this approach are usually advanced. One is the assumed cost effectiveness of using existing services, and the second is an argument that household collection routes will be more convenient for consumers than the return pathways with high direct control above.

This section focuses on the latter argument. It first considers whether consumers will in fact be able and willing to use a serialised DRS with container return as easily as is assumed. And it then considers the scope for unwanted consumer behaviours impacting return rates when the return pathway is not subject to direct controls (e.g. reclaiming a deposit remotely via an app, but not in fact returning the container properly). Mitigations can be suggested for these challenges, but in addition to introducing technical complexity (see Section 4.2.2), they may also impact consumer behaviour in other ways (e.g. if they make interaction with the system harder or less appealing).

It should also be acknowledged that behavioural friction exists in a return-to-retail DRS too. However, in terms of both inclusion and performance the net effect of these frictions is small, as evidenced by the real world performance of currently existing systems. Alternative return pathways need to demonstrate they are equally or more accessible, especially in cases where they are proposed as a substitute rather than an addition to proven return pathways.

Intended behavioural interactions

The exact way in which container identification and refund authorisation could work at home might vary, but will rely on consumers scanning both the 2D code on their used container, and (probably) an authorisation code linked to their bin or authorised waste receptacle (e.g. an authorisation code on the blue bag in the Belgium context might be one option). The act of then correctly returning the container is assumed to follow, but cannot be directly validated in a remote system.

Superficially, the convenience of this system for consumers would appear to be high as consumers can return UBCs at home. However, its application in a real operational context poses a number of challenges against the COM-B behavioural framework outlined above. In particular, the provision of an 'at home' return option should not be assumed to be the only factor influencing perceived consumer convenience.

Capability and Opportunity

We consider these drivers together, as there is significant overlap between the barriers likely to be encountered in the context of a serialised DRS with digitally dependent return pathways via existing municipal collections for households. Key challenges likely to be encountered are summarised below.

Two of these are however particularly critical. **Digital or financial exclusion from a DRS is an essential social justice consideration.** As a deposit-based system, consumers will have had to pay money into the DRS at point of purchase, and it is essential they have the opportunity to reclaim it, or the system effectively profits from this barrier to access. Performance will of course also suffer in these cases, with even marginal declines in participation likely to matter when DRS performance in Europe is usually measured at or above 90% return rates.

The combination of return pathways offered is critical here. Digital and financial exclusion is a particular problem in situations where *only* digitally dependent return pathways are offered. In a scenario like that proposed in Wales, where the digitally dependent return pathway would be *additional* to classic return routes, such concerns do not arise, provided alternative provision is widespread. For a hybrid situation, where, for example, a digitally dependent return pathway is offered alongside a more limited return-to-retail pathway, the implications for access and performance might be more complex.

Issues of exclusion are not unique to proposed at home return routes, and access should be considered in all DRS design (return-to-retail may pose challenges for people with limited mobility – though as access to retail sales is already an essential, integrating take-back of UBCs into existing retail access arrangements should overcome this). At home return may be more inclusive for *some* people than return-to-retail – but the reverse is also true. Return-to-retail has proven it works in multiple contexts, and mitigations in relation to convenience (for example, provision of return points at additional non-retail locations) are well understood. In contrast, serialised DRS with new return pathways has yet to demonstrate how challenges to inclusion could be met.

Challenge 1: Digital access and digital literacy

Consumers need to be able to use the app, easily and seamlessly. This is not simply a technical challenge for IT provision and app design. Smartphone penetration and internet access are not 100% in Europe. Smartphone penetration in Belgium is estimated at 90% in 2023[51]. In 2022 household internet access ranged from 93% in rural areas to 95% in towns and suburbia[52].

Even where access exists, ability and willingness to engage digitally may be weaker. In Belgium, the number of individuals aged 16-74 who ordered goods and services over the internet (which might be one proxy measure for ability and willingness to engage with an online service involving financial transactions) was only around 75%[53]. This survey sample excludes demographics (like children and older people) who would be expected to interact with a DRS. Other studies suggest lower levels of digital

[51] https://www.statista.com/statistics/568069/predicted-smartphone-user-penetration-rate-in-belgium/

[52] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Digital_economy_and_society_statistics_-_households_and_individuals

[53] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Digital_economy_and_society_statistics_-_households_and_individuals

literacy (e.g. 54% in Flanders, 51% in Wallonia, and 62% in Brussels)[54], but may be setting a higher standard than is required for interaction with an at home return pathway.

Even for individuals that are digitally enabled and willing to engage, temporary barriers to engagement may occur, such as loss or damage to a phone, a lack of charge or memory space for the app, or poor network or internet coverage, either at home, or in an on-the-go location where they wish to return a container. As a serialised DRS relies heavily on real time data transfer for a very large number of transactions, this might be particularly challenging for both consumers and the system. The need for high levels of customer support was highlighted in interviews conducted for this project, with VVSG highlighting a concern that as municipalities are seen to be responsible for the collection of household waste, they may be seen as the default place to go with problems with the digital technology, regardless of actual responsibility.

Workarounds can be suggested where access is an issue. For example, handheld scanners for households without smartphones are proposed in Belgium, with Fost Plus highlighting that these could be enabled in a similar way to electricity smart meters to allow remote reporting without access to a household internet connection[55]. However, **the challenges of deploying handheld scanners to households and individuals that are likely to be among the least digitally enabled members of the population is unlikely to be easy.** In the Belgium case, the PwC study suggests municipalities are best placed to do this, but both Testankoop and VVSG highlighted the engagement and cost challenges likely to be encountered in any such effort. A service of this nature would also likely need to be ongoing, as people move, equipment fails, or users encounter problems. Handheld scanners would not work for on-the-go returns, effectively excluding this route for those without smartphones.

Challenge 2: Banking access and practice

Additionally, as online refunds are integral to this approach, digital financial access, and banking access more generally, are an essential prerequisite to this approach. The UK has a well-developed digital banking culture, with around 88% of people using online banking[56]. However, 2.1% of the adult population have no bank account, 6% predominantly use cash for transactions, and 7% were classified as 'digitally excluded', disproportionately among the elderly. A Belgian stakeholder additionally identified concerns that individuals with bank accounts but in debt might see any payments to their account immediately taken for debt repayment.

A final group that may be de facto excluded from a national DRS dependent on refund to a registered bank account are those with foreign bank accounts, which could include tourists, immigrants, or foreigners temporarily working and resident in Belgium.

It is worth noting that while the handheld scanner solution proposed for Belgium may address exclusion relating solely to smartphone or internet access at home, it would do nothing to address issues of online financial access.

Challenge 3: System reliability and accuracy over time

The level of reliability and resilience in a serialised DRS will be a design choice. Some elements of reliability are technical, but other features may relate to the operational environment and how users interact (for example, if authorisation codes are legible in all contexts). While features like geofencing may seem desirable to minimise fraud, they could cause challenges if they block legitimate reclaim (for example, if a location is close to a geofence around a retail location that prevents reclaim on that site,

[54] https://www.vlaanderen.be/statistiek-vlaanderen/digitale-economie/digitale-vaardigheden-bij-burgers

[55] Interview with Fost Plus.

[56] chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.fca.org.uk/publication/financial-lives/financial-lives-survey-2022-key-findings.pdf

or if a phone cannot get accurate location data in a specific location). Helplines and careful management of these kind of issues may be manageable in pilot contexts, but could be complex to scale to a national system. **Customer support will be important, especially at system launch.**

From a behavioural point of view, problems with the system will undermine confidence, perceptions, and potentially participation. System accuracy in both validation and refund needs to be exceptionally high. As an example, if there were around 4 million UBCs returned in the system each day, a 5% fail rate would be equivalent to 200,000 UBCs, with a refund value lost to consumers of €40,000.

Challenge 4: Consumer preferences for return pathways

There is undoubtedly a large group of consumers for whom digitally dependent return at home will be more convenient provided technical challenges are resolved. Several interviewees for this project highlighted the likely appeal of this model for younger, digitally confident demographics in particular.

However, it may be the case that return via existing household collection services is not more convenient for some demographics. Take up of these services is variable between different areas and housing types currently, reflecting in part differential service provision, understanding, and convenience, not all of which will necessarily be overcome by the application of a deposit. For example, barriers to participation in existing household services may include factors like limited storage space, especially as wider ambitions for recycling and reuse collection services expand[57] [58].

Motivation

In considering motivation in relation to a DRS, the focus is typically on the deposit, and there is no question that the deposit is an essential incentive for the levels of performance DRSs can achieve. However, the value of the deposit as motivational incentive has to be weighed against any barriers that may demotivate consumers.

Challenge 1: Willingness to use an app-based system that shares personal or financial data

Even where people have the access and knowledge required to take part in a digitally dependent return route, some people may simply be resistant to using an app for this purpose. Downloading, installing, and having the app to hand when disposing of UBCs, may all impose barriers to participation. This should not be overstated – no return solution is perfectly barrier free. However, assessing likely levels of take-up and participation via an app-based system is essential to assessing likely participation in a DRS that would be dependent on this method to function. Opting in to alternatives (such as the Belgian proposal for handheld scanners) would impose a higher barrier, one that is likely to fall on groups that are more struggle with participation in a system of these type.

Some consumers may have more fundamental concerns about participation, which would predispose them not to participate in a system that is dependent on sharing personal and financial data. Minimal system data requirements would almost certainly need to include personal identification and financial details. It might also be the case that some of the anti-fraud measures and controls designed to prevent unintended behaviours would need geolocation features or data to be shared, which could raise additional privacy concerns. Examples would include any form of geofencing in store (which might be necessary to stop deposits being claimed prior to sale), or to home address or public bin location (designed to ensure that consumers are at least close to a genuine return opportunity at the point they claim).

[57] WRAP, 2021, Recycling Tracker Report 2021: Behaviours, attitudes and awareness around recycling, https://wrap.org.uk/resources/report/recycling-tracker-report-2021-behaviours-attitudes-and-awareness-around-recycling..

[58] WRAP, 2018, Increasing Recycling in Urban Areas, https://wrap.org.uk/resources/guide/increasing-recycling-urban-areas

Interviewees differed in their views on the level of concern these design features might rase in a country like Belgium – data sharing of this kind is common, and people largely trust online payment and banking technology. Convenience or necessity mean many people would participate regardless. However, it is not unreasonable to suggest that some individuals or groups might be put off by these features, regardless of safeguards in place.

Challenge 2: Any delays in refund may weaken the financial incentive

Classic DRS return routes link container verification, refund, and return. From a consumer perspective, refund happens at the same time as return, and there is no waiting or delay. In a serialised system this may not be the case, depending on design decisions made.

From the perspective of system costs a micropayment via the banking system for each deposit refunded is likely to incur significant cumulative transaction costs. There is therefore a strong case for batching repayments either for a fixed time period, or to a fixed amount. Fost Plus highlighted in interview this might also be preferred by many consumers. The PwC proposal also suggested much longer delays might be introduced to prevent certain forms of fraud (for example users purchasing products, claiming the deposit immediately without consuming the product, and then returning the product for a full refund).

However, delays between return and refund could weaken the incentive effect in unexpected ways, with evidence in the behavioural literature suggesting deferred rewards are valued less highly[59]. Delays could also cause financial hardship for those on low incomes or tight budgets.

4.2.2.4 Public bins in on-the-go locations

A key benefit of a classic DRS design is that it helps reduce litter – a result that has been demonstrated in multiple contexts (see Section 5.0). A classic DRS delivers this in two ways. First by incentivising return by the consumer (who loses their deposit if they do not return the container) and secondly by financially incentivising other citizens to collect and return eligible UBCs that have been littered.

Serialisation would enable the return of DRS UBCs to public bins in much the same way as that outlined for return to kerbside services. The public bin needs to have an authorisation code, the consumer scans that code and their UBC 2D code to identify their container, the refund is authorised and paid, and the consumer places the container in the bin.

The nature of the 'bin' can vary, as discussed in Section 3.0. Regardless of the bin type deployed, in theory, extensive provision of such bins would provide a higher frequency of incentivised drop off points for UBCs than other return pathways. **Although the material collected through such routes will be of lower quality than in return pathways with high levels of control (and almost certainly lower than in kerbside collection return pathways too) due to contamination with other materials, if incentivisation works as intended, litter reduction would still occur.**

Behavioural considerations

The behavioural challenges arising from the delinking of UBC identification and refund, and the act of correct UBC return are even more acute than for return to kerbside. In seeking to tackle potential litterers we are already dealing with a less responsible fraction of society, and proofing the system against negative or careless behaviour is essential. For example, it would be possible to scan a container, claim the refund, and litter an item immediately rather than use a bin. This might seem illogical, but littering is already an anti-social behaviour, and such behaviour might be careless rather than deliberate, as much littering behaviour is. **Issues such as full or overflowing bins would be no impediment to scanning a container and reclaiming a deposit, but would prevent correct return.** Equally, consumers on-the-go

[59] https://journals.sagepub.com/doi/10.1111/j.1467-9280.1994.tb00610.x

could scan a not-yet-empty product while passing a bin and litter the UBC later when it has been emptied.

Contamination with non-target waste is also highly likely in on-the-go settings. On-the-go provision of waste collection, and especially of separated recycling bins is operationally challenging[60]. A small number of users can easily contaminate a whole bin. Factors such as weather, time of day, day of the week and so can lead to a very inconsistent waste stream[61]. Rapid changes in volumes of waste also make servicing bins challenging, and situations where bins fill faster than they can be emptied, or spill their contents are inevitable. This means **the waste stream, and the likely quality of any material, is also highly variable, and challenging to improve over time.** In this environment, the factors identified as problematic for return pathways with low direct control – misunderstanding, oversight and accident, and fraud and deliberate bad behaviour - are even more likely, and harder to mitigate. Contamination and misuse will also undermine the behavioural norm of correct return in these contexts, as people are likely to see mixed waste present in collection containers intended for recyclable waste.

System reliability will also significantly influence behaviour in on-the-go settings. At home a problem with the system may see people proactively seek help and resolve a problem (for example, leaving UBCs to try again later). Consumers may place items in the wrong bin at home, but are unlikely to leave them outside of the waste collection system altogether. This kind of care is less likely in on-the-go situations where **many disposal decisions around litter are rapid and unthinking, and people are less likely to feel a sense of responsibility for a poor littering outcome[62].** An unreadable authorisation code, a wait for the system to authenticate a transaction, or a smart bin that is inoperative may all push a consumer towards littering behaviour.

Finally, this return pathway only works for consumers who have an app and are willing to use it. In a situation where these pathways are additional to a conventional return-to-retail network, the option to return an item to a return-to-retail location will also exist (and retail is often close to urban high footfall destinations**). In a situation where only return at kerbside and return to public bins in on-the-go locations are available, then a consumer without the app will be entirely excluded from the on-the-go pathways.** The consumer would have to take the container home, regardless of the place where the container is actually consumed – and assuming they are actually using the at home system. Specific issues arise in this regard for very different groups, ranging from homeless people to tourists.

Potential impacts on the wider system

The existence of serialisation and this return pathway within a DRS (regardless of the other return pathways available) will also weaken or remove the financial incentives for other citizens to pick up litter. In a classic DRS, any eligible container outside of the system is known to be worth its deposit value. However, once pathways with lower direct control are introduced, it is possible that littered UBCs have already been scanned, had their deposit claimed, and are now deactivated. Picking up a littered item to claim a deposit is now more speculative, as some could already have had the deposit reclaimed and the average payout will tend to be less than the absolute deposit value per container. The extent this shapes behaviour in financially motivated litter pickers will depend on the proportion of deactivated UBCs that end up in the litter stream. In addition, **financially motivated litter pickers may be those least likely to be registered within a digitally dependent system – for example enterprising teenagers, or homeless people**.

[60] Zero Waste Scotland, 2014 (unpublished), Evaluation of recycle on the go infrastructure provision

[61] Zero Waste Scotland, 2013, Scotland's Litter Problem: Quantifying the scale and cost of litter and flytipping

[62] Zero Waste Scotland, 2013, Rapid Evidence Review of Littering Behaviour and Anti-Litter Policies, https://www.zerowastescotland.org.uk/resources/rapid-evidence-review-littering-behaviour-and-anti-litter-policies

4.2.3 Future-proofing behaviour change for a reusable future

The future of sustainable packaging will involve a growth in reuse. The EU's draft Packaging and Packaging Waste Regulation proposes targets for reusable packaging, including beverage containers[63].

Additionally, beverage containers are the form of consumer packaging with the most extensive and at scale reuse options already (e.g. Germany, Denmark, Netherlands, Belgium) and may offer some of the best opportunities for near term growth. Deposit mechanisms are likely to be a key feature of reusable packaging systems, as return is essential to reuse, just as it is to recycling.

DRS is already a feature of the national reuse systems mentioned here, and the PPWR clearly anticipates a role for DRS in facilitating reuse, with a clear preference expressed for compatibility between systems, and for return for reuse to be equally convenient as that for single use[64]. **From a consumer perspective, returning UBCs to the same locations, whether they are single use or reusable is the easiest behaviour, as it requires no differences in action.** This also means that the packaging format is unlikely to influence purchase decisions directly (as might be the case, for example, if one format is seen as less convenient).

While serialisation may play a useful role in reuse systems in future (for example tracking packaging rotations) it is not essential, and serialisation is not a feature of existing national reuse systems for beverage containers. **Reuse does however depend on return pathways with high direct control.** Material quality, and the collection of intact containers, is more important than for single use return models.

Current reuse models are largely based around return-to-retail models, though return via home delivery services is also possible, if not widespread. **Reuse would be completely incompatible with takeback via a kerbside packaging waste collection.**

This makes return-to-retail return pathways appealing not just for their behavioural benefits within a DRS for single use beverage containers, but also for the compatibility of return behaviours across single use and reusable systems. In Belgium, with an existing reusable system already in place with a return-to-retail model, this comparison already exists.

4.3 The Belgian case

The Belgian proposal presented by PwC is notable for its complete reliance on return channels with lower direct control, and, critically, for all users to be digitally enabled (to both scan UBCs for return and in terms of financial access) in the absence of any alternative return pathways. As it stands, this raises significant access concerns around access to both the digital tools and knowledge to participate in return, and also the financial services needed for refund[65]. Digital access and literacy are not 100% in Belgium (see section 4.2.2.3), and the groups impacted may be among the more marginalised and financially vulnerable in society. Fost Plus have highlighted that thinking continues to develop and that ensuring access to all groups is part of planned development.

In terms of serialised DRS performance for return pathways with lower direct control, this is currently unknown. Belgium has well developed kerbside collection services for recycling packaging waste in

[63] European Commission, November 2022, Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on packaging and packaging waste, amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and repealing Directive 94/62/EC, article 26

[64] European Commission, November 2022, Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on packaging and packaging waste, amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and repealing Directive 94/62/EC, annex X

[65] Project interview with Testankoop

international terms, but there is still variance in participation and material quality within Belgium. Belgium also has an existing DRS for reuse, with a return-to-retail model, independently of the Fost Plus system.

While collection of targeted UBCs could be expected to increase with the addition of a deposit incentive to existing kerbside services, consumer error and misunderstanding will also remain. Additionally, those currently not using the service correctly (or at all) may not be doing so due to factors other than the deposit, such as concerns around space. Fost Plus claims that material collected through the kerbside services currently can be sorted to a standard suitable for closed loop recycling[66]. However, quality and losses will be higher than those seen with the very high-quality material streams collected via classic DRS return routes (see Section 3.4).

Additionally, while a classic DRS records sales and returns with very high fidelity – which is higher than any other collection system -, auditing performance in a serialised DRS with return pathways with lower direct control will be challenging, as the record of scanned UBCs and refunded deposits may not tally with the number of UBCs actually returned and received by the system, and there is no current technical option for post-collection verification on a per container basis. **However, this information would be necessary to understand any behavioural gaps between claimed return and actual return behaviour.** Obtaining insight into performance via the current pilots in Flanders is essential, as is consideration of how performance could be audited in a full operational setting.

Litter may be the most challenging problem for a serialised DRS to address. On-the-go return will not be accessible to consumers (or members of the public) without the smartphone, app, and digital banking. The scope for poor behaviour in these on-the-go contexts is also high, including those scanning UBCs for a refund and then littering anyway, and the risks UBCs returned to on-the-go bins spill. Material quality will vary, but will generally be much poorer than that collected through classic DRS return pathways. While a large number of return locations could potentially be provided, the anti-litter effect, and the amount of material viable for recycling that is collected, are both unproven. **This may be of particular concern in Belgium, where the anti-litter impact of DRS is a key policy driver.**

[66] Project interviews with Fost Plus and a larger producer

5.0 Environmental Performance & Effectiveness

5.1 Policy requirements

The policy drivers for a DRS can vary slightly between countries, but always include the following elements:

- **Increased return rates for targeted containers**, leading to:
    - **Reduced rates of litter in the environment**
    - **Increases in recycling rates**
- **An improvement in the quality and consistency of material collected for recycling, and reductions in subsequent losses during sorting and reprocessing.** This both increases the amount of material that is ultimately recycled relative to other collection methods, and the likelihood that material is suitable for closed loop container-to-container recycling. This outcome is also of increasing relevance for beverage producers, who face mandated recycled content targets (in the EU's existing Single Use Plastics Directive, and draft PPWR), and may have set more ambitious corporate targets[67]. DRS is commonly seen as essential to achieving these outcomes.

As classic DRSs are established in many European countries, the performance benchmark that any alternative DRS model should be expected to meet is relatively easy to establish. There is no reason to set performance requirements lower than best performance already seen in classic systems.

National policy makers may of course wish to go further. For example, while classic DRSs have consistently delivered litter reductions, not all systems formally set targets for litter reduction, although this is increasingly an explicit objective.

Reuse is also an area where policy makers may wish to place additional requirements on DRS design. While discussion around DRS generally and serialisation in particular is still typically focused on single use beverage containers, DRS is a feature of existing national systems for reusable beverage containers, and compatibility now, or in the future, between single use and reusable container return is gaining growing attention. **From a behavioural perspective, alignment of the locations to which consumers should return both single use and reusable containers has significant benefits,** and the draft EU Packaging and Packaging Waste Regulation requires for return for reuse to be 'equally available'[68] as return for single use beverage containers, with additional elements of the draft seeking to encourage alignment of reuse and single use DRS for beverage containers[69]. As discussed in section 4, DRS for reuse relies on return-to-retail models (as is the case in Belgium), and is likely to continue to do so.

Approach to comparing classic and serialised DRS

Classic DRS performs exceptionally well against all of the indicators above. The rest of this section sets out the evidence on classic DRS performance on return rates, litter, and material quality specifically. It then compares the evidence on how serialised DRS, and specifically alternative return routes with lower direct

[67] Unesda, December 2021, What's next for beverage packaging?, https://www.unesda.eu/whats-next-for-beverage-packaging-2022-will-be-a-year-filled-with-opportunities-to-continue-making-beverage-packaging-fully-circular/

[68] European Commission, November 2022, Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on packaging and packaging waste, amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and repealing Directive 94/62/EC, article 44 (6)

[69] European Commission, November 2022, Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on packaging and packaging waste, amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and repealing Directive 94/62/EC, article 45

control may compare. However, the extent and nature of evidence on performance for the two approaches is quite different.

The performance of a classic DRS using return pathways with high direct control are proven and well understood both operationally and behaviourally, with multiple benchmarks now available across Europe.

In contrast, the way in which a serialised DRS might perform are not yet proven, even if explicitly technical challenges to serialisation, identified in section 3, are resolved. Importantly, there is no single serialised DRS approach established yet, as highlighted in previous sections of this report. The precise design choices made will therefore determine performance. Additionally, there are no case studies to look at for indications of the likely performance range.

This rest of this section therefore shows evidence of actual performance for classic DRS, but can only highlight where performance between classic and serialised DRS might differ and why, and the design choices that could make this more or less likely.

Serialised DRS performance will depend not just on the technical solutions, but on how the return pathways with lower direct control actually perform in the real world. This will be a result of technical, operational, and behavioural factors.

This uncertainty over performance in a serialised DRS is a significant risk from the perspective of ensuring the policy outcomes typically driving a DRS. Understanding likely performance, whether any differentials in performance expectations between classic DRS and alternatives are tolerable, and how performance risks could be reduced is essential.

5.2 Benchmarking performance: return rates

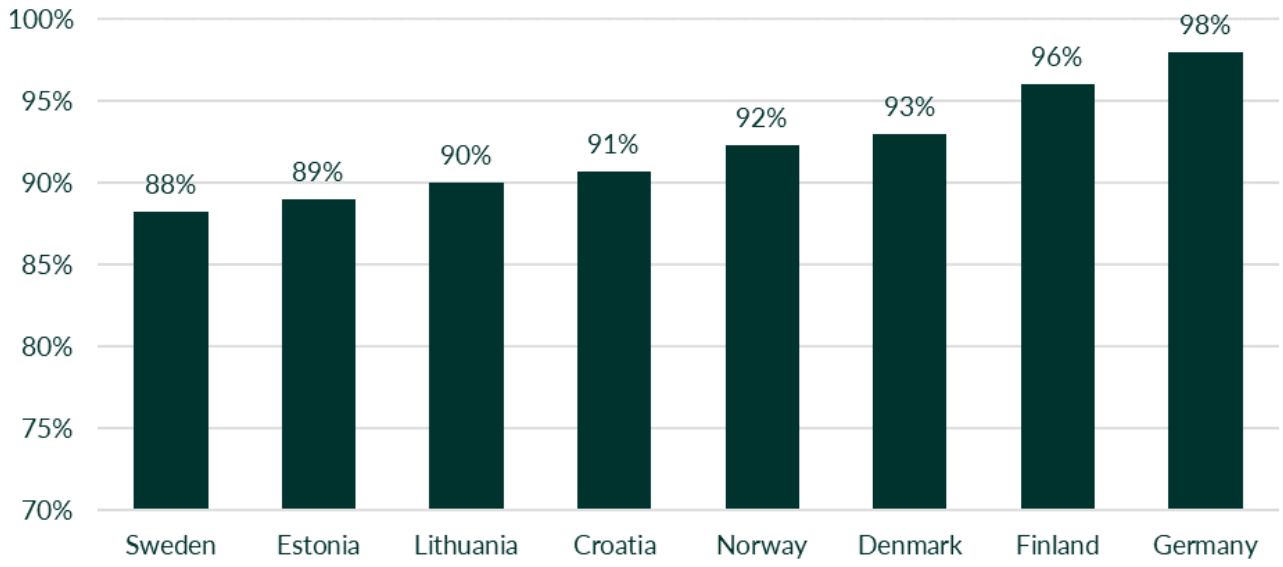
This section first sets out typical current performance levels for classic DRs with convenient return-to-retail. It then discusses how alternative return pathways may compare.

5.2.1 Classic DRS return rates

Well-designed return-to-retail DRSs in Europe consistently see return rates at or above 90%. Germany has the highest performance at 98%, while the median return rates for PET and cans were 91% and 89% accordingly.[70] While return-to-retail may not be perfectly convenient for every individual, actual operational systems perform to incredibly high standards, and have ensured over time that access is optimised. This poses a very exacting test for alternative systems.

[70] ReLoop (2022) Global Deposit Book.

Figure 5-1 European DRS Return Rates



Source: Reloop (2022). Global Deposit Book[71]

5.2.2 How might a serialised DRS compare?

As discussed in Section 4.0, **the deposit level alone does not determine the expected return rate**. **Ability and willingness to access the system are also key.** There is a case for elements of a serialised DRS being more convenient for consumers, but also a case that larger numbers may be excluded from participation in some return pathways. This is particularly the case for digitally dependent return pathways, where these are offered to the exclusion of alternatives. Considering these factors alone, the combination of return pathways offered is potentially central to expected performance.

Adding return pathways

Discussion in Wales has assumed that new return pathways would be *additional* to a return-to-retail network. Provided coverage via the retail network is extensive, this limits risk of exclusion relative to a classic DRS benchmark, and there are fewer reason to think the *reclaim* rate would not match or even exceed that seen in a classic DRS.

However, the reclaim rate and the true return rate may not match. Specific performance risks also arise if:

- there is any way for consumers to reclaim deposits without ensuring that the claimed container is disposed of correctly
- there is a possibility UBCs escape the system even after correct return
- there is a reduced incentive for other members of the public to pick up and return UBCs that have been littered

Based on the analysis in Section 4.0, it seems likely that these factors would apply at least to some extent, and that this would inhibit the return rate actually obtained by the system, though not necessarily the

[71] ReLoop (2022) Global Deposit Book.

reclaim rate recorded**.** Only testing in fully operational environments could demonstrate whether this drag on performance was offset by gains from the provision of additional return pathways.

Substituting return pathways

In Belgium, the serialised DRS proposal *substitutes* return pathways (relative to a classic DRS design) rather than adding them. This places much higher performance requirements on the new pathways, ones that these pathways would struggle to achieve if even a small proportion of the population are unable or unwilling to access them.

The impacts of performance losses

As classic DRS delivers very high rates of return, meaning even marginal gains and losses in performance can make a difference to the likelihood that return rates of 90% can be achieved. High return rates in closed loop systems also significantly increase material circulation, as shown in Figure 3-1 earlier in this report. Changes in return rate also impact system – and consumer – finances, as unredeemed deposits are a source of system income. A serialised DRS may also struggle to demonstrate its return rate, which is a requirement for European reporting.

5.2.3 Return rate performance risks in a serialised DRS

In terms of return rates, the risks largely relate to the return pathways offered. It is not serialisation per se, but the introduction of return pathways with less direct control, or lower access, that introduce the greatest risks.

Access is a risk. If a system is pursuing return rates of 90%, it needs to ensure extensive opportunities for participation, quite apart from equity and social justice concerns (see section 4). If even small fractions of the population are unable or unwilling to access the system, this will impact the return rates that are achievable. Systems that are entirely dependent on digitally enabled consumers, such as that proposed for Belgium, run this risk to the greatest extent.

Even where access is ensured, behavioural factors may create a gap between reclaim behaviour and correct return behaviour. If consumers are in any way able to scan and reclaim deposits without the act of return being simultaneously guaranteed, a gap between the number of UBCs reclaimed and the ones actually returned is likely, though the size of the gap is unknown.

This does not necessarily pose a significant *financial* risk to the system. Although the system would be paying out for non-returned UBCs, it would have the necessary deposit money to do so, as these would be eligible system containers, and they could only be claimed for once.

Post-collection verification (see section 2) is therefore an essential part of these return pathways, as without it, any gap between reclaim and actual return will be unknown. This is in stark contrast to classic DRS where data quality is excellent.

Considering purely environmental policy outcomes, both these elements create risks that the overall return rate falls short of its potential, with impacts on the associated environmental outcomes that a high return rate represents. In terms of wider packaging policy objectives, not simply single use DRS performance, it is also worth noting that a mismatch between single use and reusable container return locations may adversely impact the overall performance of single use and reusable systems, as the demand on consumer behaviour would be more complex.

Proponents of a serialised DRS would highlight that the additional or alternative return pathways may enable higher participation and return overall. This additional performance might offset or even outweigh any shortfall between claim and actual return, when compared to return rates in a classic DRS.

Without data on actual performance it is impossible to judge the likely net effect of potential changes in return between a serialised DRS proposal and a classic DRS. Given the high return rates in a classic DRS, even marginal performance issues in a serialised DRS would make it very hard to match performance.

Net benefits are more likely in cases where return pathways with lower direct control are offered as additional return routes. Where return pathways with lower direct control, and which are entirely dependent on digital access are offered in isolation, then the risks around digital exclusion from the system could start to erode performance potential significantly.

5.3 Benchmarking performance: litter

This section first sets out typical current litter impacts seen with classic DRS, before looking at how these effects may be complicated by the impacts of alternative return pathways.

5.3.1 The impacts of a classic DRS on litter

The evidence on litter reductions is strong, though the specific changes in measured litter impacts vary a little more than for the return rates.

Beverage containers make up a significant proportion of the litter stream. CE Delft estimated those containers to make up for 40% of the litter volume in Flanders, and between 20% and 33% by weight[72]. Eunomia has previously identified very similar values elsewhere (40% and 20% respectively for volume and weight)[73].

In assessing potential litter reductions for beverage containers that could arise in the Netherlands from a classic DRS, CE Delft undertook an evidence review that suggested reductions between 70% and 90% should be expected, based primarily on data from the US and Denmark[74]. **A separate analysis, following DRS introduction for plastic bottles in the Netherlands, suggested that the reduction seen was around 85%[75].**

These figures are matched by data from other sources, and should give a good indication of the expected anti-litter gains from a classic DRS in Belgium also. Reloop[76] have identified similar scales of reduction from classic DRS elsewhere. In Estonia, UBCs as a proportion of roadside litter dropped from 80% to 10% within two years of DRS introduction, while UBCs as a proportion of litter volume in Germany fell from 20% to negligible levels following DRS introduction. Analysis by Ce Delft[77] also highlights that studies in both Denmark and the Netherlands show greater reductions in littering for deposit-bearing containers than for non-deposit-bearing containers.

While a DRS may mean a higher propensity to return UBCs overall as consumers and the public are now aware most UBCs are worth a deposit, this finding additionally implies consumers (or those picking up

[72] CE Delft, October 2016, Impact analysis of the introduction of deposits on single-use beverage packaging, https://ce.nl/publicaties/impactanalyse-invoering-statiegeld-op-eenmalige-drankverpakkingen/

[73] Eunomia 2017, Impacts of a Deposit Refund System on Local Authority Waste Services, https://www.eunomia.co.uk/reports-tools/impacts-of-a-deposit-refund-system-for-one-way-beverage-packaging-on-local-authority-waste-services/

[74] CE Delft, October 2016, Impact analysis of the introduction of deposits on single-use beverage packaging, https://ce.nl/publicaties/impactanalyse-invoering-statiegeld-op-eenmalige-drankverpakkingen/

[75] Zwerfinator, 2022, ONDERZOEK DRANKVERPAKKINGEN 2017-2022H1

[76] ReLoop (2021) Fact Sheet: Deposit Return Systems Reduce Litter.

[77] Ce Delft (2017) Costs and effects of deposit on small bottles and cans. https://ce.nl/publicaties/kosten-en-effecten-van-statiegeld-op-kleine-flesjes-en-blikjes/

litter) are specifically assessing whether particular containers are deposit-bearing or not when choosing what action to take.

Therefore, if we assume beverage container litter makes up 40% of all litter by volume, and a reduction of around 85% in beverage container litter can be expected from the introduction of a classic DRS, the overall reduction in litter volume is around 34%, or just over a third. This scale of reduction can be financially quantified.

While potential reductions in anti-litter impact are unknown, even marginal differences could be very large. Litter costs can be quantified in terms of their social disamenity (the value of the burden it places on society). Based on Eunomia studies elsewhere[78], and an older assessment of the public's willingness to pay for a cleaner environment in Belgium (Wallonia)[79], we estimate every 2% reduction in anti-litter effectiveness would cost at least €1 million a year in lost social benefits for beverage cans alone.

Classic DRS is one of the few national policy measure to have proven litter reduction impacts at this kind of scale. This sets a high requirement for a serialised DRS to match.

5.3.2 How might a serialised DRS compare?

Classic DRS has demonstrated significant litter gains, and these continue to be projected for new DRS proposals which follow this return-to-retail model, with an expectation beverage container litter specifically would reduce by around 85% by volume (and overall litter volumes by around a third).

Performance risks

There are significant behavioural risks around littering with a serialised DRS. This includes:

- Cases where UBCs are deliberately or accidentally not correctly placed in the bin, or subsequently spills from the bin, despite the deposit being claimed.
- The high likelihood that any delays or frictions in using the system will result in people giving up and choosing to dispose of a container incorrectly.
- A reduced propensity to pick up litter in the hope of claiming a deposit, in the knowledge that the container may already have been claimed.

High litter contexts, such as city centres, are particularly challenging to manage, and will place a high burden on any proposed return pathway operating in these locations. On-the-go contexts will see high levels of contamination and low material quality, limiting the value of the UBCs returned to the system by these routes, and the likelihood they are actually separated from the waste stream and ultimately recycled.

Another limitation on performance in the Belgian case is that on-the-go return pathways will only be accessible to those with access to the smart phone app. No alternatives are currently envisaged. The specific challenges this poses for some groups were described in Section 4.0.

The feasibility of proposed mitigations

Some measures have been proposed to mitigate these risks in serialised DRS proposals. Bins could have authorisation codes on them, which could require consumers to at least be in proximity to the bin to

[78] Eunomia, 2023 (forthcoming), Unlocking the Benefits of a Deposit Return Scheme in Italy

[79] RDC Environment, 2011, Évaluation contingente du coût des désagréments visuels causés par les canettes dans les déchets sauvages en Wallonie

reclaim a deposit. Alternatively, geofencing could have the same effect. Neither approach actually ensures the container is then returned correctly.

Mitigations on quality issues are likely to have limited effects. 'Smart' bins could be programmed to only open when an eligible container is scanned in the vicinity, but this would not ensure that only target material was deposited.

Proponents of a serialised DRS also highlight that on-the-go provision with a serialised DRS could potentially be higher frequency, or in more targeted locations, than a return-to-retail coverage can achieve, improving convenience relative to return-to-retail in some situations.

5.3.3 Litter performance risks in a serialised DRS

The return rate challenges above also apply to return in on-the-go contexts, but are magnified. Behaviourally this is a context where careless and deliberate poor behaviour are more common, people feel less ownership than at home, and they have less opportunity to make conscious decisions and form good habits.

At the same time, **when littering does occur, the incentive for other members of the public to pick up and return UBCs that have been littered will also be weakened in a serialised system**, as those picking up litter do not know if a container will still be eligible for a deposit. Observed experience in countries with classic DRS is that both homeless people, as well as enterprising teenagers, may be relatively systematic in collecting and returning littered and UBCs in a classic DRS, in addition to more occasional pick up by members of the general public. This contribution this makes to the anti-litter benefits actually seen in classic DRSs is not known, but the effect is likely to be real.

Mitigations like smart bins with authorisation codes may mitigate some risks (by, for example, requiring proximity to a bin to be able to reclaim a deposit) but they do not ensure correct return behaviour. A net increase in public bin provision might have anti-litter effects independently of the deposit, but littering still occurs in areas with public bins.

While potential reductions in anti-litter impact are unknown, even marginal differences could be very large. In financial terms, and based on the scale of social disamenity gain suggested in Section **Error! R eference source not found.**, a 10% reduction in anti-litter effectiveness would see a decline in social benefits from a DRS of €5.4 million per year (see section **Error! Reference source not found.**). U nderstanding the net effect of a serialised DRS on litter is therefore key, especially as anti-litter objectives become increasingly prominent as a driver for DRS introduction given concerns around plastic pollution in particular.

It is unlikely a serialised DRS dependent on a bin network (smart or otherwise) will have the same performance benefits as a classic DRS.

5.4 Benchmarking performance: material quality

Material quality can be hard to prove and compare in many collection and sorting contexts, where data may be commercially sensitive. It is however well understood in a classic DRS, where the initially collected material is already exceptionally consistent. Alternative return pathways in a serialised DRS are likely to match pre-DRS material quality via those same routes, and, as a result, be far more variable by location, even when collection arrangements are superficially similar.

5.4.1 Material quality in a classic DRS

Material quality is ensured by the nature of the return pathways in a classic DRS. The return pathways only accept eligible beverage containers, and ineligible material will not be accepted by either automated RVMs or manual return points.

Even in cases where plastic bottles and aluminium cans are transported together after collection, separating these in a sorting process is fast and of extremely high fidelity. With tightly controlled target material streams and no contamination from non-target materials, material values are high, and the suitability for container-to-container recycling is excellent. Additionally, the consistency of material collected is excellent across the system, in contrast to high levels of variability seen in local recycling rates, and quality, for municipal collections for households.

Classic DRSs also provide consistency material over time and across all geographies, whereas alternative collection options see much greater inconsistency.

5.4.2 How might serialised DRS compare?

The material quality for a serialised DRS will be completely dependent on the return pathways that collect it. Where return pathways with high direct control are used, material quality will comparable to a DRS.

Return pathways with lower direct control will see higher levels of contamination with non-targeted waste. In addition, it is usually expected that UBCs will be deliberately collected alongside other packaging waste or dry mixed recycling. Even in the absence of contaminants, more sorting will be required and material losses during sorting are likely to be higher. While material from a classic DRS is always assumed to be suitable for recycling back into food grade packaging material, this is not always the case for other collection routes, though this varies significantly by location, and the sophistication and thoroughness of the sorting infrastructure available.

Return pathways with lower direct control will also see higher levels of inconsistency in materials received. While classic DRS material from any location is similar due to the deliberate exclusion of inappropriate materials, performance for other recycling typically sees significant variation at multiple levels. Some municipalities perform better than others, and some collection rounds with a municipality perform better than others. This is also seen at household level, where one neighbour may participate perfectly, and one may not. These variations in household performance can in turn impact the wider system – a small number of high contamination households will significantly undermine the material quality of an entire collection round.

These challenges to both quality and consistency are particularly serious for bins in on-the-go locations. Given these locations see much more challenging behaviours, high footfall, and reduced opportunities to build habits, and littering behaviour is at best careless and at worst deliberately criminal, behavioural outcomes are less likely to work as intended. Contamination is more likely, and the same location may see very different performance rates at different times of day or on different days of the week. This inconsistency is also an operational challenge for servicing bins which can further impact the quality and consistency of the material ultimately collected by the system. Smart bins that only open in the presence of an eligible container may mitigate these risks, but they do not actually guarantee correct return occurs, or that no contaminants are added once opened.

Introducing a deposit element to these collection arrangements may encourage *participation,* but does not in itself do anything to encourage *correct* participation. It is likely that quality levels seen prior to the introduction of the deposit will continue. Quality and consistency will typically always be poorer than return pathways with high direct control in a classic DRS as a result. Changes to collection arrangements (such as a dedicated collection for UBCs) might impact quality, but this would then be as a result of changed kerbside collections rather than the introduction of a deposit in itself. Nonetheless, the combination of these two elements could impact performance over time. However, it is not usually a

feature of proposals for serialised DRS with kerbside return, which are usually designed to preserve existing investments in current collection arrangements.

Poor quality and consistency can result in a both a loss of material and the unsuitability of material for container-to-container recycling. Sorting operations can separate UBCs collected in mixed recycling collections (or even in some cases as part of residual waste). In the former case good collection and sorting arrangements can extract high quality material with sufficient investment of effort, though losses will occur in this process, and the extent of losses will depend on the exact nature of the inputs. Typically, loss rates between tonnages collected and tonnages actually entering the recycling process can be around 20% for plastic bottles and 10% for aluminium cans with a kerbside collection, though systems vary in performance. In contrast, for a classic DRS which collects very high quality material streams in the first place, these losses are negligible.

In Belgium, Fost Plus do divert material collected in the 'blue bag' mixed packaging waste collection to container-to-container recycling, though this is unlikely to occur for all UBCs placed into the collection service.

As discussed in section 2, over time the benefits of the highly segregated collection stream enabled by a classic DRS with return pathways with high direct control may increase if this improves material quality and suitability for recycling across multiple cycles in a closed loop system. Section 2 also identified that a DRS can facilitate container-to-container recycling if linked to opportunities for producers to access collected material directly.

5.4.3 Material quality risks in a serialised DRS

Material quality and consistency in return routes with lower direct control will be lower, but this may be remediated by the extent to which additional sorting and separation is undertaken after collection. The effectiveness of this will vary based on the facilities available and the nature of the inputs. It is likely that quality and consistency will largely match the performance seen prior to the introduction of a deposit as there is no reason to expect features such as contamination, or targeted material compositions to change significantly (though more target material may be expected in the mix). Experience shows that material quality and consistency in bins in on-the-go locations is particularly poor, and again, it is unlikely performance for these pathways will change with the introduction of a deposit.

5.5 Focusing on Belgium

The nature of the Belgian proposal, which relies exclusively on digitally dependent return routes with lower direct control makes the proposal relatively high risk in terms of return rates. These return pathways are currently unproven and will have to deliver all the benefits of classic DRS on their own. This is a challenging test to meet.

- **A gap between reclaim and correct return is likely, but the extent of this gap is unknown.** Measuring the extent of this gap will be key to understanding the true performance potential of the system.
- **While some people may be more likely to participate in a DRS with kerbside collection than in a classic DRS with return-to-retail, the scope for improvement is very limited**, given the high return rates seen in classic DRS models.
- **Conversely, digital exclusion poses not just a social justice risk, but also a performance risk** if significant numbers are ruled out from participating. System design (including concerns around personal data) will be important as well as straightforward concerns about technology and

internet access, and digital literacy. Again, there is limited scope to lose potential participants and still perform as highly as a classic DRS.

The above risks are magnified in a litter context. It seems unlikely a serialised DRS can achieve the same anti-litter reductions as a classic model given the barriers, however, the extent of any performance gap here is unproven.

Dependence on container return via kerbside packaging waste collections rather than return-to-retail also creates a mismatch with Belgium's existing DRS for reusable containers in terms of how consumers will need to think about return. Return via kerbside waste services will not be compatible with systems for reusable containers in terms of consumer behaviour.

Belgium has an established kerbside packaging waste collection system and current performance is likely to reflect the quality and consistency of material collected after the introduction of a deposit. Currently this material is sorted to a quality that enables container-to-container recycling, though this will require greater effort than would be the case for material collected via a classic DRS. The quality of material collected via public bins is likely to be much poorer than either a classic DRS or existing kerbside packaging waste collections in Belgium.

6.0 Conclusions: How Feasible is a Serialised DRS?

6.1 Which countries might consider a Serialised DRS?

The *theoretical* attractiveness of a serialised DRS will depend on context. In addition, assessment of this option should involve two considerations. The first is the pros and cons of serialisation as a marking technology, and the second is the desirability and feasibility of opening up additional return pathways for UBCs within a DRS.

For countries with existing high performing DRSs, the incentives to change will be relatively low. Serialisation as an alternative marking technology might offer additional anti-fraud benefits, but in a high performing system change is unlikely to be a priority, certainly until serialisation is a proven approach elsewhere, or for other reasons.

For countries without high performing and extensive municipal waste and recycling services for households the potential for DRS return via these routes is not relevant, and one appeal of a classic DRS is that it can bypass the need for extensive investment in such services. In these markets, the focus will be on classic DRS return routes, with or without serialisation.

There are two circumstances therefore where countries are more likely to consider a serialised DRS.

- Where countries expect significant levels of manual return in a classic DRS and have concerns around maintaining the chain of custody on UBCs after return, a serialised DRS may offer some additional ways to detect and minimise fraud, without impacting the choice of return pathways.

- The other case is countries that have made extensive investments in municipal waste and recycling collection services for households, and are reluctant to change for perceived financial or efficiency reasons, or to maintain service continuity around household collections for consumers. This is the situation in Belgium.

In both these cases however, a proposal for a serialised DRS still has to be able to show that it can work, and that it will be effective in achieving targeted policy aims. These may include those around return rates (for either single use or reusable containers), anti-litter impact, or better material quality and consistency to enable more circular material use.

6.2 Criteria to assess serialised DRS proposals

A serialised DRS is not a single idea. Each proposal for a serialised system will combine different features. It is however possible to set clear criteria against which a specific serialised DRS proposal should be judged. Thirteen criteria are suggested below, grouped against three themes: performance and wider policy alignment; access for all; and technical readiness.

Theme 1: Performance and wider policy alignment

Assessment Criteria	Benchmark and Commentary
1. **Litter:** Will the system deliver litter reductions on a similar scale to those seen in a classic DRS?	**A classic DRS is expected to deliver reductions for targeted containers of around 85%.** A serialised DRS may deliver weaker behavioural incentives to both potential litterers and those that might pick up a littered container to claim a deposit.
2. **Return Rate:** Will consumers return UBCs at similar or better rates than those seen in a classic DRS?	**A classic DRS with return points at retail location should deliver return rates of at least 90%.** A serialised DRS may prove more convenient and accessible for some consumers, and less convenient and accessible for others. The range of return pathways offered to consumers will be a key factor in determining the net effect of this on return rates. A serialised DRS also introduces an additional risk, which is that in some cases deposits may be reclaimed, but UBCs may not be correctly returned, or may escape the system after the deposit is reclaimed. Unlike with a classic DRS, the claim rate cannot be assumed to reflect the return rate, and additional verification of performance will be needed.
3. **High quality and consistency of material:** Will the material mix collected be suitable for sorting into different material streams with minimal material losses, and can these then be reprocessed into high quality food grade recycled material?	**A classic DRS achieves very high material quality and consistency, and minimal process losses by tightly controlling the items that can be returned into the system. Almost all material should be suitable for recycling into food grade recyclate.** Quality in a serialised DRS will vary by return pathway. Pathways with high direct control would be expected to match a classic DRS. Pathways with low direct control are likely to match their performance prior to the introduction of a deposit, as the deposit may encourage participation but will do nothing to reduce contamination from untargeted materials, or the impact of other targeted materials on beverage containers.

	Material collected from bins in on-the-go locations is likely to be of poor quality and consistency.
4. Compatibility with Reuse: Will return locations and infrastructure fit with longer term requirements to expand the provision of reusable containers, and normalise consumer behaviour for that future?	**The draft PPPWR requires that single use return and reusable return should be 'equally available'. Consumer behaviour now and in future will also be greatly facilitated by matching return requirements across formats, especially as reuse grows in importance.** Where countries already have DRS for reusable beverage containers, aligning the consumer experience, in the most positive way, between reuse and single use for beverage containers will improve the consistency of the requirement on consumers. Where countries do not yet have reuse return systems, ensuring future alignment is possible will both facilitate consumer return behaviours longer term and may also provide future-proofed efficiency or investment benefits for both single use and reuse systems.

Theme 2: Access Criteria

Assessment Criteria	Benchmark and Commentary
5. Accessibility of system for consumers: Can all consumers easily reclaim their deposits and return their UBCs?	**Classic DRS with a return-to-retail return model has demonstrated easy access to a full range of demographic groups. This is essential for both system performance, and social inclusivity, as an inability to participate also implies financial consequences in foregone deposits.** Some features of alternative return pathways may aid participation, while others may discourage it. Where alternatives are suggested in addition to proven return pathways, this should not create additional access issues. Where alternatives are proposed as substitutes, the burden of proof on their inclusivity will be higher.

6. Consumer Confidence and Safeguards: Are measures to protect consumers personal and financial data sufficient to enable mass participation?	**Where a DRS holds personal or financial data this must not just be handled safely and securely, in line with all legal and ethical requirements, but also commend consumer confidence.** A classic DRS does not *need* to hold personal or financial data as cash refunds are available (though digital refunds may also be possible). Digitally dependent return pathways will need to hold personal data and be linked to financial payment systems. In some cases geolocation data may also be required. Thought should also be given to intra-household privacy in cases where system accounts or bank accounts are shared. Both the reality and perception of the safeguards in place will be key to consumer participation. Where digitally dependent return pathways are the only available options, a lack of trust will effectively exclude people from the system. Cyber security and counter-fraud protections will also be critical to both the system and consumers using it.
7. Market Access for Producers: Can all producers and importers access the market fairly and without excessive costs?	**Classic DRS has been proven to deliver excellent environmental outcomes without excessive costs for producers and importers of all sizes, and irrespective of packaging format. As systems become increasingly standardised across Europe, barriers due to unfamiliarity with DRS should also decrease.** Serialised DRS will need to demonstrate that the labelling and IT requirements are open to all in a non-discriminatory way, paying particular attention to implications for different packaging formats, SMEs, and importers. In addition to consideration of fairness, any system that effectively excludes products from the market or disproportionately impacts product prices will also impact consumer choice.

Theme 3: Technical Readiness

Assessment Criteria	Benchmark and Commentary
8. **Labelling With Serialised Markers:** Can all container formats, and all producers appropriately label their containers affordably and equitably?	**Classic DRS labelling requirements primarily use existing 1D barcode technology which is near-universal. Additional consumer labelling and anti-fraud requirements can be printed on to all existing packaging formats, and delivered without excessive costs for producers.** Serialised markers will require changes to packaging printing processes, as individualised markers are needed for each container. It is essential that the cost of this transition and the technology required is affordable for all producers, across all packaging formats.
9. **Integrated IT Systems:** Can all producers, retailers, and consumers access and operate appropriate hardware and software in real time?	**All DRSs are digital. However, the data system for classic DRS are all 'backend' systems and do not require consumer participation. In addition, the deposit transaction is tracked in a similar way to the sales transaction, using existing 1D barcodes and the enabling technology for this.** The database behind a serialised DRS will contain very large amounts of data as hundreds of millions of containers will need to be registered. All stages of the supply chain will need to access this data in near real time, and the variety of retail locations (including small shops, kiosks, hospitality and catering, and informal sales) will need to be catered for. Consumer data will also be associated with some of these systems. Accuracy and reliability will need to be extremely high throughout, and the system must be secure from attack.
10. **Easy and Controlled Deposit Activation:** Is the deposit activated in a way and at a time that reduces eliminates risk, fits with retailer operations and technology,	**In a classic DRS the deposit is associated with the container throughout the supply chain. There is no scope for 'virtual' deposit theft however as physical return of empty UBCs is the only way to claim a refund.** In a serialised DRS there is a significant trade off in determining where a deposit should be activated. If this is done at point of

and does not inconvenience consumers?	sale, the technology required and the impact on retailer sales transactions is significant. If it done earlier in the supply chain, anti-fraud measures such as geofencing will necessitate significant extra controls and complexity. This is a hard design choice for a serialised system, and it needs to be stress tested to ensure it is both technically and operationally feasible for all, while still providing a smooth consumer experience for both sale and return.
11. **Easy and Controlled Reclaim and Deactivation Stage:** Can deposits be reclaimed quickly and easily by consumers, and in a way that maximises the likelihood that deposits are reclaimed only for UBCs returned correctly?	**In a classic DRS refunds are authorised when UBCs are correctly returned. Refunds can be made digitally or in cash. Any eligible container that has not been physically returned to the system is worth its deposit value.** There is a trade-off in a serialised DRS that enables self-claim of containers. The easier the claim process, the harder it is to encourage correct return. Controls like geofencing increase the risk of a poor consumer experience, but increase the prospect the container is returned in a location that at least has a valid return pathway. No self-claim system can eliminate the chance of incorrect return, but it must be able to demonstrate that the gap between reclaim and correct return is not undermining system performance.
12. **Ability to Audit and Verify Performance:** Are opportunities for fraud minimised and can claimed return by consumers be checked against actual returns to the system?	**Classic DRS records both containers placed on the market and UBCs returned in high detail.** A serialised DRS might be expected to have even more detailed container data, but at the critical point of return, the system is directly measuring reclaimed deposits, not correctly returned containers. Even correctly returned containers could 'escape' the system after consumer return and before the system takes custody of them. An ability to audit and verify actual performance is therefore essential.
13. **Timescale:** Can all of the above be resolved within the delivery timescales set	**Timelines for classic DRS launch can be extrapolated from past experience. System elements like 1D barcodes use existing supply chain systems. Technological and operational answers are known.**

by policymakers in a given country?	**It is easy for governments and regulators to set realistic but challenging timelines.** The significant uncertainties around serialised DRS technologies require further work before a timeline for launch can be confidently committed to. Both technology and operational practice need clearer resolution and solutions will need to be socialised to the entire supply chain, posing a significant commitment of effort.

6.3 How does Belgium's proposal currently compare to these criteria?

Pilots are currently underway in Belgium on various aspects of how a serialised DRS might work and whether it would be ready for launch in 2025. These pilots and associated industry discussions may result in changes to the existing published proposal for a serialised DRS. They may also demonstrate much clearer answers against some of the criteria. However, a short summary is presented based on current knowledge against each of the three criteria areas.

- **Performance:** The potential anti-litter benefits of a serialised DRS in Belgium are currently unknown, but the behavioural incentives are weaker than in a classic DRS. The likely return rate for a serialised DRS in Belgium is also currently unknown. Unlike discussions elsewhere, the choice of return pathways does not include return points at retail locations, which means all performance will have to come from return routes that have not been behaviourally or technologically demonstrated at scale previously.

  Fost Plus have full knowledge of collection and sorting quality in the existing blue bag system for packaging waste and report that beverage containers can be - and are - recycled into closed loop applications after sorting. The quality of material collected in on-the-go locations with a future serialised DRS is unknown, but on-the-go contexts are usually extremely difficult contexts for ensuring quality. It is likely however that losses during these processes are higher – and in the case of on-the-go bins a lot higher – than would be the case with material collected via a classic DRS.

  It is unclear that the proposed serialised DRS can verify performance as reliably as a classic DRS. The published proposals would rely entirely on an assumed perfect fit between claimed deposits and genuinely returned UBCs, and do not mention any post-collection verification.

  Serialisation as a marking technology is completely compatible with a DRS for single use or reusable containers. However, the proposed return pathways in Belgium (via existing kerbside collections and bins in on-the-go locations) differ from the existing DRS for reusable beverage containers in Belgium, which are returned to retail locations, and this would create a behavioural mismatch for consumers. The return pathways being proposed currently are only suitable for single use.

- **Access:** Belgium's current proposal focuses exclusively on return pathways that are digitally dependent from a consumer perspective. Suggested alternatives to dependence on the smart phone app (i.e. the provision of handheld scanners) are also digital, and only available for kerbside return not on-the-go locations. It is also worth highlighting that these scanners, will, by

definition, be required by those that struggle most with digital access, and thus the rollout and support requirement may be significant. Considering the risks of digital exclusion, for both those unable or unwilling to participate via a digital reclaim route, is essential for both fairness and performance.

Challenges around market access are likely to depend heavily on elements of the technical requirement for system participation, but in having a unique and exclusively serialised system, the Belgian approach may create challenges for importers.

- **Technical Readiness:** Experts interviewed for this project, and previously, differ in their assessment of how ready different aspects of serialised DRS, and the alternative return pathways it enables, are. Costs are also highly uncertain. Overall, while many aspects of the technology can be demonstrated in isolation or in theory, they have not been delivered end-to-end in a complex operational environment. Belgium has committed to an extensive programme of piloting and industry engagement, and interest in the outputs will be high. Detailed and transparent sharing of the findings would be a significant contribution to the debate on the feasibility on serialised DRS and potential new return pathways.

  Currently, the most significant challenges to *serialisation* itself relate to: problems printing serialised labels for certain packaging formats; the stakeholder challenges of building robust IT infrastructure (both hardware and software) with truly universal reach and access through the supply chain; and challenges around how and when to 'activate' deposits in the supply chain.

  In relation to the *return pathways*, the extent to which steps are taken to increase the likelihood containers are only scanned and deposits are only reclaimed at the same time as someone correctly returns a UBC is challenging. The final proposed trade-off between consumer experience and level of controls is not known.

  These are significant challenges, which would need to be both technically resolved and scaled for a mass market launch on a very tight timeline to achieve a system launch in 2025. Even taking the optimistic timelines outlined for technical development in the Belgian proposal prepared in September 2022, this is likely to be challenging. Purely technical challenges will also have to be addressed alongside significant challenges for supply chain engagement and roll out, which would be likely to extend any purely technical roll out requirement.

Serialised DRS would offer some benefits for consumers in many contexts, but the operational and technical barriers to be overcome are significant and the timeline needed to do so is uncertain. This is especially so with the very short timescales for delivery in Belgium, where it is unclear cost-effective solutions, which will work for the full range of supply chain actors, can be developed in the time available. In addition, key behavioural questions about how and how well consumers will interact with certain return pathways with lower direct control within a serialised DRS still need answering. Finally, the nature of the current Belgian proposal, with an exclusive reliance on novel return pathways enabled by serialisation accentuates these risks, as all the pressure is on the new pathways to deliver both inclusion and performance. Overall, the delivery and performance risks create significant uncertainty in terms of both feasibility and performance in the Belgian context on current evidence.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