Digital DRS Feasibility Study

Phase 1: Stakeholder perceptions of DDRS design and feasibility

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resourcefutures

Document prepared for

Contact name	Howard Davies
Client	Welsh Government
Telephone	03000 258981
Email	Howard.Davies022@gov.wales

Document prepared by:

Consultant name	Carla Worth, George Cole, Sam Reeve, Stuart Woodham, Sarah Hargreaves, Kate Chambers

Document checked by:

Name	George Cole, Sam Reeve

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Executive Summary

Resource Futures has been commissioned by the Welsh government to research and evaluate if and how a Digital Deposit Return Schemes (DDRS) might be implemented in Wales as well as in England and Northern Ireland, and whether the purported benefits can be realised. The study was split into two phases. This report is from Phase 1, the aim which was to **explore key stakeholder perceptions around the design and feasibility of implementing a DDRS in Wales, as well as in England and Northern Ireland**.

Deposit Return Schemes (DRS) incentivise consumers to return deposit-bearing items (typically drinks containers) to a recycling point, typically reverse vending machines located at retailers, but also manual returns at convenience stores, in order to redeem a financial deposit. However, advancements in digital technology create the potential for innovation in how a DRS is implemented. A popular digital DRS design is based around the ability to scan a serialised barcode on the container to redeem the deposit using a smart phone app (see Glossary in Appendix A for definition of technical terms, e.g. serialisation, barcode, etc). The consumer would then place the container in their existing home recycling bin. A key advantage of such a system is that it would give the consumer more flexibility in the method of redeeming their deposit, i.e. at home via a digitally (app)-enabled return, or at a physical return point (i.e. an RVM).

While DDRS has received considerable attention in the past year, particularly off the back of the Governments' latest consultation for a DRS in England, Wales and Northern Ireland[1], key knowledge gaps remain, and an end-to-end system has not been defined. In this report, key questions were identified around the design and feasibility of a DDRS, and these were posed to experts and organisations that could be involved in designing and operating a DDRS or who would be impacted by its operation. The information received from these key 'knowledge holders' has been consolidated, summarised, and presented in this report. In total, 34 hour-long interviews were conducted between November-December 2021 with producers/brands, retailers, technology providers, trade/industry bodies, waste management companies, local authorities, and non-profit organisations. The interview questions were grouped by topic into workstreams, and the information shared by interviewees is summarised for each workstream below.

Overarching questions

Stakeholders interviewed varied in their support for a DDRS, however all were engaged and curious around the practicalities of such a system. Nonetheless, an end-to-end DDRS system design has not been agreed or finalised. Discussions of feasibility therefore varied and remained open-ended, largely because the basic requirements of a DDRS have not been set, and thus several solutions exist. Recurring themes from most interviews regarding the overarching system/design centred around:

- **Timing of implementation**, and whether a phased introduction could be feasible, to account for the current challenge of printing unique codes on aluminium cans. Stakeholders were generally not in favour of phasing in a DDRS due to operational issues, however some contemplated the introduction of a DDRS for glass containers first, to demonstrate feasibility, particularly given the benefits of keeping glass at the kerbside and the recent challenges around whether to include glass in a DRS.

[1] https://consult.defra.gov.uk/environment/consultation-on-introducing-a-drs/

- **Uniform solution across all nations,** stakeholders across the value chain were clear in their desire to have a uniform system that could be rolled out across all nations and was clearly aligned with other legislation i.e. collections consistency and EPR. There were strong reservations around a DDRS unique to one market, as investing in serialisation and customising only a proportion of SKUs was deemed economically unfeasible
- Ensuring **DDRS does not delay the introduction of a DRS**, and if DDRS were to happen, it should work alongside the current proposal for DRS. Stakeholders felt that consumers should still be able to return containers at physical return points, with DDRS facilitating the option to return containers at home through existing kerbside recycling.
- Ensuring that **material value and quality is maintained**. This was particularly important for producers. Many thus highlighted the need to move toward multi-stream collection systems.

Labelling and data management

Questions around labelling and data management are central to the design and development of a DDRS. There was consensus amongst stakeholders interviewed around some aspects of the labelling process, e.g. a preference for 2D data matrix barcodes, and understanding of the technical feasibility of applying serialised codes to plastic and glass containers at pre-production stage (i.e. when designing the labels that are later attached to the plastic and glass containers). Another key finding was a viable solution for labelling multipack products; this entails linking an informational (i.e. not deposit-bearing) code on the outer (secondary) packaging of the multipack with the individual deposit-bearing serialised codes of the products within the multipack.

However, key uncertainties remain, such as the feasibility of printing unique codes onto cans, given incompatibilities between digital printing speeds and can production line speeds. While options exist for printing onto cans, they are still under investigation.

Another point of uncertainty is the point at which codes should be 'activated', i.e. linking/activating the serialised code with a financial DRS deposit that is redeemable by a consumer. The two options presented by stakeholders are either to activate the codes at the point of production, or at the point of sale (i.e. the till). Both options have benefits and drawbacks. This is a key decision that needs clarity in order to support other aspects of the end-to-end process, such as placement/location of the codes on the container, and whether additional measures are needed to activate multipacks.

There was also general agreement amongst technology providers interviewed that Bitcoin is not a good comparator regarding CO2 emissions of a DDRS system. Bitcoin relies on an energy-intensive verification protocol ('Proof of Work') that would not be required of a Blockchain-based solution for DDRS. Others suggest that a Cloud-based (i.e. database) solution is also an option, which is significantly less carbon intensive that Blockchain.

Integration into kerbside collections

Waste collection organisations were generally supportive of a DDRS, however qualified that an integrated system that utilises both RVMs, to allow redemption of items consumed outside of the home, and a digitally-enabled home-return system was seen as preferable, and indeed viable.

The general view of waste collection companies was that a DDRS could technically work with all collection profiles, and that waste collection companies could "produce" DDRS material at the required / desired

quality level of the DRS, given investments in either MRF sorting lines and/or local authority collection profiles moving toward multi-stream collections.

Many stakeholders interviewed shared that kerbside quality improvements (and investment) are expected anyway under Extended Producer Responsibility (EPR) obligations and consistent collections policies.

Nonetheless, the benchmark expected by some stakeholders of a DDRS was for it to match or exceed the performance of a traditional RVM-based DRS to collect, sort and deliver high capture rates and high quality of material to reprocessors. The discussions mainly centred around the ability of the DDRS system to match the quality and amounts of material compared to a RVM DRS as well as producing and evidence the flow of material from the point of redeeming the deposit through collection, sorting, and transport to the reprocessor. Whether this evidence is needed in a DDRS, and how to verify this flow of material, particularly that it has reached a reprocessor, is a key remaining question.

Infrastructure required beyond kerbside: on the go and retail take back

Many respondents were interested in the idea of a DDRS in public locations (i.e. on-the-go), however this remained secondary to its application at the kerbside.

Nonetheless, some saw DDRS as an enhanced opportunity to provide a solution for tackling litter, over and above an RVM solution. Given the flexibility of the system to redeem deposits closer to the point of consumption, and not the point of sale, existing litter bins could effectively act as 'return points' (i.e. mirroring the system at the household/kerbside, with litter bins equipped with a 2D code).

More sophisticated 'smart' bins could add additional benefits to increase recyclate quality by segregating the waste. This flexibility in return points was seen by some to be more convenient for consumers than a traditional DRS, whereby consumers would have to hold on to their empty container and return it at a retailer or convenience store. However, there remains limited evidence on whether an on-the-go DDRS system would reduce littering, and stakeholders were hesitant about whether introducing an on-the-go solution would provide value for money, particularly if investment is required for more sophisticated 'smart' bins. There was consensus that more research is required to explore feasibility of DDRS on-the-go.

DDRS was also seen as a potential opportunity for retailers that provide home deliveries, particularly those that solely operate online as well as smaller convenience stores. Under a DRS, retailers that provide home deliveries will be required to provide a take-back service, i.e. organising the collection of empty in-scope containers from households. This was seen to be overly burdensome and would introduce logistical challenges, with the general sentiment that online retailers would essentially be replicating a waste collection system that is already well functioning.

Behavioural acceptability, social accessibility, and real-life stress testing of the approach

Generally, DDRS was believed to be both accessible and acceptable by the public, based on current trials. However, it was acknowledged that this should be verified via a large-scale trial, with different demographic groups and recycling behaviours.

The digital nature of a DDRS app opens interesting opportunities to build in tailored resident messaging and could increase householders' knowledge of the products they are consuming. Careful consideration should be given to selection of incentive options to maximise behavioural levers. Non-smartphone users need to be accommodated but due to high smartphone penetration this is a small minority and could be managed through use of a hybrid system.

Further discussion/summary

An interesting finding that came from the interviews was the general trend in printing of 2D barcodes on packaging by large producers, mainly for tailored consumer engagement purposes. While serialising these codes is less common, some producers interviewed shared that they are conducting research to serialise their products for their own purposes (e.g. proving authenticity of products), although these tend to be higher value products, such as tobacco and medicines. Nonetheless, these producers were keen to align their producer obligations (i.e. DRS) with existing strategies around 2D barcode printing and serialisation. GS1, a non-profit organisation developing international standards (including barcodes), have recognised this trend and have plans to align with industry to support their transition to the 'more capable' 2D barcodes[2]. Furthermore, trade bodies also pointed to the 'big win' that serialisation could provide in terms of data and waste tracking, which will be necessary to robustly gather the data to evidence the movement of waste and improvements in recycling. In the EU, the Sustainable Products Initiative is investigating the development of digital product 'passports', which will likely contain unique product identifiers[3]. Whilst DDRS design should align with this trend, without legislative deadlines it is unlikely that all DRS containers will be serialised before DRS implementation dates in Wales and other UK nations.

Conversations with stakeholders revealed that the headline concept of a DDRS is valid, and with the right drivers and adequate timelines, an end-to-end solution could be designed. However, the timescales for innovation, cost and impact of the end-to-end solution, particularly compared to the RVM alternative, is unknown. In contrast, many point to the fact that the impact and cost of an RVM-based DRS solution is better understood. However, the world is changing, particularly that of digital technology, and this research has identified future innovations around product tracking digitisation that appear to be heading in the direction of serialisation-enabled solutions. The potential benefits that brings to material resource management are clear and looking to implement a future-proofed DRS solution that is flexible is the optimum solution. The implementation timescales of such a solution are critical, as a digital-kerbside element that is introduced after a DRS roll-out appears to be very challenging in regard to CAPEX and OPEX solutions that would need to be put in place to facilitate a traditional RVM based system.

For the system to work as a whole, a DDRS will require the co-ordination of many organisations across the value chains of manufacturing, retail and waste management. A national DDRS design must therefore set out the basic requirements of an end-to-end solution so that each organisation knows what is expected of them. Throughout the course of this research, interviews revealed that several options and solutions exist for a DDRS, and while an end-to-end system is needed to compare those solutions, stakeholders also emphasised the need for clarity and alignment so as not to delay coordinated action.

As is natural with the design of any new system, more questions are raised as design decisions are explored in more depth. This was evidenced during the course of this research as the interviewees raised a number of new feasibility questions that will need to be considered. These are summarised below:

1. **Timeline for implementation** – could a DDRS be implemented at the same time as a DRS, and if not, is it feasible to start with glass containers?

[2] https://www.prnewswire.com/news-releases/gs1-us-celebrates-50-years-of-digital-commerce-and-facilitates-collaboration-toward-next-generation-barcodes-to-engage-consumers-301259239.html
[3] https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/digital-2021-trust-01-digipass

2. **Activation point** – if a single and common point of activation is needed for all drinks containers, where should this be?
3. **Serialisation** - could serialisation be encouraged and brought forward to support a DDRS, and the scope increased to all DRS containers? If serialisation is not possible within the desired timescales for implementing a DRS, can a system be designed without serialisation?
4. **Verifying recycling quantities** – how will a DDRS replicate the function of DRS counting houses to verify the quantity of DRS material 1) collected, and 2) recycled?
5. **Material quality** – what quality is required, what changes are needed to meet that quality, and how much would it cost?
6. **Value for money** – how do DDRS designs compare to RVM-based DRS, when all costs and benefits are fully considered, and which gives the best value for money?

In order to drive these questions forward, an end-to-end DDRS system integrating all consideration points needs to be designed. There could potentially be several different designs, depending on different consideration points (e.g. activation point). These need to be developed and compared in order to understand the relative strengths of a DDRS solution as a whole, as well as any current gaps or uncertainty in the system, and the likely timescales for implementing a national scheme.

Next steps for Phase 2 of this Study

To address the above remaining questions and drive forwards the development and consideration of an end-to-end DDRS, we list below some recommendations for further research to be conducted by Resource Futures in Phase 2 of this study. While Phase 1 of this research aimed to take a deep dive into the different considerations surrounding specific practicalities of a DDRS, in Phase 2 we propose to take a more holistic view focussing on the overarching research objective to "research and evaluate if and how a DDRS might be implemented in Wales as well as in England and Northern Ireland, and whether the purported benefits can be realised**"**. To answer these questions we recommend the following research activities:

1. **How** might a DDRS be implemented in Wales as well as in England and Northern Ireland?
    - Here we suggest identifying the basic requirements of a DDRS that are essential to the success of the scheme and develop a roadmap or sequence of questions mapping a generic pathway towards DDRS implementation, with key design decisions and issues that must be addressed to develop an end-to-end solution. As part of this, an investigation into the different approaches being developed in order to enable clear comparison.
2. **When** could a DDRS be implemented in Wales as well as in England and Northern Ireland?
    - We recommend evaluating the 'technology readiness level' of each element of the end-to-end DDRS designs developed in the previous step so that the critical factors in timescales stand out. This will allow an assessment of what drivers might speed up implementation, and what actions might be supported by the Welsh Government and the DDRS IWG.
3. **Can** the purported benefits be realised?
    - For each DDRS design developed, explore the remaining questions around feasibility and benefits. This could be done by conducting a SWOT analysis of each DDRS design and comparing the results. Research, for DDRS as a whole, around value for money compared

to the RVM-model (e.g. value of consumers time, value of differing material quality, the cost of bringing kerbside up to RVM-output quality).

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Glossary

Term	Definition
1D barcode	Method of representing data in a visual, machine readable form using variable widths and spacing of parallel lines. There are different types of 1D barcodes for different use cases, the most recognisable is the EAN/UPC which is the one commonly used at point-of-sale retail checkout scanners. These barcodes can only hold limited data – usually just the **Global Trade Item Number (GTIN)**. Point-of-sale scanners read the GTIN and look up the price in retailer back-end systems. There are other types of 1D barcodes used for other use cases that can be used to hold additional information to the GTIN, such as expiry date, serial number, etc. However, these barcodes will be much bigger (as they hold more information) and thus are often not suitable for small packaging items as they won't usually fit on individual products.
2D barcode	Use rectangles, dots, and other shapes to encode data in the barcode. Compared to 1D barcodes, 2D barcodes can hold much more data as the data is held in a 2-dimensional space. This also allows the barcode to be a manageable size while still containing lots of information. The most common 2D barcodes are **QR codes** and **Data Matrix barcodes**.
QR Code	Or 'quick response' code, is a type of 2D barcode. They are square in shape and can contain up to 4,296 alphanumeric characters. Its 'finder' pattern consists of three square structures in its corners, which makes it easy to recognize. QR codes are recognised by most cameras on electronic devices (e.g. smartphone, tablet, etc). Users can thus usually scan a QR code directly from their phone camera, without using a specialist app. 
Data Matrix barcode	Another type of 2D barcode. They are typically square in shape (although they can also be rectangular) and can contain up to 2,335 alphanumeric characters. The L-shape that follows its borders is its finder pattern, which is used by scanners to recognize and read the code. As Data Matrix barcodes contain less data compared to a QR code, they can be printed in a much smaller size. Many smart phones do not have the functionality built in to scan Data Matrix codes, and thus require a third-party app to read the information 
Serialisation	A way of encoding additional data (serial numbers) in a barcode, so that the barcode for that item is completely unique. For example, if using GS1 standards, a

	serialised barcode could contain the GTIN plus a serial (unique) number. This can be done with a 1D barcode, but frequently done with 2D barcodes as they can store much more data in a smaller space. Note, you can serialise both 1D and 2D barcodes, but in the context of DDRS and barcodes on drinks containers, in this report we discuss serialisation with 2D barcodes specifically. However, 2D barcodes do not have to be serialised (and indeed many aren't). For example, if a consumer scans a QR code on their drinks container, they will likely be directed to a website displaying information about the product.

1 Background

Deposit Return Schemes (DRS) incentivise consumers to return deposit-bearing items (typically drinks containers) to a recycling point in order to redeem a financial deposit. This has been proven to reduce littering and boost recycling of the targeted in-scope material[4]. A common form of DRS found in Europe and the USA requires consumers to return containers via reverse vending machines (RVMs) or in person at over the counter take back points (such as convenience stores).

Advancements in digital technology create the potential for innovation in how a DRS is implemented. There are several different organisations developing digital DRS (DDRS) technology, and different system designs exist. Some trials have been conducted in the UK, but the concept is new and no DDRS systems are operating yet at national scale. A popular DDRS design is based around the ability to scan a code on the container to redeem the deposit. This could be done by the consumer using their smart phone, who will then place the container in a suitable recycling bin (e.g. in their Council kerbside recycling service). To prevent the user scanning the same drinks container multiple times to fraudulently claim extra deposits, the containers would be marked with uniquely serialised barcodes so that each deposit can only be redeemed once.

A DDRS could combine the traditional RVM and take-back model with more modern digital innovation, as described above. The digitally-enabled, at-home/kerbside return operates differently from the traditional return-to-retail methods, although it is thought that the financial deposit on the item provides the same incentive in both systems for the consumer to return the deposit-bearing item[5].

The benefits of a DDRS are currently being explored in pilots and research studies. Benefits include:

- Integration into existing kerbside recycling systems
- Reduced levels of fraud as once the serialised code is scanned the deposit value is removed
- Increased tracking and tracing of material throughout the value chain – linking production, distribution, retail, consumption and end-of-life
- Potential cost savings on the DRS infrastructure
- Ability for the serialised code to provide other functionality, such as customisable consumer engagement and product information
- Flexibility of the point of deposit return to be closer to the point of consumption (i.e. not necessarily tied to the point of purchase), opening possibilities to provide more convenient return points to target littering. E.g. for on-the-go consumption with the use of 'smart' bins that can scan the container and return a digital deposit
- Lower embedded carbon emissions over a traditional design due to operational efficiencies[6] (e.g. reduced consumer car journeys to return containers, material and energy savings from having fewer RVMs, etc.)

[4] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/694916/voluntary-economic-incentives-working-group-report-drinks-containers-final.pdf

[5] In a recent trial in Conwy, 97% (n=263) of registered households participated by scanning at least one bottle during the pilot. 73% (n=193) of participating households scanned all their bottles. See full trial results here: https://wrapcymru.org.uk/sites/default/files/2021-12/DDRS%20Pilot%20WRAP%20EN.pdf

[6] http://iwma.ie/wp-content/uploads/2021/05/210505-501.181.9_SLR-SmartDRS_CarbonStudy_BriefingNote-for-IWMA_Final.pdf

However, a DDRS also presents new challenges and risks, which will have to be designed out or managed. As no end-to-end DDRS is currently operating, let alone at national-scale, it is important to understand how such a system might work, and when it might be ready for largescale application.

Costs and benefits of a DDRS were explored, at a high-level, in the DDRS Industry Working Group's Impact Assessment, conducted by Resource Futures.[7] A number of knowledge gaps were identified in the Impact Assessment study, largely around how a DDRS system would work as a whole, as it consists of several interfacing components and its operation requires the involvement of different stakeholder organisations.

2 Aims and approach

Resource Futures has been commissioned by the Welsh government to research and evaluate if and how a Digital Deposit Return Schemes (DDRS) might be implemented in Wales as well as in England and Northern Ireland, and whether the purported benefits can be realised.

This report is from phase 1 of the Resource Futures study for the Welsh Government, which aims to collect expert views on specific questions on the feasibility of implementing a DDRS in the UK.

In October 2021, GS1 UK, a non-profit organization developing and maintaining international standards (including barcodes), facilitated a series of workshops with a wide group of stakeholders to discuss the overall process map of a DDRS[8]. Following the workshops, Resource Futures identified several key knowledge gaps around the feasibility of a DDRS. These knowledge gaps were presented to the DDRS Steering Group[9], who then agreed on a prioritised list of areas to focus on in this study.

These focus areas were posed as questions to experts and organisations that could be involved in designing and operating a DDRS or who would be impacted by its operation. In total, 34 hour-long interviews were conducted between November-December 2021, including producers/brands, retailers, technology providers, trade/industry bodies, waste management companies, local authorities, and non-profit organisations. The purpose was to explore the key questions surrounding the implementation of a DDRS, gather information from experts, discuss the nuances and factors that must be considered, as well as identify and discuss the merits of possible solutions. The report thus is a deep dive into specific and complex feasibility questions; for a more overarching introduction to DDRS, please refer to further reading suggestions[10].

Information from key 'knowledge holders' has been consolidated, summarised, and presented in this report. A full list of contributors to the research is included in the Acknowledgements section at the beginning of this report; their contributions and time are greatly appreciated.

The report has been structured around five workstreams, representing the major areas of research for a DDRS, identified by the Welsh Government and the DDRS Industry Working Group:

1. Overarching questions
2. Labelling and data management

[7] https://www.brysonrecycling.org/downloads/DDRS_Impact_Assessment.pdf
[8] A summary of key considerations from the workshops can be provided upon request.
[9] DDRS Steering Group is comprised of The Welsh Government, the Digital DRS Industry Working Group and WRAP Cymru.
[10] https://www.recycling-magazine.com/2021/03/25/digital-drs-has-the-uk-got-the-bottle/ ; https://www.thegrocer.co.uk/sustainability-and-environment/the-future-of-deposit-return-schemes-could-be-digital-heres-why/655632.article

3. Integration into kerbside collections
4. Infrastructure required beyond the kerbside, retail takeback, and on-the-go
5. Behavioural acceptability, social accessibility, and real-life stress testing

Each workstream section delves into specific questions that are critical to the feasibility of a DDRS.

The stakeholder views presented in this report should not be interpreted as representative of Resource Futures, the Welsh Government or the DDRS Industry Working Group. Nor should they be interpreted as the current state of policy development, policy options considered by UK governments, or wording of legislation. Governments of UK nations are currently considering DRS and other policy interventions, typically at different stages of policy development and implementation, and are not necessarily considering the same system design and scope. Stakeholder views presented in this report reflect the stakeholder's opinion and their understanding of the policies discussed, but this may differ from discussions within government and public consultation.

3 Overarching questions

Stakeholders interviewed varied in their support for a DDRS, however all were engaged and curious around the practicalities of such a system. Nonetheless, discussions highlighted the fact that, while a 'working' system design has been drafted following industry workshops (prior to the commencement of this project), an end-to-end DDRS system design has not been finalised. Discussions of feasibility therefore varied and remained open-ended, largely because the basic requirements of a DDRS have not been set, and thus several solutions exist. Recurring themes from most interviews regarding the overarching system/design centred around:

- **Timing of implementation**, and whether a phased introduction could be feasible, to account for the current challenge of printing unique codes on aluminium cans. Stakeholders were generally not in favour of phasing in a DDRS due to operational issues, however some contemplated the introduction of a DDRS for glass containers first, to demonstrate feasibility, particularly given the benefits of keeping glass at the kerbside and the recent challenges around whether to include glass in a DRS.
- **Uniform solution across all nations,** stakeholders across the value chain were clear in their desire to have a uniform system that could be rolled out across all nations and was clearly aligned with other legislation i.e. collections consistency and EPR. There were strong reservations around a DDRS unique to one market, as investing in serialisation and customising only a proportion of SKUs was deemed economically unfeasible
- Ensuring **DDRS does not delay the introduction of a DRS**, and if DDRS were to happen, it should work alongside the current proposal for DRS. Stakeholders felt that consumers should still be able to return containers at physical return points, with DDRS facilitating the option to return containers at home through existing kerbside recycling.
- Ensuring that **material value and quality is maintained**. This was particularly important for producers. Many thus highlighted the need to move toward multi-stream collection systems.

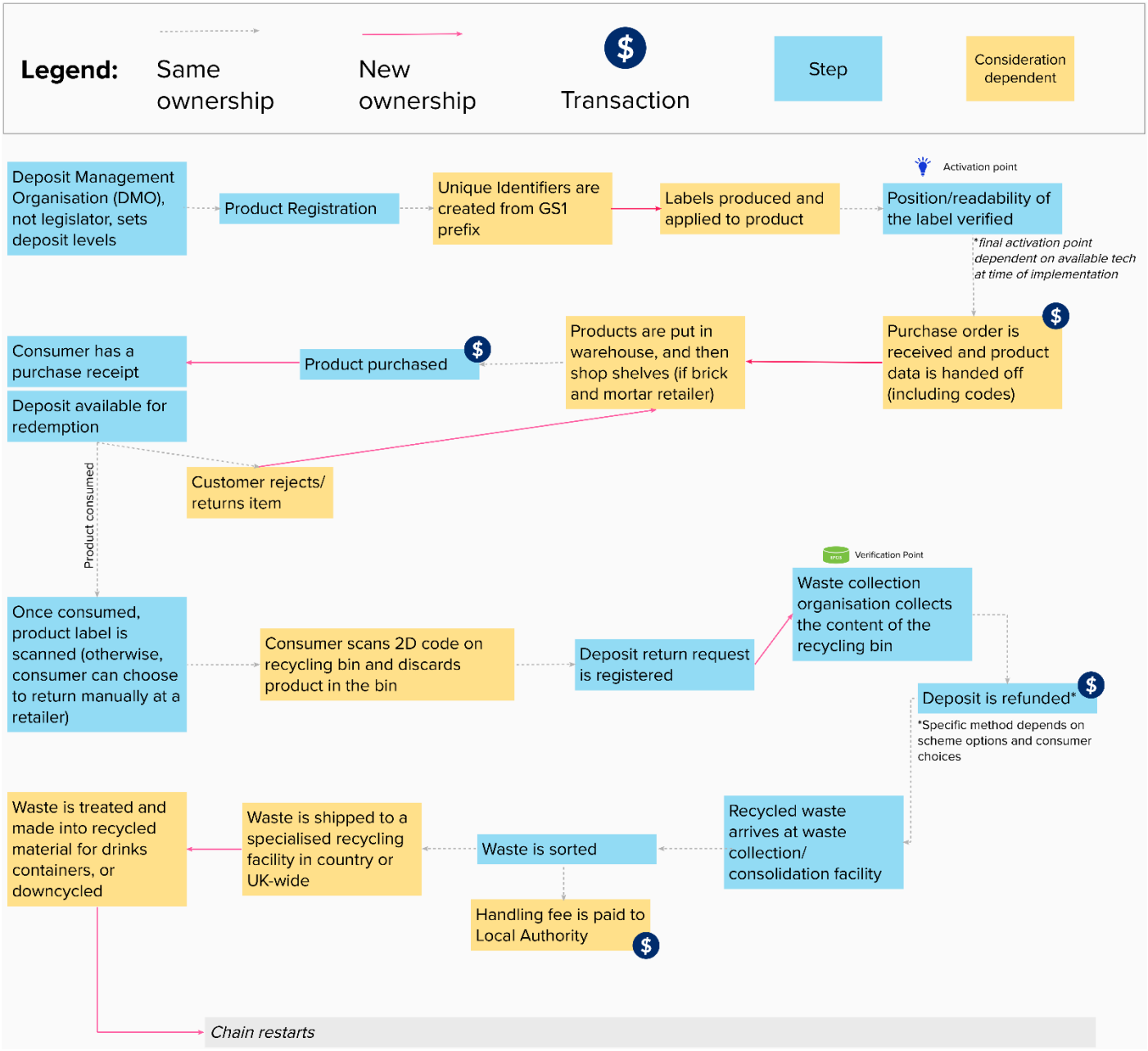
3.1 What is the detailed structure of a DDRS?

In October 2021, GS1 UK, a non-profit organization developing and maintaining international standards (including barcodes), facilitated a series of workshops with a wide group of stakeholders to discuss the overall process map of a DDRS[11]. The resulting process map from these workshops has been included below. It should be noted that the below is not the 'final' process map for a DDRS. The development of process maps is discussed further in section 4610.

In the figure below, while the blue-shaded 'steps' follow the general life cycle of a product from production to waste management, the yellow-shaded 'consideration point' steps represent areas where there are currently multiple and/or divergent options under a DDRS. The process map thus is not fixed, and indeed several of these steps and consideration points (such as the code activation point) were discussed during Resource Futures' interviews and elaborated in more depth in this report.

[11] Several stakeholders believed that calling the scheme a 'digital' DRS was misleading and pitted the system artificially against the traditional DRS design, when in actuality DDRS is an extension of DRS, proposing increased flexibility in waste collection methods through serialising containers. One stakeholder argued that DDRS should be viewed more broadly, not solely as an app-facilitated DRS, but rather a 'Smart' DRS that allows for convenient and cost-effective waste collections, whether this be at the kerbside, or through handheld scanners, electronic 'smart' bins, simplified RVMs, etc. A DDRS could support multiple use cases, not just kerbside return of containers. Furthermore, and strictly speaking, a traditional DRS is already 'digital' – as current barcodes are read by technology in RVMs and contain information to identify the product being scanned.

Figure 1. Latest process map of a DDRS, facilitated by GS1 UK.



When discussing the structure and practicalities of a DDRS, there was widespread agreement among stakeholders that any such solution would have to work alongside traditional operation of a DRS, i.e. allowing kerbside containers to be an additional method of collection, alongside the physical in-store return points of a traditional DRS. This was primarily due to the long-awaited legislation for a DRS in England, Wales and Northern Ireland, and the fact that the process and benefits of a traditional return-to-retail model are generally well understood. In order to have a 'hybrid' system facilitating both the traditional return-to-retail and the digital home returns, stakeholders highlighted important considerations that must be acknowledged.

For example, in-scope containers under the hybrid system would need to have the serialised code in addition to the DRS logo. This is important for consumer understanding and engagement with the scheme;

the DRS logo will signal to consumers that it is a deposit-bearing container, and the serialised code will signal that it is eligible for at-home returns. The inclusion of an additional code may be problematic for brands in the design of their packaging, as space on the consumer-facing packaging is already highly optimised.

However, discussions with a few stakeholders revealed that the requirement to have three codes (i.e. product barcode, DRS logo, and serialised code) may only be necessary at the start of the scheme. There seemed to be a general understanding that as digital technology advances, and as producers prepare for and invest in serialisation, the current barcode may become obsolete and be replaced by a 2D Data Matrix barcode. Indeed, GS1, a non-profit organisation developing international standards (including barcodes), have recognised this trend and have plans to align with industry to support their transition to the 'more capable' 2D barcodes[12] [13], a strong signal of the trend in digitisation of packaging.

In the case of a DDRS, it would be important that there are not 2 different Data Matrix codes on the in-scope containers, and that both the information contained in the previous barcode, and the information contained in the deposit-bearing serialised DDRS code, are integrated. How this integration is managed was not discussed in this research and would require further understanding in order to future-proof a DDRS. However, conversations with an RVM manufacturer confirmed that the RVM software can be upgraded remotely to support reading of data matrix codes instead of barcodes, meaning that RVMs could accept containers with only Data Matrix codes[14].

3.2 Could a phased DDRS system be feasible?

One of the main concerns raised by stakeholders interviewed was that the investigation of the feasibility of a DDRS would delay the introduction of DRS in the UK. With this in mind, ideas around the introduction of a phased system (i.e. DDRS being introduced after DRS) were discussed.

There were divergent opinions regarding the phased introduction of a DDRS. Some stakeholders believed that it would need to be launched at the same time as the traditional DRS, while others saw benefits in phasing the scheme in. Several justifications were given for phasing in a DDRS. These centred around ensuring that a DRS is not delayed, proving the feasibility of a DDRS, and allowing brands and producers time to prepare and decide when they want to invest in serialisation.

Stakeholders proposed several ways that the scheme could be phased in; phasing a DDRS by material had the most traction amongst stakeholders. Several highlighted opportunities for demonstrating the feasibility and benefits of a DDRS by starting the scheme only for glass containers. British Glass confirmed that Welsh local authorities already have high collection rates for glass (~ 90%) through kerbside collections, so a system that would support this existing high collection rate would be desirable. One producer suggested that reducing the flow of glass through RVMs would alleviate the wear and tear of the machines. It would also avoid consumers having to transport glass back to retailers, increasing the accessibility of the scheme

[12] However, a large part of these plans involves supporting retail 'point of sale' scanners to be capable of reading and processing both old (1D) and new (2D) barcodes by 2027, which some believe may not be feasible by the target date

[13] https://www.prnewswire.com/news-releases/gs1-us-celebrates-50-years-of-digital-commerce-and-facilitates-collaboration-toward-next-generation-barcodes-to-engage-consumers-301259239.html

[14] Current limitations exist around RVM reading of serialised codes. Conversations with an RVM manufacturer confirmed that while RVMs can read Data Matrix and QR codes, this is currently only possible if the code is printed on the side/body of the container. Current RVMs cannot read codes that are printed at the top/ends of the container, as is being considered for cans (see Section 3.4). However, the RVM manufacturer qualified that this is not a major challenge, as it would just be a question of developing the hardware to support reading codes in this new position, which can be done given time.

compared to a traditional RVM-DRS for glass containers on the basis that these are heavier materials, and many consumers walk to stores. The weight issue was echoed by another stakeholder, who also highlighted that glass containers usually hold higher value contents such as spirits and wines, as the disparity between product value and deposit value (e.g. 20p deposit on a £30 bottle) could make consumers less inclined to collect, store, and return these for recycling to a retailer. Another stakeholder suggested that it would also reduce the amount of space needed at shops to store the empty glass containers, particularly smaller convenience shops that have limited space. In terms of labelling, stakeholders also confirmed that the technology to add serialised codes is not a challenge for glass containers (see Section 4). Once feasibility of a DDRS is demonstrated for glass containers, other material streams and/or products could be rolled into the scheme as well, e.g. when brands decide to invest in serialisation (see discussion under Section 7.1)

This would, however, require the glass industry and producers of products in glass containers to participate in the scheme, and would only work for local authorities that collect glass at the kerbside, which not all do. However, residents that live in a local authority who do not collect glass at the kerbside would still have the option to physically return the glass containers at RVMs or convenience stores. Furthermore, a potential risk could be that brand owners are not convinced of the feasibility of the scheme and move away from glass toward different packaging materials and formats (i.e. plastic, carton, etc).

Counterargument to phasing a DDRS

The counterargument to these suggestions, i.e. those that believed a DDRS for all material streams and eligible to all locations would need to be launched at the same time as introducing a traditional DRS, centred around the fact that the investment needed to serialise products may outweigh the benefits if limitations are placed on the number of products that can be channelled through the DDRS. This is particularly true for producers that would need to serialise only certain products (or only for certain markets, if it is not rolled out UK-wide). It may not be economically feasible for a producer to invest in serialisation for only a small proportion of products ending up in a Welsh DDRS, for example.

Other consequences of a phased DDRS introduction would be uncertainty in forecasting the quantity of materials returned via the kerbside versus RVMs, making waste management operations both at the kerbside and further down the line at recycling centres difficult to plan, adding considerable risk to investment in vehicles and infrastructure. For this reason, a phased introduction of a DDRS was generally not looked upon favourably by the waste collection organisations interviewed, due to the long lead-in times and investment needed for waste collection equipment. For example, the life expectancy of waste collection vehicles and kerbside recycling containers is generally 5-7 years. These vehicles and containers are optimised for the specific waste collection profile of a particular local authority (e.g. twin stream with glass collected separately, commingled, multi stream, etc.). If a traditional DRS is introduced then the waste collection vehicles, services, downstream infrastructure, and private waste contracts will adapt to the loss of material from kerbside waste collections. This is a significant change for WMCs and local authorities and the waste sector. If a DDRS is then later introduced, potentially diverting some DRS material back to the kerbside, this presents a second significant change with associated investment costs and timelines. The costs and benefits of introducing a DDRS in a later phase of DRS implementation would have to be carefully understood. However, implementing a DDRS incorporating glass containers at the kerbside at the same time as DRS (i.e. only glass containers participating in a DDRS) was not dismissed outright by the glass industry and some WMCs but, comes with challenges around messaging.

Finally, there was also concern that capital investment for RVM infrastructure would be less cost-effective if DDRS is introduced in a phased manner. As some material would be diverted from RVMs to the kerbside in a DDRS, a smaller amount of RVMs may suffice compared to the traditional return-to-retail DRS model. If RVM infrastructure is introduced first, with sufficient RVMs for all DRS containers, then introducing DDRS in a later phase will divert material away from the RVMs, effectively resulting in the oversupply and overinvestment in RVM technology. However, one producer organisation mentioned that retailers would typically lease the RVM, not purchase them outright, so this is perhaps a smaller risk.

3.3 What timeline could each of the key stakeholders realistically work towards to achieve a working DDRS?

Responses to this question varied greatly, from 12 months to 4 years (from the point of the appointment of a DMO). Those that answered toward the lower end of the range believed that the critical challenge would be around labelling, and as a labelling change is required regardless of serialisation or not, and serialised codes can be printed on labels for plastic and glass, this could be done relatively quickly (12-18 months). The higher end of the range is reflective of the current challenges on printing serialised codes on aluminium cans at the required production speed (see Section 4.4). One stakeholder representative of the aluminium industry suggested an additional 12-18 months from the proposed start date of an RVM-based DRS would be needed to develop a working solution for serialising cans.

However, most stakeholders qualified that timescales would depend greatly on the level of verification needed by the system. The general view was that a DDRS would not rely on counting centres to verify the number of containers returned against the number of deposits returned (more on this in Section 5), however the way in which verification/evidence of the items being recycled post collection is an area that needs clarification in order to understand the scale of investment needed.

Another factor that would heavily impact the implementation timeline would be if changes are required of kerbside collection systems. For example, if local authorities must change their recycling containers from bags to bins, or indeed entire collection profiles from commingled to multi-stream, this would require appropriate lead-in times. However, it should also be noted that a traditional RVM DRS will also require significant changes to kerbside waste collection systems. Another stakeholder representing several producers indicated that feedback from their membership is that a date should not be set by government, and instead producers should serialise their products for their own commercial reasons; serialisation of products generally is being considered (and indeed is already being done) by many producers anyway due to the additional benefits it provides (see Section 7.1). Those that do serialise their products with codes provided by the DMO could qualify to have their products in a DDRS. However, there are serious operational and messaging challenges with this “phased” approach that limits the appropriateness of such an approach in the authors views.

3.4 What are the possible synergies between DRS and EPR in the event of a DDRS?

Understandably, there was generally poor understanding amongst the stakeholders interviewed regarding the governance of the various upcoming policy changes for waste and resources and how they will fit together – regardless of if and how a DDRS would fit into it – due to delays in legislation and policy development. It was also the case that there was differing interpretations of the consultations on DRS and EPR and how they will align, be managed and what materials are covered in which policy area.

One non-profit saw particular synergy with regards to litter and litter payments. The EPR for packaging reform consultation documents state that producers will cover costs up to and including the cost of litter[15]. As many of the containers being considered within scope of DRS by UK nations are also found in litter, the non-profit believed that producers that come under a DRS should contribute to surveys (e.g. cleanliness surveys, periodic waste composition analyses, etc.) that would be used to determine the litter payments to local authorities under EPR. However, it should be noted that producer obligations under DRS and EPR have not been defined (i.e. if producers of DRS deposit-bearing items will pay litter costs under EPR legislation). Nonetheless, as the expectation is that a DRS (and DDRS) would reduce litter of deposit-bearing containers, the synergies between DRS and EPR with respect to litter payments must be closely considered.

Another stakeholder, more cautious about introducing a DDRS, believed that the strong potential for synergy between DRS and EPR would make the potential benefits of a DDRS redundant. In their view, EPR and DRS legislation should be linked, and local authorities and material recycling facilities (MRFs) should be adequately compensated under a well-functioning EPR for the loss of high value materials at the kerbside (PET, aluminium, etc.) that would occur under a DRS. While losing this material stream may have a negative economic impact (i.e. the local authority would see less revenue for every tonne of kerbside material processed) this 'gap' would be paid for by producers under an EPR scheme. What this effectively means is that if the unit collection cost / tonne increases as a result of a loss of material to RVM based DRS then the EPR full cost recovery burden would increase for the in-scope EPR materials. In this way, the argument in favour of a keeping high-value materials at the kerbside, which a DDRS would support, is not so much of an advantage, as the stakeholder believed that the losses would be covered by EPR. They further added that as sorting technology advances, the ability to extract value from the low-value kerbside recycling material that is not in-scope of a DRS would increase, thus increasing revenue for local authorities and MRFs.

One respondent pointed out the benefits in aligning the scheme administrators for DRS and EPR i.e. have 1 single body overseeing both to minimise the risk of conflicting messaging and signals to the market about what to do and/or requirements around quality of materials collected.

3.5 What significant costs need to be considered?

Besides the technology required by producers to label their products with serialisation codes, other significant costs may need to be considered. These vary greatly depending on the different consideration points highlighted in Figure 1.

The costs associated with the design and implementation of the digital infrastructure and data management ecosystems is an area that was covered in the initial IWG impact assessment but would warrant further detailed analysis to understand the scale of investment and requirements in light of the preferred system design.

The costs associated with upgrading local authority collections to multi-stream collections, as seen in the majority of Welsh local authorities, if required by a DDRS would be substantial. However, the view in Defra's Consistency in Household and Business Recycling in England consultation[16] is that in order to achieve high-quality recycling, recyclable waste streams must be collected separately from each other (i.e.

[15] https://consult.defra.gov.uk/extended-producer-responsibility/extended-producer-responsibility-for-packaging/supporting_documents/23.03.21%20EPR%20Consultation.pdf
[16] https://consult.defra.gov.uk/waste-and-recycling/consistency-in-household-and-business-recycling/supporting_documents/Recycling%20Consistency%20Final%20Consultation_May%202021.pdf

multi-stream collections). Under this policy, operational practicalities of DDRS align with the policy intentions/goals under England's consistent collections policy (i.e. both support multi-stream collections). Nonetheless, local authorities will likely still have an exception to justify the use of commingled or multi-stream collections where is not technically or economically practicable (TEEP) to implement multi-stream collections.

Stakeholders interviewed also believed that investments would be required to meet material quality standards and data evidence requirements post collection, a similar function to counting centres under DRS, may also be significant. The scale of these changes and investments are linked to collection consistency and EPR and in an ideal scenario the material resources management ecosystem is designed with all requirements in mind rather than in isolation. This report reflects key stakeholder views on key questions pertaining to a DDRS but does not independently research the costs and benefits. The elements that are critical to the feasibility of a DDRS (see Section 9.2) should be investigated in more detail to further understand cost implications of each option.

4 Labelling and data management

Questions around labelling and data management are central to the design and development of a DDRS. There was consensus amongst stakeholder interviews around some aspects of the labelling process, e.g. around the solutions for multipack products, and the technical feasibility of applying serialised codes to plastic and glass containers at pre-production stage (i.e. when designing the labels that are later attached to the plastic and glass containers). However, uncertainties still remain, largely around the feasibility of printing unique codes onto cans, and the point at which codes should be activated.

Stakeholders provided solutions and ideas for resolving these uncertainties. Depending on which solution is chosen, it will impact further steps along the end-to-end process.

There was also overwhelming preference by those interviewed for a UK-wide system, with strong reservations around a DDRS unique to one market, as investing in serialisation and customising only a proportion of SKUs was deemed economically unfeasible.

4.1 At which point in the process is the most appropriate to activate the codes?

Activation of the codes refers to a point along the product life cycle where the serialised codes on the containers are 'activated', thereby associating them with a financial DRS deposit that is redeemable by a consumer. There were differing views amongst the stakeholders interviewed about where the most appropriate point in the supply chain would be for code activation, with opinions generally grouped around point of sale (i.e. at the till) or at manufacturing.

Activation at point of sale

Proponents of activation at point-of-sale point to the assumption that the closer the activation happens to the point of consumption, the less opportunity there is for fraud. As, even though individuals would be able to physically see the code, they would not be able to redeem the deposits until it was purchased. Activation at point-of-sale would require retailers to ensure that software and hardware at checkouts are capable of scanning and reading the serialised code and a digital link to the DDRS system to register the serialised code as now being activated with a deposit, along with staff and customers (self-service checkouts) being able to reliably and quickly scan the requisite markings on each container.

A technological barrier is that the existing scanning hardware currently required to read barcodes needs, as a minimum, laser-based scanning hardware. However more sophisticated digital camera-based hardware would be required in order to scan 2D codes such as QR or data matrix codes, along with different software requirements. One large retailer interviewed indicated that it likely (but unconfirmed) would have the capacity to support 2D codes across all point-of-sale touchpoints by 2023.

One large retailer raised how activation at point of sale could be incorporated into "checkout free" stores which are currently being trialled by various retailers.

One further challenge to activation at point of sale raised by those representing smaller retail outlets was that up to 25% of retailers (representing over 40,000 convenience stores) typically do not have an electronic point of sale system[17]. For those retailers, a DDRS that requires activation at point of sale would need to accommodate their set of circumstances, for example, providing a separate handheld scanner to scan and activate the codes.

Activation at manufacturing

Proponents of activation at manufacturing point to the assumption that manufacturers can place the code out of the line of sight of consumers, lessening the risk of fraud from the redemption of deposits before a container is sold. For example, if the code is placed inside a bottle cap or on the underside of the pull tab of a canned drink container then it won't be visible until the drink is opened. However, others raised that consumer engagement with a system that has codes that are more difficult to find should also be considered.

Some stakeholders interviewed from the beverage manufacturing sector expressed concern that placing code scanning and activation systems on bottling lines is not currently favourable. For example, bottling lines for Bourbon produced in USA or Tequila produced in Mexico would not realistically be able to add scanning hardware specifically for the UK (or Welsh) market. In addition, scanning of containers on a production line can be problematic on lines where the orientation of the containers is not controlled to ensure the code is in the correct position to be read by the scanner (assuming the code can only be read from one direction – which is not true of all potential DDRS technology).

4.2 What criteria must the code fulfil to support a DDRS? Is it necessary to have one uniform approach to serialised labelling?

Most stakeholders interviewed advocated the use of a unified system - GS1 being the common global standard - and see this as a way of avoiding duplicate serialisation codes and a point of familiarity for consumers identifying the DDRS marking to scan for deposit redemption.

However, in-house barcodes do exist with the main example being own-label branded goods. One potential IT supplier indicated that their software could cope with different code formats – essentially, if the hardware can read the serialisation code the software can process it successfully. In this case, each producer becomes a node and would populate that node on the system with their own codes. They would tell the IT supplier what codes they have or will place on the market.

The information that the codes must contain needs to be agreed as well (e.g. how many characters, numbers, alphanumeric or alternative encoding, and the minimum size of the cell that is required). One technology provider shared that in other digitasion schemes they have worked on, negotiating the data

[17] https://www.acs.org.uk/research/local-shop-report

content of the code has proven to be one of the most difficult in moving a scheme from concept to practice. It has the potential to have a big impact on implementation costs and system performance.

Finally, while a 2D code could have multiple use cases, for now, containers would need a barcode for sales and a seperate data matrix code for DDRS, as the sale of the item is still registered through the EAN barcode. However, this may not be the case for long, as GS1 have announced their intention to align with industry and support more 2D barcodes, as explained in Section 3.1.

4.3 What are pros and cons for each labelling technology? Which is the most economically advantageous?

Two main options were put forward by stakeholders for the physical serialisation technology: radio-frequency identification (RFID); and a visual marking. The consensus amongst the interviewees is that RFID technology is the most expensive option, and too costly for beverage containers. There was thus general agreement amongst interviewees that visual markings in the form of a 2D code, e.g. data matrix or QR code, would be the option of choice, with a general preference toward a 2D data matrix code over a QR code.

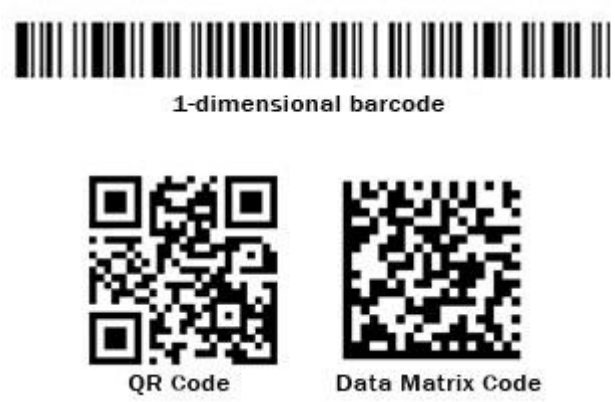


Figure 2. 1D barcodes vs 2D QR code and 2D Data Matrix code. Data Matrix codes can be printed at lower resolutions and smaller sizes, compared to QR codes, making them more favourable for drinks packaging. Source[18].

However, it is important to note that stakeholders knowledgeable of labelling technology and processes insisted that the labelling solution will depend on the container's physical materials and aspects of the production process it goes through – there will generally not be a single printing package/solution to fit all circumstances.

There are essentially two ways to serialise containers using visual markings:

1. Pre-print codes onto labels, which are then later applied to the containers;
2. Print container serialisation markings directly on the container in the production line.

Regarding the first option, marking pre-printed labels with serialised codes (e.g. for plastic and glass containers) was considered by stakeholders interviewed to be straightforward; it was agreed that it does not present significant issues. There is a cost consideration to support digital printing of unique codes on labels, however it is technically feasible. However, there were conflicting views offered as to the current state of technology regarding the technical and economic feasibility of the second option, i.e. printing on

[18] https://plasticsdecorating.com/enews/2012/plastics-decorating-enews-11/

containers as they move through the production line. This is currently the only feasible option for marking cans, as they do not have labels attached to them as the other in-scope materials do (i.e. plastic and glass containers).

Serialisation of cans was thus considered to be more challenging with existing technology. Aluminium cans are more difficult to print on due to can production line speeds and the inability to isolate and orient each can to print the code in a consistent place (see more on options for labelling cans in Section 4.4). Similarly, laser etching onto glass containers produces a marking that consumers may find difficult to locate, which is another reason why printing the code on the label for glass containers was favoured.

4.4 What are the options for labelling cans, and where should the label printer be placed? e.g. filling lines or the packaging production lines for the can ends?

Labels are not generally applied to aluminium cans and so it raises the challenge of directly marking the cans with a serialisation code. These challenges include:

- Current printers that mark and colour can bodies do so in 'batches' that are later cut to form the body of the can. These printers do not currently support printing unique codes.
- Can production line speeds are generally understood to operate at speeds quicker than serialised printing can cope with.
- Speed of the can filling lines is slower than the speeds of a production line, so serialised codes could potentially be added at that point, but container orientation would need to be controlled which is expensive.
- Location of the code with respect to activation (e.g. some producers have explored printing serialised codes on the reverse side of tab ring pull. However, these codes could not be activated at the point of sale without opening the can).
- A question remains regarding which is the most advantageous point in the manufacturing process to apply a serialised code – if at the earlier stages of can production, it may not necessarily be known or decided what product the can would be filled with.

There is a diverse range of views amongst those interviewed for the research on the technical and economic feasibility of printing serialisation codes onto cans. Some are running trials with various technologies, but the results of those tests have not been published or shared. However, there seemed to be agreement by those interviewed that, currently, the most feasible placement and printing of serialised codes would be on the can ends, i.e. the flat tops of the cans. The production speed of can ends is slower than the can bodies, and so can accommodate the digital printing of codes. However, some trials have revealed that the codes can be difficult to read by scanning technology. Due to the aluminium surface of the can end, a printed code on aluminium will be very reflective, making it problematic for a camera to read due to the low contrast between the serialisation markings and the metallised surface colour of the can end. A solution to this is to add contrast by dying the can end a solid colour, e.g. golden, so that the serialised code can be more easily read by smart phone cameras. However this solution would involve an additional cost consideration.

Practicalities around serialised printing on cans are thus still under investigation, and sufficient time should be given to the industry to identify a practical solution.

4.5 What if a product fails validation/activation?

Failure of activation and mechanisms to remedy that situation was an aspect of DDRS the various interviewees did not, in general, demonstrate a depth of knowledge about when interviewed.

Identification of a problem with a code would depend on when/if the code was validated with a validation test. A validation test could be performed on the production line (post application of the code on the container). If activation was to be at the point of sale, then the consumer would be alerted at that point and probably before a monetary transaction would be completed. If, for some reason, the container was not activated, then the consumer would not pay the deposit on the item and would therefore also not be able to claim anything back.

An advantage of 2D labelling is its ability to handle damage. For example, up to 30% of 2D Data Matrix barcodes can be damaged (e.g. via scratches) and still be machine readable, protecting against some risk that a product would not be able to be activated.

4.6 What solutions exist for labelling on multipacks?

There is a perceived challenge for a DDRS system with regards to handing containers purchased in a multipack, particularly if code activation happens at the point-of-sale. If code activation is at the point of sale, then each individual item within the multipack would need to be scanned at the till in order to be activated. However, conversations with technology providers have confirmed that the secondary packaging on the multipack could contain a serialised code that is purely information (i.e. itself does not contain a deposit); it would link to the individual serialised codes on the containers within the multipack. While this linking is technically feasible, and indeed is done in other contexts such as for tobacco multipacks, the practicalities would need to be further investigated, e.g. manufacturers to be able to track and record which individual containers are placed in each multipack on their production lines, which is likely to be complex.

Some industries have overcome these technical challenges but, in general, they add cost and are consequently limited to higher value products such as pharmaceuticals and tobacco.

One potential DDRS technology provider claims to have a solution to the multipack serialisation challenge using existing packaging markings but was not able to share details due to commercial confidentiality reasons. The plausibility of the solution could not be assessed by the research team.

The practicalities around multipack solutions are especially pertinent for smaller producers, particularly as many sell directly to consumers. A small producer interviewed suggested that smaller producers would likely prefer to activate codes directly on the production line, as they don't have the speed issue that larger retailers have and would thus avoid having to manually link multipack codes with serialised codes on the individual containers.

The research team considers that the solution proposed for handling multipack containers in a DDRS system which requires activation at the point of sale (i.e. linking codes on the secondary 'multipack; packaging to codes on the primary 'container' packaging) has not been investigated in depth in the context of drinks containers and may potentially require substantial changes to the way that multipack containers are packaged and presented for sale. One way to avoid this issue is to activate the codes at manufacturing, so that regardless of whether they are sold individually or in a multipack, each container can be activated individually pre-consumption. However, activation at production poses its own challenges as well, which are discussed in Section 4.1.

4.7 What are the carbon impacts of using the preferred approach? Is Bitcoin a good comparator?

The Irish Waste Management Association recently commissioned a report to assess the high-level carbon impacts of Smart DRS (i.e. DDRS)[19]. The findings suggest that a DDRS could deliver a net benefit of approximately 20,000 tCO2e per annum compared to a traditional DRS, largely due to the increased carbon emissions from transportation to retailers to return containers. However, as far as could be understood, these carbon impacts only compare the physical infrastructure of both systems; the carbon impacts associated with the IT infrastructure to support a DDRS was not considered.

While a traditional DRS will also require some IT support, e.g. according to one stakeholder, it would use a large central database that would need to be backed up and operated in a robust environment, with each RVM requiring a certain level of IT support and linkage to the network, the central IT infrastructure required to support a DDRS will be much larger. However, the choice of IT approach used (e.g. using a cloud storage/database solution vs. a blockchain solution) will vary in their level of carbon impact.

When considering blockchain, most critics point to the power used to operate the Bitcoin network. However, one technology provider suggested that Bitcoin is not a good comparator, and that the comparison should be made with an RVM-based DRS, not Bitcoin. This is because Bitcoin operates a 'Proof-of-Work Protocol' (POW) to protect against fraud that consumes an excessive amount of energy; a DDRS would not need to operate such an energy-intensive mechanism to protect against fraud. The same organisation advocates instead for the use of a 'Delegated Proof-of-Stake Protocol' (commonly known as DPos). Unlike Bitcoin's POW protocol, where the proof-of-work algorithm has all the computers in the network trying to find the solution, the DPos protocol allows users to vote a witness and the witness has the right to validate a transaction. By controlling the permissions of which computers are allowed to participate in the mining process, energy would be saved by stopping other computers in a network from wasting power searching for the solution in a proof-of-work algorithm. That way, the technology provider suggests that the energy consumption of the blockchain could be cut by 99%. This is not something Bitcoin could achieve because power sources for Bitcoin mining is not controlled amongst its many stakeholders.

Other approaches, e.g. using a central database, have been suggested as well. One stakeholder suggested that the carbon impact of creating a database of 50 million unique codes, that are unique and long enough to ensure an extremely minimal chance of duplication, would use about 1200 kWh of power a month, which includes generation, storage and retrieval. According to this technology provider, by using a database, the environmental impact is more traceable as you are more likely to be able to determine what energy source is being used, and from where the energy is being sourced.

4.8 What is the impact of producing SKUs for various regions of UK/Ireland/rest of Europe if there is a mix of serialised codes and bar codes?

This question was one of the main concerns felt by stakeholders interviewed, and links with the discussion of the question in Section 3 which stressed that stakeholders primarily want a uniform system across the UK, due to the impacts of producing customised SKUs for specific markets.

[19] http://iwma.ie/wp-content/uploads/2021/05/210505-501.181.9_SLR-SmartDRS_CarbonStudy_BriefingNote-for-IWMA_Final.pdf

Stakeholders interviewed revealed a common viewpoint that customisation of containers for small markets adds costs. In balancing costs and benefits, the smaller the sales market, the greater the net costs of customisation per container. This issue is exacerbated for smaller producers with one small producer stating that they are considering pulling out of the Scottish market because of the labelling requirements for the proposed DRS system there. The same situation may apply to low volume SKUs in general - even larger manufacturers have indicated that potentially only their best-selling products would remain on the market under a DDRS system as they think DDRS labelling requirements would add significant production costs.

The counter argument is that country specific labelling already exists. For example, for different languages, and to meet regulatory requirements, as described in Section 8.

In terms of DDRS serialisation markings, it is envisaged that they would not replace existing barcodes for many years to come. While GS1 have laid out a goal to support industry moving toward 2D barcodes, a large part of these plans involve supporting retail 'point of sale' scanners to be capable of reading and processing both old (1D) and new (2D) barcodes by 2027, which some believe may not be feasible by the target date. Until such a time, both types of barcodes would need to be accommodated on containers.

Generally, manufacturers do not want to invest in a system that only works in one country context. Agreeing on a standard for serialisation is considered to be fundamental. Some even believed that in order for DDRS to gain traction, standardisation of serialisation should be international, not just applied to the UK.

4.9 Who would have ownership of the data?

One view put forward by a potential technology provider is that product data should be owned by the product manufacturers and that consumer data should be owned by the consumer. Which organisation would be the data *controller* in a GDPR context is another matter. The suggestion put forward by those interviewed is that the DMO should hold that role. The DMO should also set the data standard(s).

There is scope for consumers to opt into enhanced data sharing – exchanging consumer habits data (see Section 4.10) for rewards, much like retailer loyalty schemes.

4.10 Could data be sold to help fund the DDRS system?

Little comment was received with regards to the concept of DDRS system data. The strong view from those interviewed was that if consumer data were to be sold, this would need to be done on an 'opt-in' basis only (as opposed to an 'opt-out' basis). Product data is likely to remain the intellectual property of the product manufacturers with no overt desire to share that with competitors or others.

4.11 Does a digital DRS reduce the opportunity for fraud compared to a traditional DRS?

No organisation interviewed claimed that a DDRS would be able to eliminate fraud.

According to those interviewed, the two main risk points for fraud in a DDRS are:

1. Before a container is purchased by a consumer; and,
2. Scanning and redemption of serialised barcodes of a purchased container, without placing it in a DDRS recycling receptacle.

Discussed in a real-world context, one retailer said that their voucher rewards takeback scheme for returning cosmetics packaging has seen 3% of individuals deliberately attempting to cheat the system and 16% of items returned not being eligible for a reward.

Technology providers have suggested that a DDRS may have additional mitigating actions available to halt fraud attempts, compared to a traditional DRS. According to the technology providers interviewed, these fraud detection methods would be sufficient to halt fraud attempts regardless of where codes are activated. These methods include:

- Enforced geo-location information sharing via the DDRS app / mobile phone at deposit claim (i.e. deposit can only be claimed if followed by a scan of the geo-located recycling bin registered to the consumer)
- A delay between a deposit claim and deposit redemption (payment by DMO) to enable fraud prevention checks to be made
- Additional scanning of containers at MRFs (using serialisation code scanning, invisible ink scanning for container type and brand, and/or visual scanning using AI) to track differences between geolocations of sales and deposit claims
- Fraud detection algorithms in the DDRS IT system incorporating artificial intelligence techniques
- Sanctions for fraud attempts administered via the DDRS app, e.g. suspension from the system.

One organisation involved in DRS systems believed that DDRS should not be the main mechanism for deposit redemption in a DRS because it is too open to abuse, at least in terms of containers being guaranteed to having been placed in a recycling receptacle post deposit claim.

Arguably, unless sophisticated fraud detection measures put in place by DDRS technology providers are demonstrated to work sufficiently well with activation at some point before point-of-sale (i.e. likely at manufacturing), a scheme-wide decision will need to be made for where the activation point will be. There will likely be a trade-off between the effectiveness of fraud prevention, its cost and which stakeholders along the value chain face the burden of implementing it. No clear consensus emerged from the research to date on where this should be.

4.12 What measures would need to be put in place to protect privacy for individuals?

The measures required would depend upon how the DDRS scheme is designed and administered. Use of RVMs under a hybrid system would require less, perhaps no, personal information to be shared.

The Data Protection Act 2018 is the UK's implementation of the General Data Protection Regulation (GDPR) and would apply to a DDRS scheme. The system should also be compliant with the Payment Card Industry Data Security Standard (PCI DSS). PCI DDS is a set of security standards designed to ensure that all companies that accept, process, store or transmit credit card information maintain a secure environment.

5 Integration into kerbside collections

An integrated system that utilises in-store return points (potentially RVMs) to allow redemption of items consumed on the go within the home digital-based system was seen as a viable system by collection organisations. The counter view was also given that on the issue of quality there were serious concerns on the ability of the current kerbside collection services being able to produce a comparable quality of in-scope DRS material as would be produced through an RVM based system.

5.1 At what point in the chain should deposits be redeemed, and how frequent should the redemptions be?

Based on the concept process map of the DDRS presented by GS1 UK the feedback was that it should mirror traditional DRS in that the deposit is redeemed at the point of "handing back" the container. In the case of home recycling, this is the point where the container is scanned in the home and deposited in the recycling container. However, technology providers suggested other points along the life cycle of the product to 'trigger' the deposit redemption. For example, one technology provider said that through a combination of UV scanning and visual product recognition it would be possible to scan a volume of containers (e.g. after kerbside waste collection) and cross reference this with the redeemed deposits through the DRS smartphone app to verify collection. As such the view of the technology provider was that the deposit should only be redeemed once this post collection scanning and verification has taken place. The authors note however, that this process doesn't mirror an RVM-based DRS and adds significant costs through the need of additional scanning and visual recognition software which are not used at scale in the resources sector at present.

5.2 What is the redemption mechanism for those without a bank account?

This was an area that kerbside collection organisations felt they did not have the knowledge or expertise to add an informed view. Tech providers believed a digital DRS card was a way of enabling payments to be made. When combined with a simple handheld home scanner this solution would also address the issue of people without smart mobile phones.

5.3 Would DRS material need to be collected separately? Would DDRS work with all collection profiles?

The repeated view from waste collection organisations was that they were "collection system agnostic". All collection organisations spoken to were also of the opinion that DRS material would not need to be collected separately, i.e. there is no need for householders to have a separate container for in-scope DRS drinks containers and/or a separate compartment on the waste collection vehicle. The main data gap that exists is understanding how the upcoming policies (namely EPR and DRS, but also consistent collections) will impact materials, and building a holistic service that achieves high capture rates of high-quality material at low environmental and economic costs.

One of the main benefits of a DDRS and flexible return points is that it allows a DRS to integrate and utilise the existing kerbside collection services to collect DRS material. In Wales particularly, there is a well-developed existing waste collection infrastructure with the majority of authorities collection systems based around the collection blueprint achieving high capture rates of high-quality material. The website: https://myrecyclingwales.org.uk/ is an online source of information that reports on recycling rates and end destinations for the whole of Wales.

Regarding the suitability, from a technical perspective, of different collection systems being able to integrate with a DDRS there were no issues or preference raised. This was based on the fact the home would be the registered point of disposal and then it is simply the case of the resident depositing the material in their recycling container for collection.

5.4 Is it possible to achieve the necessary standard of each of the material types through integration into kerbside waste collections?

It is noted that this question refers to a "standard" while the reality of the current market is that there are no material standards. However, for the purposes of the research this was based around producing material that would mirror the material quality produced through an RVM-based DRS i.e. PET bottles, aluminium cans etc. that are suitable for food contact closed loop recycling. The first point to note is that several interviewees made the point that a joined up holistic resources management system is about material rather than form i.e. PET not just a PET bottle.

The impact of the lack of material quality standards means the market is effectively left up to its own devices on producing a quality of product that can find a buyer at the right price and each collection and sorting organisation will find the solution that 'works for them. The greater diversity you have in collection systems the higher the investment you will need to make in post collection sorting equipment and infrastructure. This is what the collection consistency legislation will look to address and understanding how DRS collection could align with that is a point of interest for several stakeholders.

The general view of the waste collection organisations was that they could achieve the necessary standards to produce high quality recyclate material. However, the caveat being that depending on the 'standard' would impact on the cost on the investment that would be needed in post collection sorting. Given that an RVM-based system introduces significant costs it is worth investigating whether the post-sorting costs (environmental and financial) for a DDRS would be greater or less than the costs associated with an RVM-based system.

Kerbside collection system types

The general view was that a multi-stream collection system was likely to produce a material quality that was a better starting point to produce recyclate that would meet the requirements of reprocessors and be a closer comparable to the material collected through an RVM.

However, the point was made that there are very well used and managed commingled services producing high quality material product post sorting in the MRF. Conversely, there are also poorly used and managed multi-stream collection systems that are producing a very poor quality of material.

All collection organisations made the point that multi-stream collection systems collect plastics and cans together on the vehicle and so these already require sorting. It is also the case that any DRS collection point (RVM or manual take back) that collects the materials together will also require sorting, and this is the role of the counting houses. Due to the lack of collection consistency and/or material standards, how this material is sorted is down to each collection company and their approach to maximising the value they can extract from the material.

The case was also made for a well-managed commingled collection being able to produce good quality material suitable for food contact closed loop recycling. However, the issue of contamination was acknowledged and the impact this has on the efficiency and thus cost of sorting. There were strong reservations about the ability of communal household collections being able to achieve the necessary material capture and quality i.e. the well-reported lower capture rates and higher contamination of dry recycling material collected through these types of systems.

An interesting point was also raised about the impact of extreme weather on collections of kerbside material (the interviews were conducted during a period of winter storms) and the fact that in these

conditions dry recycling bins and bags get blown around meaning that material doesn't get collected. The question raised was how would this be accounted for within a DDRS?

The scale of DDRS post-collection sorting investment was viewed to be significant. However, the scale and pace of the investment is linked to the wider EPR and collection consistency legislation and the potential for synergies. See also Section 5.5. This is a **significant area of further research** to understand the synergies and holistic ecosystem of the post collection sorting infrastructure needed to support DRS, EPR and collection consistency.

Material quality – Glass

Currently glass PRN targets include a remelt target, i.e. glass being sent to remelt to be made back into glass bottles and jars. The glass sector was very keen that this driver for high quality recycling is not lost through the DRS if glass in included. For colour sorting of glass bottles there is an optimum size of cullet (i.e. broken or waste glass) that the sorting technology works at. This means that how the glass is collected is important to maintaining glass in the remelt closed loop cycle. The UK glass sector is on the public record as having serious concerns on the ability of RVM collected glass to remain in the remelt cycle. However, it is noted here that a view from a European DRS operator was that the glass they collect is going to remelt.

The view generally was that multi-stream collections are likely to yield the highest amounts of glass going to remelt. A view was given that the capture rates of glass are so high in some existing multi-stream collection services that a DRS wouldn't result in an increase. The view was given of significant amounts of glass lost through the commingled collection sorting process and that which is captured being "down cycled" in aggregates.

Material quality – Plastic

Plastic PET bottles were universally agreed to be the material that was likely to be most problematic in respect to achieving high quality material. It is noted that for existing traditional DRS systems, PET bottles will need to undergo a degree of post-deposit sorting to sort by colour and this is often a key function of the counting centre.

For kerbside collection services there is the issue of non-plastic contamination, i.e. food waste, and the need to sort the material by polymer and colour. The point to understand and that needs quantifying is how much overlap there would be in sorting technology needed to achieve the same end result for EPR material.

It is possible through MRFs and/or Plastic Recycling Facilities to produce material of suitable quality for single polymer recycling. It is also possible to sort by form, e.g. bottle, but for kerbside collections where the material is mixed each level of sorting requires investment.

Material quality – Aluminium

The view was that aluminium material could and is being produced at the required level through kerbside collections.

5.5 How would data be provided to the DMO post collection?

A DRS measures capture rate based on the proportion of deposits redeemed. However, in addition it is likely that the regulator will require the DMO to be able to produce evidence, if asked, that the container has been recycled. Understanding how a DDRS could support this whole value chain data requirement was a topic explored with stakeholders. In respect to the specifics of how data would flow and be managed

between stakeholders, this was not discussed in depth as it was viewed as being something the DMO would set out in their scheme requirements and the technology solution providers would build the solution that works for stakeholders.

This section looks at the issue of how a DDRS can provide evidence that the material is being recycled. Many respondents believed that the serialised code on containers could be leveraged to provide this evidence. One of the strengths of a DDRS is the enhanced data granularity that can be provided regarding which producer, which retailer, where the item was sold (depending on code activation point) up to the point of the deposit being redeemed. Several respondents discussed the exciting prospect/potential that further scanning of the items through the serialisation code could offer. One referred to it as "the holy grail of material waste management" while another referred to a requirement needing to account for every item post collection as a "hammer to crack a nut".

A query was raised around how the 'evidence' requirement is done in an RVM-based DRS and whether the counting centres actually count every item or simply sort materials and then verify based on average item weights vs. number of deposits redeemed and tonnage of materials. From initial discussions with a DRS operator in Europe it did not appear that RVM-sourced material was "counted" on a per item basis, rather a reconciliation against deposits redeemed and using average weights, tallied against tonnages sent to reprocessors.

Evidence of recycling could potentially be provided by collection crew scanning. However, there was universal agreement that any scheme that required the collection crews to scan items was simply not practical. One respondent did make the point that they could sample random containers ahead of collection to understand whether items were indeed being set out in the correct bins. This would of course come at a cost to the overall DRS operating costs. In reality it is simply a labour-intensive solution to what the artificial recognition visual sorting sector is working on providing a solution to and whether there is an adaptation of scanners in-situ at sorting facilities is a potential solution, but not one that could be verified on market readiness at this point.

The points raised regarding scanning of serialised codes post-consumption included the following:

- The ability of scan the code, particularly following the consumer placing the waste out for collection and subsequent steps in the waste value chain. E.g. crushed / broken items, bagged items, dirty codes, baled material etc. all prevent the code from being scanned.
- Questions around the feasibility of deposit code scanners on sort lines and potential to model successfully scanned deposits using algorithms to map that against redemption locations.
- The potential for AI vision identification technology to assist with identifying the number of in-scope materials.
- The issue of mixed material products i.e. a bale of PET from a MRF could currently include pots, tubs and trays and so composition data would be needed to understand the proportion of DRS material vs. EPR vs. other sources.

However, acknowledging the points above it was generally the view of the waste collection companies that if the requirement of providing evidencing of recycling was clear, then it would be possible to design a monitoring and evaluation system that would provide the data to evidence that the in-scope DRS materials were being delivered to reprocessors. It would likely be based on gathering data through a mix of composition data, digital scanning/AI vision and average item weight data. This is an area of further research and important to link to the data requirements for EPR.

5.6 What are the dynamics of ownership of material between DMO and local authority - and what are the impacts?

This question was very emotive for some collection organisations with a strong feeling that there was no need to change anything. A system that required an agreement / contract between the DMO and collection organisation for DRS material was felt to be over complicated and unnecessary. The collection organisation in question was of the opinion that the ownership and thus the value of the material should remain with them and not the DMO.

However, the counter view given was that there would be an agreement for the collection / handling of the material between the DMO and WMC and that would need to set out the requirements in terms of quality of material required. Those requirements would inform the negotiation of costs agreed for handing the material. The consistent point here is that the WMC needs to be recompensed financially in some form for collection the material if that is what is required. The point was raised that if a RVM based DRS is introduced then the unit cost / tonne of collecting EPR material is likely to increase as collection costs will not reduce proportionally to the value of the material lost to RVMs. There is of course the potential to collect more in-scope EPR material.

5.7 What role should EPR & collections consistency legislation have in achieving these standards?

All stakeholders emphasised the need for clarity on the requirements of what materials were in and out scope of the various legislations, including DRS, and the timings of implementation.

The cost would be kept to a minimum if there was collection consistency and clear material quality standards providing clarity to the market of what they need to achieve. Part of the issue at the moment is that there are so many different collection systems delivering a variety of materials and quality for post collection sorting. A uniform collection system would thus enable the sector to align communications and infrastructure to deliver the required quality. The DMO would need to specify this quality standard.

There are a range of desired outcomes around quality that need to be aligned across the EPR, DRS and collection consistency to ensure a holistic resource management ecosystem is designed rather than competing elements. An important factor in the sorting requirements and thus investment is to understand what requirements will be set by the respective administration bodies in terms of material quality. A key issue around the material quality requirement is around the form or material i.e. is a DRS system aiming to produce a stream of drinks containers only, or is it aiming to produce a material stream suitable for recycling through a closed loop system back into general food contact use.

6 Infrastructure required beyond kerbside: on the go and retail take back

In this section, ‘on-the-go’ refers to the location of consumption (and waste generation) of drinks containers outside of the home. It does not refer to specific container formats or sizes. Generally, there were mixed opinions about how a DDRS would work in an on-the-go context, i.e. in parks, train stations, and other locations not at the retailer or at the kerbside. While most were interested in the concept, stakeholders interviewed lacked understanding or agreement on how DDRS would be implemented on-the-go and what would be the best approach to do so.

Further infrastructure required under a traditional DRS is the logistics for online retailers that are obligated to provide collection of empty containers. This was a main concern felt by impacted stakeholders and is discussed in this section. In both instances (litter occurring on-the-go, and online retailer take-back obligations) DDRS was generally seen to be able to provide a solution over a traditional RVM DRS.

6.1 How would DDRS work on-the-go?

Several stakeholders believed that an on-the-go DDRS system could have the potential to add an additional level of convenience for consumers looking to recycle drinks containers outside of the home by allowing consumers to redeem deposits closer to the point of consumption, rather than the point of sale. However, others believed that on-the-go DDRS could confuse the message around how and where the container should be deposited, and lead to greater contamination.

There was consensus around low-levels of on-the-go recycling in the present system (i.e. with no DRS) but there were differing perspectives on how DDRS would work in practice in on-the-go locations, with disagreements around consistency and addressing contamination. These concerns are explored in more detail below.

It is noted by the authors that the trigger for the behaviour change in a DRS is the financial deposit attached to each container. The point of return is a user touch point and linked to convenience and ease of access etc. Some existing DRS systems in operation have resulted in an "informal" recycling sector that addresses the littered and/or items disposed of on-the-go collecting them and taking them to a return point.

Consistency

For most stakeholders, it was important that there was consistency across all DRS systems as far as possible – both across all nations of the UK, and in methods used to collect material, e.g., RVM, manual take-back, kerbside, on-the-go. Stakeholders raised a risk that too many options for disposal, e.g., infrastructure mix of RVMs, DDRS at the kerbside, and a different DDRS on-the-go could lead to confusion for the consumer. If the system is complicated and inconsistent, this could lead to reduced return rates for drinks containers. An on-the-go DDRS system must be easy and convenient to use and reinforce overall DRS messaging to minimise further confusion for consumers, e.g. from an already complicated situation if there are differing DRS systems around the UK. There must be clear communication to the consumer around the route for disposal, i.e. at the retailer via RVMs or at the home via DDRS.

In contrast, another stakeholder highlighted that inconsistency across infrastructure is actually the benefit of DDRS, as it introduces an element of flexibility, and thereby accessibility, not possible in a traditional DRS. It was suggested by this recycling company that a range of different bin infrastructures could be available, from a high-tech RVMs and 'smart' bins, to a basic bin with a QR code to facilitate DDRS, depending on the context. This flexibility in return point types would allow for specific sites to provide for higher on-the-go density, e.g., sporting events, festivals, where drinks containers will be the dominant waste type.

Other stakeholders suggested that the best approach to on-the-go DDRS would be exploring the feasibility of using QR codes on existing bin infrastructure (i.e. attaching a QR code to existing on-the-go litter and/or recycling bins), with the opportunity for higher-tech smart bins to be introduced later. A description of the different types of on-the-go bins is provided in Section 6.2.

Contamination

There was a lack of understanding around how contamination of materials will be minimised under a DDRS supporting on-the-go collection of containers. Stakeholders emphasised that, on-the-go recycling that takes place in the UK has generally not been successful in signalling correct consumer disposal habits and thus return poor quality material. There is limited clarity and evidence around the success of 'smart' bins and whether the cost of implementing such a solution would be feasible. However, some stakeholders highlighted that if the technology was sophisticated and available (which producers of this technology have confirmed it is), 'smart' bins could support in minimising contamination, but more trials would be required to prove the case.

6.2 How do the different on-the-go bin types compare?

There was limited engagement from stakeholders on comparing different on-the-go bin types. In comparing different container types, it is important to acknowledge the deposit is the trigger to prevent littering and the RVM is simply the point of redeeming the deposit. It is the case that some traditional DRS systems have resulted in 'informal recycling' activities where littered and/or DRS items disposed on in on-the-go bins and collected and taken to RVM by third parties. However, the current options include:

- Additional RVMs
- Deploying 'smart' bins, which are more sophisticated bins with varying levels of abilities, from simple solar-powered bins with crushing technology, to bins with controlled apertures that will only open if an in-scope item is detected
- Using existing on-the-go bins (e.g. general litter or recycling bins, or other specialised litter bins for specific waste streams) that would have a unique code attached to it. Consumers would then scan the code using their mobile phone app, scan the code on the in-scope item, and then deposit the item in the bin as they would normally. This system mirrors that proposed for the kerbside.

The three different types of on-the-go bins to support a DDRS are discussed below

RVM

There was hesitancy about the role of RVMs in incentivising on-the-go engagement with DRS, as some stakeholders felt that even if RVMs were in public spaces, such as high streets or retail parking lots, consumers may still find it inconvenient to carry drinks containers to a central location for return. In this way, RVMs were not seen to 'solve' the issue of litter. However, proponents of traditional RVM-based DRS systems pointed to the fact that locations in Europe and USA with RVMs have proven to have decreased litter compared to places without DRS. A similar comparison could not be made with DDRS-facilitated locations and DRS locations, as DDRS has not yet been trialled on-the-go.

'Smart' Bin

Some stakeholders felt that 'smart' bins could play an important role in capturing on-the-go drinks containers in specific circumstances. Although evidence remains limited, there was interest in the role of 'smart' bins in reducing contamination and potentially 'gamifying' the return of drinks containers (i.e. goal orientated rewarding and/or promoting local incentives to incentivise more people to participate).

One example of a 'smart' bin is the RecySmart, produced by Recircula Solutions[20]. RecySmart technology can be retrofitted onto any waste container, including kerbside recycling bins. The product is equipped with

[20] https://recirculasolutions.com/digital-drs/

a scanner that can read any barcode/QR code. It is powered by a battery, so no mains electricity connection is required. It functions best when paired to a smartphone via Bluetooth, so no internet connectivity is required in basic applications. It can also work without an app/smartphone, given internet connectivity to release the deposit in real-time onto a user card (similar to gift-card used in shops). RecySmart also can also come with an ultrasonic sensor to measure the filling level of the container and can notify the system when the bin requires emptying. For a discussion of costs for these devises, please refer to the DDRS Impact Assessment[21].

Existing bins fitted with 2D barcodes

A 2D barcode system for on-the-go DDRS would involve adding a 2D barcode (e.g. Data Matrix or QR) to existing litter bin infrastructure and would work in the same way as a 2D barcode on a kerbside recycling container, i.e., the 2D barcode on the recycling container or bin is scanned before drinks container is placed in the receptacle. The unique codes on the litter bins would be open for anyone registered on the app to use (whereas the home kerbside recycling container is only eligible for use by the householder).

There was recognition that adding 2D barcodes to existing bin infrastructure could provide a financially viable means to include on-the-go infrastructure in a DDRS system. However, there was recognition of the contamination risks linked to this bin type and the additional costs linked to managing this contamination issue. On the other hand, proponents of using a DDRS to support reducing litter pointed to the fact that incentivising consumers to dispose of their containers in a litter bin (i.e. not a recycling bin), rather than dropping it as litter should be a first priority, and once this behaviour is well established, further efforts to segregate this waste stream and minimise contamination through 'smart' bins could be developed.

6.3 How would DDRS impact litter? What leverage points does DDRS have to tackle litter over an RVM-DRS?

There is evidence to show that DRS systems generally reduce litter due to the financial deposit linked to the drinks container, which sends a strong cultural message that empty drinks containers have a value and are not waste/litter, which influences positive behaviour[22]. Respondents generally agreed that the introduction of an incentive (financial or otherwise) reduces litter in a traditional DRS model. Some respondents believed that a DDRS could create additional incentives beyond financial return of a deposit, e.g., gamification and goal orientated returns through the use of the mobile app. "Gamification", as raised by stakeholders, is an interacting concept where desired behaviours are rewarded with specified incentives in a game-like context. The *anticipation* of a reward builds commitment to the activity, helping people adopt and develop specific behaviours; the repetition of an activity driven by the promise of a reward aims to drive the formation of new habits. Even the act of marking a task completed can support the formation of habit, and the provision of progress bars or percentage completion rates helps remind people of the task in progress.

There remain significant unknowns in translating a DDRS scheme to on-the-go litter, as it depends on the aims of an on-the-go DDRS. For example, some respondents were of the view that DDRS on-the-go could be used simply to reduce litter. In this case, then the solution of QR codes on existing bins may be adequate, as the financial incentive of the container, and the convenience of nearby bins would incentivise consumers

[21] https://www.brysonrecycling.org/downloads/DDRS_Impact_Assessment.pdf (page 47)
[22] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/694916/voluntary-economic-incentives-working-group-report-drinks-containers-final.pdf

to correctly dispose of their container to redeem their deposit, rather than throw it on the ground. However, others viewed DDRS as an opportunity to segregate litter and achieve higher quality recyclate. In this case, more sophisticated measures (i.e. 'smart' bins) would need to be put in place to segregate the waste, due to the lack of on-the-go recycling infrastructure currently available across the UK. Keep Wales Tidy conducted an (unpublished) large-scale analysis of local authority waste strategies, and a major finding was that most local authorities do not provide on-the-go recycling bins at present, as it is too costly to manage contamination. Some local authorities are removing on-the-go bins entirely (except for roadsides and laybys).

The type of bin deployed would depend largely on the context, additional bin infrastructure on its own will not solve litter; infrastructure must be tied into existing data on litter hotspots. If leverage points of a DDRS for targeting litter are to be better understood, additional research and infrastructure thinking would be required to successfully address on-the-go littering within a DDRS.

However, some stakeholders raised the knock-on benefit that serialised containers could have on litter prevention. While not directly related to DDRS, by serialising products, individual items could be tracked i.e. where they were purchased to inform targeted communications. While this application of serialisation linked with litter enforcement has not been investigated in this research, it could be an interesting benefit of serialisation to explore.

6.4 Is the issue of mobile phone coverage an issue that would impact on the ability to use on-the-go bins?

There was consensus that differing access to technology could be a barrier to on-the-go engagement with DDRS. Not everyone has a smart phone so there is a need for a hybrid solution including physical technology. There were also suggestions that for consumers where access to mobile phone coverage could be an issue, there could be an opportunity of providing an in-home scanner. It was agreed that any DRS service should be accessible to all and having a kerbside collection available would be more accessible than a DRS system with remote RVMs only.

6.5 What are the requirements of a DRS on retailers who provide home deliveries?

In Scotland, DRS regulation states that online retailers are obliged to collect in-scope drinks containers at the kerbside. For brick-and-mortar retailers, having an RVM in-store does not satisfy take-back requirement; if they provide home deliveries the understanding is that they must also provide home take-back collections. This is agreed to be especially problematic for online retailers who do not have brick-and-mortar retail space.

One online retailer highlighted the fact that online retail home deliveries are highly optimised, and if DRS legislation requires them to collect empty drinks containers, it would have a negative impact on their business. According to one online retailer, if required to collect empty containers, they estimated that drivers would spend an additional 10-20 seconds at each doorstep, which would impact on overall delivery times per shift and require online retailers to have more vehicles on the road to deliver the same amount of groceries. This was considered to be counterproductive as an unintended consequence would be more environmental impact from vehicle emissions. Further considerations, such as health and safety concerns in carrying fresh produce/groceries along with recycling waste in the same vehicle, or whether retailers would be required to provide separate vehicles for collections, were expressed.

There were also further complications with the online retail take-back obligation for consumers that use third-party delivery services, e.g. Deliveroo, to purchase groceries from larger retailers. Moreover, it was unclear whether convenience stores would be exempt from collecting empty drinks containers that were delivered to homes, as it is estimated that 39% of Association of Convenience Store members offer home delivery to customers who order over the phone and 15% provide home deliveries through a third-party app service[23].

Due to these perceived complications, retailers providing home deliveries were generally supportive of a DDRS, as it would allow for the in-scope drinks containers sold through their business to continue to be returned at the kerbside. They emphasized that a straightforward solution is needed, particularly as online grocery sales have 'skyrocketed' since the Covid-19 pandemic started. One retailer (not online, i.e. a brick-and-mortar retailer) interviewed shared that their online share of online drink sales has increased +122% over the past two years. Other retailers interviewed believed that the trend toward online shopping and home delivery of groceries will continue into the future[24], so requiring retailers to take back these containers (in their view, essentially replicating a waste collection service that already exists) would be operationally very complicated and could be instead facilitated through a DDRS.

7 Behavioural acceptability, social accessibility, and real-life stress testing of the approach

The introduction of any DRS system is likely to cause some householder confusion when working recycling systems are already in place. There is a danger that adding more complexity to the system might reduce engagement in recycling overall, with one stakeholder considering it might impact how householders treat non-deposit bearing recyclable materials.

The digital nature of a DDRS app opens interesting opportunities to build in tailored resident messaging. Careful consideration should be given to selection of incentive options to maximise behavioural levers. Non-smartphone users need to be accommodated but due to high smartphone penetration this is a small minority and could be managed through use of a hybrid (i.e. DDRS alongside DRS) system.

7.1 How can householders be better educated/signposted regarding what the deposit is for and why they are paying it?

As we get closer to the introduction of wider Government mandated recycling changes such as EPR reform, it is to be expected that media interest in topics such as DRS will heighten. This question is thus not unique to a DDRS system, and indeed a traditional DRS must clearly communicate what the deposit is for on drinks containers and why consumers are paying it. This wider context piece for residents will serve a key role in

[23] Association of Convenience Stores (2021) *The Local Shop Report*

[24] The Industry Grocery Division (IGD) estimates that Online sales/retailers will retain 2020 gains and become the fastest-growing channel post-2024. According to IGD, Online sales will slow after the 2020 growth, as some shoppers, particularly the older demographic, return to stores. However, new capacity and the new quick commerce channel – which sees food and grocery delivered in less than one hour and often sub-30 minutes – will see online become the fastest-growing channel post-2024 (https://www.igd.com/articles/article-viewer/t/uk-retail-food-and-grocery-market-growth-to-slow-sharply-in-the-short-term-according-to-latest-igd-market-forecasts/i/28369) .

addressing confusion around why the DRS system is being introduced, how people can get involved and why they should. It was noted that this was a big point of confusion in the current DDRS pilots as they were operating outside of this wider national context piece.

Alongside this media coverage, one stakeholder felt that the provision of clear information and leaflets to communicate key education/signposting details would be critical for success of the scheme. Further, all communications explaining what we're asking people to do in a DDRS must be given as part of the wider DRS context.

A stakeholder representing local authority views felt that the use of a digital app potentially opens the door for the use of very personalised and targeted messaging for different demographics, languages, etc.

One retail stakeholder felt the DDRS system would be less effective than a traditional RVM-DRS as it required too high a level of engagement from customers at too many points in the customer journey to operate effectively. Contact points included the need to voluntarily install an app to use the system and the need to individually scan each recycled drink container. It was felt the system would result in a complex user journey which would raise barriers to customer participation and could result in lower rates of consumer participation than with a traditional RVM-DRS. However, a recent trial with Cryptocycle was undertaken to test whether consumers would engage in such a system, and high-level results demonstrated that they do. This was raised in the GS1 UK workshops as a consideration for future discussion but was not covered in these stakeholder interviews, as existing pilot studies have already investigated this perceived barrier.

Two stakeholders raised the issue that consumers will likely not understand why any form of DRS is being introduced, especially as the materials covered by DRS are already commonly recycled at home. It was raised that any form of DRS could have the unintended consequence of putting people off recycling in general through the introduction of artificial boundaries that serve no purpose from a consumer perspective. For example – any rationale to vary deposit values or change the scanning system in the context of a multipack item versus an individual item, or the fact that a jam jar has no deposit value, but a drinks bottle does.

7.2 Could individual members within the same household have the same account?

The need for more than one individual in each household to have access to a DDRS account was an interesting outcome from the Conwy trial[25]. Restricting app access to only one household member provides an 'excuse' for others to not participate and introduces a lost behaviour change opportunity.

Conversations with technology providers confirmed that more than one individual could register to the same account. This option to further introduce an inter-household level competitive element is interesting as the ability to track recycling activity at individual level could help encourage wider recycling habit change across all household members. For example, the possibility of being able to choose how the deposit value reclaimed over a period is spent could help parents motivate children to engage in a family household or help motivate adults in a shared student/professional household.

[25] WRAP 2021. Digital Deposit Return Scheme Pilot Review

7.3 Can you incorporate product tracing into the app, so householders can see what happens to their bottle?

It was identified that tracing of products throughout the value chain would be interesting for householders, as local authorities have reported increased interest from householders regarding what happens to the waste they recycle. However, stakeholder conversations did not cover this specific question in depth. Nonetheless, the topic itself was discussed as part of integrating DDRS into the kerbside discussion in Section 5, the view being that it would be possible, with challenges to overcome, to "track" items through a mix of measures including scanning, visual AI and composition data with the understanding that these would all come with a cost attached. The one stakeholder who did respond to this question, a brand owner, already uses serialisation on product packaging as a means of communication. In that instance the brand owner finds this a useful consumer communication route to convey information relating to authenticity of the product, and to provide other consumer-facing information. The success of this as a communication channel, or the scope to extend this into a DDRS system, were not covered in interviews, and should be explored in more depth in order to investigate the feasibility of a serialised code with multiple uses.

7.4 How well would householders from communities/local authorities with lower recycling rates respond to a DDRS? Do different demographics respond to different incentives?

With only a few small-scale pilot projects currently completed, there remains a limited evidence base to fully unpick this question.

Learnings from the Conwy pilot indicate that DDRS was perceived as a simpler system that required less effort than a traditional RVM-based DRS. However, the Conwy pilot was only run in one specific area and whilst this comprised a demographic that typically show low engagement in recycling systems (representing a dominance of young family households), the area has historically also often been used for pilot work so has been exposed to a higher level of communications than typical and may therefore have some sensitisation to change.

The key barrier to engagement in the Conwy pilot centred around resident scepticism and a perceived lack of time and effort to engage. However, this was balanced by those that did take part – many of whom were driven by a desire to be part of the solution, and so felt the level of effort required was worth it. More research into why households did not participate in any of the DDRS pilots will be required to pull out key barriers to engagement.

Social norms theory, and specifically theory relating to perceived norms, indicate that people are more likely to adopt a positive behaviour if they perceive others are already engaged. It is possible that wider national take up will build sufficient momentum to establish a new perceived norm that in turn will drive wider engagement. Harnessing this momentum through use of normative messaging strategies in publicity, communications and app messaging will be required to further those least inclined to participate.

One stakeholder commented that the recruitment of 'champions' was a key route to success. The establishment of "community champions" occurred by chance in one DDRS pilot community and provided a highly successful route to boost wider engagement as the champions provided a point of reassurance which provided encouragement to others.

The opportunity provided by the digital platform to introduce additional incentives for low-performing communities was also raised, with incentives such as competitions or "gamification" mentioned (see description of gamification in Section 6.3). Gamification examples include financial and non-financial reward models, with examples including:

- **Leader boards:** For example, TravelWest have run a series of annual app-based competitions to drive sustainable commuting practices. Enabling people to log all journeys by transport type and distance, the app provides live leader boards showcasing allocated sustainable travel scores – with people having the option to compete as an individual or as part of their company.
- **Streaks:** A common tactic used in sporting apps such as Strava and Fitbit, and also in Duolingo for language tuition, "streaks" measure and reward continuous behaviour and app engagement.
- **Social element:** Drawing on research that showcases the interconnectedness of households in neighbourhoods, the Compare the Market app "Neighbourhood Bills Calculator" encourages people to talk about and compare their actions with neighbours.
- **Gifting/sharing:** The Bryson Recycling DDRS trial showed that just under half of those who participated donated their points to charity. Wherever financial rewards are offered, there should be flexibility for this to not just relate to personal gain or retailer loyalty reward points but also enable community and charity donation to target those driven by a more community-based focus.

Additional gamification tools include the awarding of points or badges as reward for competing specific tasks or sets of tasks and establishing "levels" to encourage users to continually strive to do more.

7.5 Would non-smartphone users engage with a home scan solution?

This specific question was not asked to stakeholders. However, insights can be drawn from the trial DDRS projects already conducted.

Neither the Bryson Recycling pilot with MEA Borough Council or the Dublin trial included non-smartphone solutions in their Reward4Waste project[26], with both quoting the high penetration of smartphone usage. The Bryson Recycling results stated that should a DDRS model move forward as a sole solution then, in the interests of inclusivity, consideration should be given to the relatively small number of people who do not have a smartphone. The Dublin pilot run by IWMA, in conjunction with Panda and Cryptocycle recommended that a hybrid model, with both physical return of containers from a traditional DRS and at-home return of containers through a DDRS, would remain the most convenient solution to address this same point.

The Polytag system used in the Conwy trial allowed non-smartphone users to register for a separate vendor system. Here crews were required to scan both the collection bin and individual unique bottle codes using a separate vendor app ahead of collection. This cross verification between household container and individual items enabled deposit tokens to still be allocated to households. This system increases workloads for crews and is unlikely to be workable or cost effective at a national scale.

[26] https://reward4waste.com/our-trials/

8 Additional insights: Serialisation

Besides the key questions listed above, stakeholder interviews revealed additional insights around serialisation that merit consideration.

Several stakeholders interviewed were interested in DDRS due to their own internal strategies and purposes for serialising codes on their products and packaging. According to these producers, there are many reasons to serialise products beyond supporting a DDRS, such as targeted consumer engagement, directly engaging consumers through rewards and loyalty programmes, mapping their supply chain, tracking consumption, and confirming authenticity of products. One producer engaged in this research already serialises plastic water bottles sold in Russia due to national regulations which stipulate that imported water bottles must have a serialised code. In Russia, the government provides producers with 2D data matrix codes, the producer prints them on the plastic water bottles, and later reports back to government to confirm which codes have been used. In other geographies, such as China, canned infant formula must be serialised to determine authenticity. There are many other applications where products are serialised, such as on tobacco, pharmaceutical products, medical devices, etc. However, it is not as common in the beverage industry given the lower unit cost of the products.

Stakeholders (particularly large producers) were thus keen to align their producer obligations (i.e. DRS) with existing strategies around serialisation. Furthermore, trade bodies also pointed to the 'big win' that serialisation could provide in terms of data and waste tracking, which will be necessary to robustly gather the data to evidence the movement of waste and improvements in recycling.

The European Commission also recently launched (November 2021) a call for proposals to develop a prototype for digital product 'passports'[27], which will likely contain unique product identifiers, as part of the EU Sustainable Products Initiative (a programme of the EU Circular Economy Action Plan). While the motivation is more for product design and sustainability, and the initial focus areas will be batteries and electronics, the intention is for the scope to eventually broaden to other product areas, such as packaging and plastics[28]. While there is no obligation on the UK to implement similar product passports, the direction of travel in the EU market toward digital tracking and recording of product information may be important to consider for future policy.

9 Further discussion/summary

In this section, learnings from the interviews are summarised and reflected, with an independent analysis about what this means for the feasibility of a DDRS in Wales, England and Northern Ireland.

9.1 Overall system design

Based on the stakeholder interviews and the current level of uncertainty, it is hard to evaluate if an end-to-end DDRS solution could be fully tested and ready for deployment on a national scale within the anticipated DRS timescales set by governments in the UK (2024 in England, Wales and Northern Ireland[29]). There are

[27] https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/digital-2021-trust-01-digipass
[28] https://www.beama.org.uk/my-beama/beama-webinars/eu-sustainable-products-initiative-and-digital-product-passports.html
[29] https://consult.defra.gov.uk/environment/consultation-on-introducing-a-drs/supporting_documents/DRS%20Consultation%20FINAL%20.pdf

significant proof of concept questions that remain. However, with the right emphasis and signals to market there is scope that ad end-to-end solution could be designed and evaluated.

A critical factor that is related, but outside the scope of this research is the messaging that the Government response to the DRS consultation will give to the market regarding both the flexibility of a DRS solution as well as who will be responsible for setting the requirements of the system, i.e. government or the DMO. The headline concept of a DDRS is valid, and with the right drivers and adequate timelines, an end-to-end solution could be designed. However, the timescales for innovation, cost and impact of the end-to-end solution, particularly compared to the RVM alternative is unknown[30]. In contrast, many point to the fact that the impact and cost of an RVM-based DRS solution is better understood. However, the world is changing, particularly that of digital technology, and this research has identified future innovations around product tracking digitisation that appear to be heading in the direction of serialisation-enabled solutions. The potential benefits that brings to material resource management are clear and looking to implement a future-proofed DRS solution that is flexible is the optimum solution. The implementation timescales of such a solution are critical, as a digital-kerbside element that is introduced after a DRS roll-out appears to be very challenging in regard to CAPEX and OPEX solutions that would need to be put in place to facilitate a traditional RVM based system.

For the system to work as a whole, a DDRS will require the co-ordination (or at least interfacing operations) of many organisations across value chains of manufacturing, retail and waste management. A national DDRS design must therefore set out the basic requirements of an end-to-end solution so that each organisation knows what is expected of them. For example, setting requirements for the quality of material collected at the kerbside. Other basic requirements might include verifying the collection and recycling performance - requiring that the number of containers collected matches the number of repaid deposits to within, for example, 5% tolerance, a similar requirement for final recycling performance, and the verification standard for evidencing this. Once the basic requirements are set the brands, producers, resources and waste management sector and technology providers will know what problems they need to solve and can form suitable collaborations to tackle this.

Existing trials have been relatively small, with only a segment of the end-to-end system being trialled (e.g. engagement with the consumer app). A more all-encompassing trial, e.g. bringing in both producers and waste management companies, that can support to answer or validate some of the remaining key questions outlined in Section 9.2 would be beneficial. Additional trials should engage with varying demographics to understand how they might respond to a DDRS to fully comprehend its potential reach as well as addressing points around recycling on-the-go. Phase 2 of this study could support the Welsh Government and the DDRS IWG to think about what role they can play in driving such work forwards.

9.2 Key remaining questions around feasibility and overall benefits

DDRS development is progressing, and key stakeholders are engaging in the UK. In this study, 34 hour-long interviews were conducted with key stakeholders to explore questions around feasibility of a DDRS. These interviews have shown where a general consensus is forming, e.g. around the type of digital marker (2d

[30] Resource Futures previously undertook an independent impact assessment for Bryson Recycling whereby the impacts of a high-level DDRS system were compared to the impacts laid out by Defra in the accompanying impact assessment to the DRS consultation. While this impact assessment was undertaken with the best available knowledge at the time and within the available timescales, these assumptions should be revisited. Particularly, Defra included non-monetised impacts that should be considered in order to fully understand the value for money of each system. More on this in section 9.2.

data matrix), the ability to digitally print serialised codes on labels for plastic and glass containers, and the solution for multipacks. The interviews also showed there are differing opinions on elements of DDRS design, timescales, and its overall benefits. As is natural with the design of any new system, more questions are raised as design decisions are explored in more depth. This was evidenced during the course of this research as the interviewees raised a number of new feasibility questions that will need to be considered. These have been summarised around key themes below:

- **Timeline for implementation** – could a DDRS be implemented at the same time as a DRS? If not, is it feasible or desirable to start with glass containers?
- **Activation point** – is a single and common point of activation is needed for all drinks containers? If so, where should this be? How would that impact the rest of the DDRS design? Which option is more cost effective?
- **Serialisation** - While stakeholders interviewed in favour of a DDRS were confident in the technical ability to attach serialised codes on plastic and glass containers in the pre-production stage, it is not clear at this point what timescales and cost would be required to develop the end-to-end system (i.e. to print, verify and activate serialised codes, particularly for aluminium cans, then process, redeem, and verify the deposits). Could serialisation be encouraged and brought forward to support a DDRS, and the scope increased to all DRS containers? If serialisation is not possible within the desired timescales for implementing a DRS, can a system be designed without serialisation?
- **Verifying recycling quantities** - How can you verify how many of the redeemed containers are being placed in kerbside recycling? Linked to this is how you verify containers are actually recycled accounting for sorting losses etc. When combined with the first point it is a complicated material data trail that needs carefully considered monitoring. How does this compare to traditional (RVM-based) DRS? Some technology providers are working on systems to scan containers using additional (i.e. not serialised) markings, e.g. on a belt in a waste sorting facility, but how accurate this could be at fast belt speeds when containers are crushed and mixed with other types of waste is yet to be proved.
- **Material quality** – What quality is required of the collected waste material? What changes are required and how much would it cost to match RVM quality material through post kerbside collection sorting of drinks containers? How would these costs impact DDRS value for money? Is the answer different in Wales where there is a majority collections blueprint? Is the answer different in the future when England and Scotland have implemented their consistent collections agendas and EPR is introduced?
- **Value for money** – The pros and cons of an end-to-end DDRS need to be fully set-out and compared to 'business-as-usual' and RVM-based DRS scenarios. This comparison must be holistic. Assumptions from the previous DDRS Impact Assessment[31] should be revisited and additional costs and benefits monetised in order to get an up-to-date picture of the value of such a system. The latest Defra impact assessment of DRS did not quantify or monetise some key costs and benefits of RVM-based DRS[32].

[31] https://www.brysonrecycling.org/downloads/DDRS_Impact_Assessment.pdf

[32] Non-monetised cost from Defra's latest impact assessment of a DRS: "the potential cost to consumers for the time required to return drinks containers to RVMs or manual take-back points". Non-monetised benefit in Defra's impact assessment: "The provision of a high-quality stream of waste for the domestic reprocessing market" : https://consult.defra.gov.uk/environment/consultation-on-introducing-a-drs/supporting_documents/Impact%20Assessment.pdf

10 Next steps for Phase 2 of this Study

This section outlines recommendations for further research to be conducted by Resource Futures in Phase 2 of this study. The recommendations are based on the findings of Phase 1 and the remaining questions around DDRS design and the feasibility of implementing different design decisions. The objective is to push forward the development and understanding of end-to-end solutions so that they can be assessed for their suitability in Wales, as well as in England and Northern Ireland.

While Phase 1 of this research aimed to take a deep dive into the different considerations surrounding specific practicalities of a DDRS, in Phase 2 of the project we propose to take a more holistic view focussing on the overarching research objective to "research and evaluate if and how a DDRS might be implemented in Wales as well as in England and Northern Ireland, and whether the purported benefits can be realised". This aim contains three distinct questions:

1. If a DDRS might be implemented in Wales as well as in England and Northern Ireland
2. How a DDRS might be implemented in Wales as well as in England and Northern Ireland
3. Whether the purported benefits can be realised

Clearly, it is not impossible to implement a DDRS in Wales and other UK countries, it is more a question of when it could be ready, and the costs and performance compared to an RVM-based system. We therefore refine question one above to make it more specific and then reorder and rephrase the questions:

1. How might a DDRS be implemented in Wales as well as in England and Northern Ireland?
2. When could a DDRS be implemented in Wales as well as in England and Northern Ireland?
3. Can the purported benefits be realised?

To answer these questions we recommend the following research activities:

1. How might a DDRS be implemented in Wales as well as in England and Northern Ireland?
    a. Identify the basic requirements of a DDRS – i.e. what is essential to the success/feasibility of the Scheme (e.g. serialisation, printing, logistics) and what is a nice to have (e.g. consumer scanning multiple bottles at once).
    b. Develop a roadmap, or sequence of questions mapping a generic pathway towards DDRS implementation. This will highlight the key design decisions and issues that must be addressed to develop a working end-to-end solution, and some of the different pathways this could take.
    c. Explore the different technologies and approaches being developed. Do they create fundamentally different designs for an end-to-end DDRS? Present each design as a system diagram to enable clear comparison.
2. When could a DDRS be implemented in Wales as well as in England and Northern Ireland?
    a. Evaluate the 'technology readiness level' of each element of the end-to-end DDRS designs (see Figure 3).
    b. Evaluate when each element of the end-to-end DDRS solutions might be ready (i.e. what year) and evaluate when the system could be implemented as a whole.
    c. Represent the technology readiness levels and market-ready dates on the system diagrams developed in the steps above so that the critical factors in timescales stand out.

   d. Explore the pathways and drivers available to the IWG and the Welsh Government to push forwards end-to-end DDRS designs. Identify specific actions that might be supported by the Welsh Government and the DDRS IWG – e.g. a large-scale trial, defining the basic requirements of a national DDRS, a government challenge fund, etc.

3. Can the purported benefits be realised?
   a. For each DDRS design, explore the remaining questions around feasibility and overall benefits (see Section 9.2).
   b. Conduct SWOT[33] analysis of each DDRS design – How does each system perform against material quality, recyclability targets, etc.? Does system X seem likely to realise all the purported benefits? Does it offer new benefits? Compare the results, e.g. one system might deliver higher material quality and fraud prevention but is more expensive.
   c. Research, for DDRS as a whole, around value for money compared to the RVM-model (e.g. value of consumers time, value of differing material quality, the cost of bringing kerbside up to RVM-output quality). These questions may require significant research resource and so priority levels must be carefully set within the time and budget available.

[33] Strengths, weaknesses, opportunity and threats (SWOT)

Figure 3. Example scale of technology readiness levels[34]

[34] https://www.cloudwatchhub.eu/exploitation/brief-refresher-technology-readiness-levels-trl