HIGH LEVEL STUDY TO ASSESS THE CARBON IMPACTS OF SMART DRS

Briefing Note

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1.0 Introduction

Deposit Return Schemes (DRS) involve the purchaser paying a deposit on a beverage container at the point of purchase, with the deposit being redeemed once the empty container is returned to an approved location. Introduction of DRS aims to increase capture rates of the target materials for recycling. In the Republic of Ireland the proposed DRS is to include PET drinks bottles and aluminium cans.

The potential for the development of DRS in the Republic of Ireland (ROI) has been set out in a report titled 'Improving the Capture Rate of Single Use Beverage Containers in Ireland' prepared for the Department of Communications, Climate Action & Environment (DCCAE) by Eunomia Research & Consulting in November 2019. The report proposes the adoption of a conventional DRS whereby empty containers are returned to locations with reverse vending machines (RVMs) or in the case of smaller outlets a manual system of returning deposits.

The Irish Waste Management Association (IWMA) has identified that (as an alternative to a conventional DRS) a Smart DRS (or digital DRS) could be implemented in the ROI in order to deliver the higher recycling levels for PET drinks bottles and aluminium cans. A Smart DRS would largely operate using a smartphone application (with unique codes placed on beverage containers and on existing bin infrastructure to track returns and deposit refunds) and would be supplemented with a small number (compared to conventional DRS) of RVMs at strategic locations.

A Smart DRS system has the potential to deliver the same benefits as a conventional DRS scheme in terms of materials captured, with (largely) the use of existing infrastructure and existing waste collection solutions. Smart DRS therefore has the potential to deliver a DRS scheme with a lower carbon impact than a conventional DRS.

A Smart DRS system also offers significant opportunities to easily introduce new items to the DRS in the future, whereas a conventional system would require more wholesale changes to infrastructure (and at present cannot handle non-cylindrical container shapes). This study however focusses only on the capture of PET bottles and aluminium cans to ensure a like for like comparison is achieved.

1.1 Purpose of Study

The outputs of this study are intended to help inform the debate surrounding whether a conventional or Smart DRS system should be implemented in Ireland. This study provides a view of the environmental impacts of both systems in terms of carbon impact.

The details provided in the Eunomia Report for DCCAE are used as the basis to assess the conventional DRS that is proposed and we compare that with a Smart DRS system that seeks to achieve the same result in capturing the target materials. The conventional and Smart DRS systems are compared in terms of carbon impacts. The results presented in this briefing note are a high level assessment and are by no means intended to be a full life cycle assessment / carbon footprint analysis of both the conventional and Smart DRS systems.

The study outputs do however allow the determination of whether a Smart DRS has the potential to offer carbon impact benefits over and above the implementation of a conventional DRS.

2.0 Methodology and Assumptions

This section summarises the methodology and assumptions including source reports utilised to characterise the conventional and Smart DRS systems, the scope of the carbon assessment (including inclusions / exclusions), an overview of the elements assessed in the carbon calculation model and key assumptions, and also details of the carbon intensity factors (CIFs) utilised.

2.1 Source Reports for the Characterisation of the DRS Systems

2.1.1 Conventional DRS

The report titled 'Improving the Capture Rate of Single Use Beverage Containers in Ireland' prepared for the Department of Communications, Climate Action & Environment (DCCAE) by Eunomia Research & Consulting in November 2019 has been utilised to characterise the key features of the conventional DRS system and its infrastructure and logistics requirements.

2.1.2 Smart DRS

The Irish Waste Management Association (IWMA) 'submission to the Department of Environment, Climate & Communications on the potential development of a deposit return scheme in Ireland' (date 12th November 2020) has been utilised to characterise the key features of the Smart DRS system.

2.2 Study Scope

The above two reports were reviewed for key relevant parameters which would result in a carbon impact. The information and data available / extractable in the reports (and associated appendices) were utilised to characterise the two options to be compared (the conventional DRS and Smart DRS).

The key elements of the DRS systems are summarised in Table **2-1** below, with commentary for conventional and Smart DRS systems provided in column 2 and 3 respectively; column 4 details where elements were scoped out of the study and provides the justification for this decision.

Table 2-1
Characterisation of Conventional and Smart DRS Systems.

Element	Conventional DRS	Smart DRS	Scoped In or Out
Positive Carbon Impact	Recycle 90% of PET Bottles and Aluminium Cans	Recycle 90% of PET Bottles and Aluminium Cans	Scoped out, as the result will be the same for both conventional and Smart DRS.
Installation of collection infrastructure	Roll-out 2,592 RVMs at 1,915 main supermarket premises and 13,809 additional manual collection points at supermarkets, petrol stations, cafes, hotels, convenience stores, etc. (these are all new and specifically designed for the conventional DRS)	Use existing mixed dry recycling (MDR) Bins at houses, apartments and business premises. Introduce c.500 RVMs at CA sites, shopping centres, train stations, airports, sports arenas, etc.	Scoped in.

Delivery of materials to collection points	Assume a % dedicated trips to the RVMs or take-back points (as currently occurs with glass banks) due to participant behaviour / limited storage space in dwellings.	No need for dedicated trips. Containers can be returned at home, in work, on the street, at events, in train stations, at entrance to park, etc.	Scoped in.
Transport of Materials to Sorting Centres	Based on collection from 15,724 drop-off points to 5 centralised Sorting Centres. Manual drop-off points will have uncrushed containers in bags/cages. RVMs will have compacted items.	Collection of materials from 500 RVMs located at CA sites, shopping centres, train stations, airports, sports arenas, etc. These would be compacted materials delivered to existing MRFs.	Scoped in.
Sorting Centres/MRFs	5 new Sorting Centres to be developed.	No new sorting centres needed. Smart DRS option to account for increased throughput at existing MRFs.	Scoped in.
Quality of Materials	Higher quality.	Relies on a higher level of sorting to reach high quality, but food grade raw materials can be produced. Allow for additional plastics sorting equipment at front end of plastic flake manufacturing facility for the processing of material collected co-mingled.	Scoped in.
Other	Impact of printed voucher receipts from RVMs (paper and ink); electricity consumption associated with central computer systems / data centre storage.	Electricity consumption associated with central computer systems / data centre storage.	Scoped out of high level carbon assessment. Complex calculations, with both options requiring data management. Assessment is conservative as arguably the conventional system (which produces printed receipts) would have a greater carbon impact for this element.

2.3 Carbon Calculation Model and Key Assumptions

A carbon calculation model was developed in Microsoft Excel to assess each of the elements identified above which were scoped into the assessment. Data regarding the key elements of the respective DRS systems were extracted from the source reports. Where the required data was not explicitely stated in the reports, the key elements / sub-elements were researched / calculated. Where required, interim calculations were undertaken before carbon intensity factors (CIFs) were applied in order to detemine the carbon impact of the element / sub-element.

Where some uncertainty exists regarding the element or component assumptions, a lower, middle and upper assumption were sourced / calculated. This provides a range of outcomes for the overall results of the carbon assessment to show the potential range of carbon impacts resulting from the conventional and Smart DRS systems.

The key elements, sub-elements and assumptions contained within the carbon calculation model are detailed in Table 2-2 below.

Table 2-2
Key Model Assumptions.

Element	Sub-element	Conventional DRS	Smart DRS
Installation of collection infrastructure	Number of Locations	Installation of 2,592 RVMs and 13,809 manual collection points.	Installation of 500 RVMs
	Space requirement	Each RVM assumed to require 1m^2 of floorspace for RVM and a further 3m^2 of floorspace back of house for storage or recyclables awaiting collection. Manual collection points assumed to require 1m^2 of back of house area for storage of recyclables awaiting collection.	Assumption as per conventional DRS for the RVMs.
	Electricity requirement for RVM operation	Calculation of annual electricity demand per RVM unit based on supplier data.	Assumption as per conventional DRS.

Element	Sub-element	Conventional DRS	Smart DRS
Delivery of materials to collection points	Distance driven for dedicated trips by householders to deliver containers to RVMs or manual collections points.	Number of beverage containers recycled divided by 15 (number of containers collected by a household before visiting a RVM or manual collection point) to derive the total number of visits annually. Total number of visits multiplied by assumed proportion of dedicated visits[1] applied (lower, middle and upper assumptions applied[2]), and then multiplied by an assumed distance to RVM or manual collection point to derive total annual distance driven for dedicated trips to collection points. Distance to collection points weighted based on population within Ireland living in urban, town/village and rural locations (also lower, middle and upper assumptions applied[3]).	Assumed that 10% of households do not want to use smartphones. Total number of visits annually (as calculated in conventional DRS) multiplied by 10%, then multiplied by proportion of dedicated visits (approach as per conventional DRS) and then multiplied by assumed round trip distance of 10km (given that the Smart DRS system will have a lower density of RVMs).
Transport of Materials to Sorting Centres	Number of vehicle trips required from RVMs	Tonnage of material collected in RVMs divided by density of compacted material to derive total collection volume.	Assumption as per conventional DRS, however tonnage collected in RVMs proportioned from 2,592 RVMs in conventional DRS to the 500 RVMs in Smart DRS.

[1] A 'dedicated' visit or trip is one where the only purpose of the journey is to return the beverage containers to reclaim the deposit. We assume that the majority of trips made to reclaim deposits are combined with shopping trips and are not 'dedicated' solely to returning beverage containers.

[2] 20%, 30% and 40% respectively, which are considered to be conservative.

[3] Weighted average distance resulted in 2.2 km, 3.1 km and 4.0 km respectively, which are considered to be conservative.

Element	Sub-element	Conventional DRS	Smart DRS
		Collection volume divided by HGV volume (90% utilisation of 86m^3) to obtain the optimised vehicle trips required per annum.	
	Number of vehicle trips required from manual collection points.	As above, albeit density factors for uncompacted material used and volume of smaller collection vehicle (90% utilisation of 39m^3) applied.	N/a as no manual collection points required in Smart DRS system.
	Distance travelled transporting materials to sorting centres	Average vehicle trip distance calculated based on area of ROI and 5 sorting centres. Approach assumes even spread of infrastructure, which is simplistic but suitable for a high level study.	Average vehicle trip distance calculated based on area of ROI and 9 MRFs. Approach assumes even spread of infrastructure, which is simplistic but suitable for a high level study.
Sorting Centres/MRFs	Additional infrastructure development and operational impacts associated with the 5 new sorting centres.	CIF applied to all tonnage captured as redirected away from existing MRFs to new sorting centres.	N/a no new sorting centres being developed.
	Additional operational impacts associated with the increased tonnage (directly associated with Smart DRS implementation) being processed through MRFs.	N/a no use of existing MRFs.	CIF applied to increased tonnage captured over and above current estimated recycling rates.

Element	Sub-element	Conventional DRS	Smart DRS
Quality of Materials	Electricity requirement for equipment associated with additional sorting of PET from co-mingled collections to meet specification of flake manufacturing.	N/a PET derived from conventional DRS assumed to meet standards without additional processing.	An additional pre-sort using an extra optical sorting machine may be required for PET delivered from co-mingled collections. Electricity requirement of such equipment derived from SLR in-house database of MRF equipment (ultimately sourced from equipment suppliers). CIF applied to tonnage from comingled collection (i.e. PET from RVMs does not require the pre-processing).

2.4 Carbon Intensity Factors

The CIFs have been derived from a number of published sources or generated in Life Cycle Assessment (LCA) model software. Table 2-3 below summarises the source of the CIF values utilised in this assessment against each element / sub-element.

Table 2-3
Carbon Intensity Factor Sources.

Element	Sub-element	Conventional DRS	Smart DRS
Installation of collection infrastructure	Space requirement	Due to the ever competing space demands of retail units (and equivalent commercial spaces) it is assumed that any space required by RVM equipment and back of house storage will result in the development of equivalent floorspace to ensure no net reduction in commercial area available. The capital carbon impacts of developing the floorspace (in terms of materials, construction, maintenance and end of life, but excluding any operational burdens (and therefore results are conservative)) is derived from the study 'An assessment of carbon emissions from retail fit-out in the United Kingdom', Fieldson & Rai (2009).	
	Electricity requirement for RVM operation	The GHG emission factors for electricity generation have been utilised from the UK Government GHG Conversion Factors for Company Reporting 2020 dataset.	

Element	Sub-element	Conventional DRS	Smart DRS
Delivery of materials to collection points	Distance driven for dedicated trips to deliver containers to RVMs or manual collections points.	The GHG emission factors for an average car / passenger vehicle have been utilised from the UK Government GHG Conversion Factors for Company Reporting 2020 dataset. Emissions data was proportionally weighted between different vehicle types (i.e. petrol, diesel, hybrid etc) based on ROI vehicle types data sourced from a report by ACEA (the European Automobile Manufacturers Association) titled 'Vehicles in Use Europe', published January 2021.	
Transport of Materials to Sorting Centres	Distance travelled transporting materials to sorting centres	The GHG emission factors for goods vehicles have been utilised from the UK Government GHG Conversion Factors for Company Reporting 2020 dataset. Due to the complexity associated with how vehicle collection rounds would be developed, the emissions factor for 'average laden' was selected for this high level study.	
Sorting Centres/MRFs	Additional infrastructure development and operational impacts associated with the 5 new sorting centres.	The LCA software Waste and Resource Assessment Tool for the Environment (WRATE) was utilised to obtain a CIF for the development and operation of a MRF. It is assumed that the sorting centres will be similar in nature to a MRF with sorting equipment, compaction and balers.	N/a

Element	Sub-element	Conventional DRS	Smart DRS
	Additional operational impacts associated with the increased tonnage (directly associated with Smart DRS implementation) being processed through MRFs.	N/a	Data regarding tonnage processed and electricity consumed was obtained from a number of MRF operators in the ROI over a 3 to 5 year period. The analysis of this data showed that there were numerous site related factors that impacted energy consumption over and above a basic throughput : energy consumed relationship. As such, components[4] of the results for a MRF from the WRATE software were utilised – this recognises that although an increased throughput associated with higher capture rates from DRS does not necessarily translate to additional electricity demand from the MRF, it will result in increased demands in certain areas such as fuel consumption for mobile plant, bale wire usage, maintenance materials.
Quality of Materials	Electricity requirement for equipment associated with additional sorting of PET from co-mingled collections to meet specification of flake manufacturing.	N/a	The GHG emission factors for electricity generation have been utilised from the UK Government GHG Conversion Factors for Company Reporting 2020 dataset.

The carbon impact modelling is conservative, as it does not take into consideration the carbon impacts of manufacturing the 2,592 RVMs.

The CIFs include those gaseous compounds that are known to contribute to the warming of the atmosphere, the so called ‘global warming’ effect. The most common greenhouse gas is carbon dioxide (CO2) however other species, primarily methane (CH4) and nitrous oxide (N2O), can be significant.

[4] direct process burdens, maintenance material input, maintenance material output, operational material input and operational water input.

The degree to which a greenhouse gas contributes to global warming is measured by its Global Warming Potential (GWP). This is a relative scale which compares the gas in question to that of the same mass of carbon dioxide (whose GWP is, by definition, 1).

A carbon impact (sometimes referred to as a carbon footprint) is expressed in the form of mass carbon dioxide equivalency (CO2e or CO2eq), a concept that describes, for a given mixture and amount of greenhouse gas, the amount of CO2 that would have the same global warming potential. The carbon dioxide equivalency for a gas is obtained by multiplying together the mass and the GWP of the gas.

Where possible, the CIFs utilised in this assessment were CO_2e, carbon dioxide equivalents, to ensure all greenhouse gas species were accounted for.

3.0 Results and Commentary

The results of the carbon calculation model are presented and discussed below. As detailed previously, the results are presented as carbon dioxide equivalent, and the summary results are presented in tonnes (tCO_2e).

Having obtained or calculated the elements / sub-elements identified in Table 2-2 (in the units tonnes, km, kWh etc) and identified appropriate CIFs as presented in Table 2-3 (which are in units kgCO2e per tonne or km or kWh), the elements / sub-elements are multiplied by the CIFs to derive the carbon impact result for each element or sub-element. All sub-element or element carbon impacts are summed to derive the total carbon impact result for each option. The results are then converted from $kgCO_2e$ to tCO_2e for ease of reporting.

3.1 Total Negative Environmental Impact of Conventional and Smart DRS

We recognise that recycling beverage containers has a positive environmental impact in carbon terms and in this report we assume that the positive impact is equal for both Conventional and Smart DRS, as both should achieve a minimum 90% recycling rate for the target materials. This report is solely focussed on the negative environmental impacts associated with each option, so our results do not estimate the total carbon impact, they estimate the difference in the carbon impact between options.

The total negative environmental impact is presented in Figure 3-1 below for both the conventional DRS and Smart DRS systems. As lower, middle and upper assumptions were applied in some cases, the results are presented as a range, with the dark grey dash in the figure (and subsequent figures) representing the medium value.

Figure 3-1 clearly shows that the development of a conventional DRS would result in significantly higher carbon impacts (i.e. negative environmental impact) than adoption of a Smart DRS (which would use largely existing infrastructure and established logistics systems).

The conventional DRS is estimated to generate between circa 17,500 and 38,000 tCO_2e, with a medium value of circa 26,000 tCO_2e. By comparison, a Smart DRS system is estimated to generate between circa 4,500 and 8,000 tCO_2e, with a medium value of circa 6,250 tCO_2e.

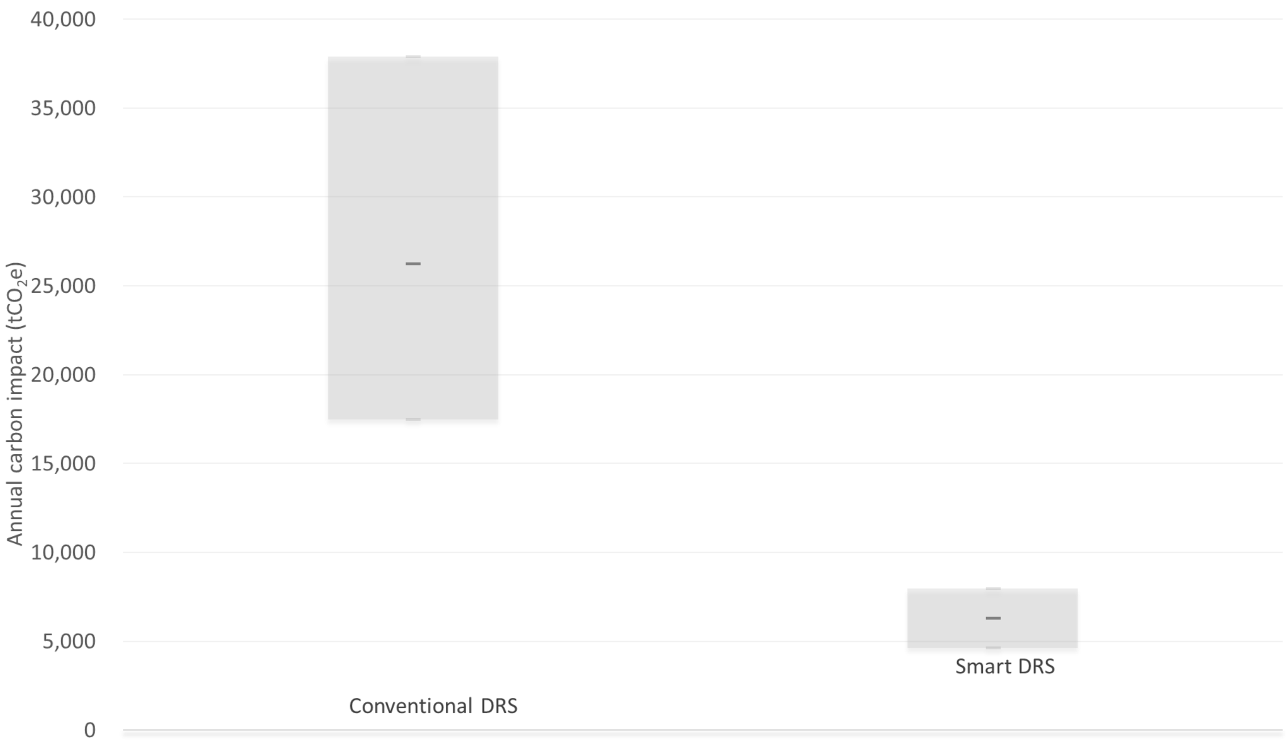

Figure 3-1
Total Negative Environmental Impact of Conventional and Smart DRS Systems

3.2 Carbon Impact by Component Elements

Figure 3-2 and Figure 3-3 below show the breakdown of the carbon impact by element for the conventional DRS and Smart DRS respectively.

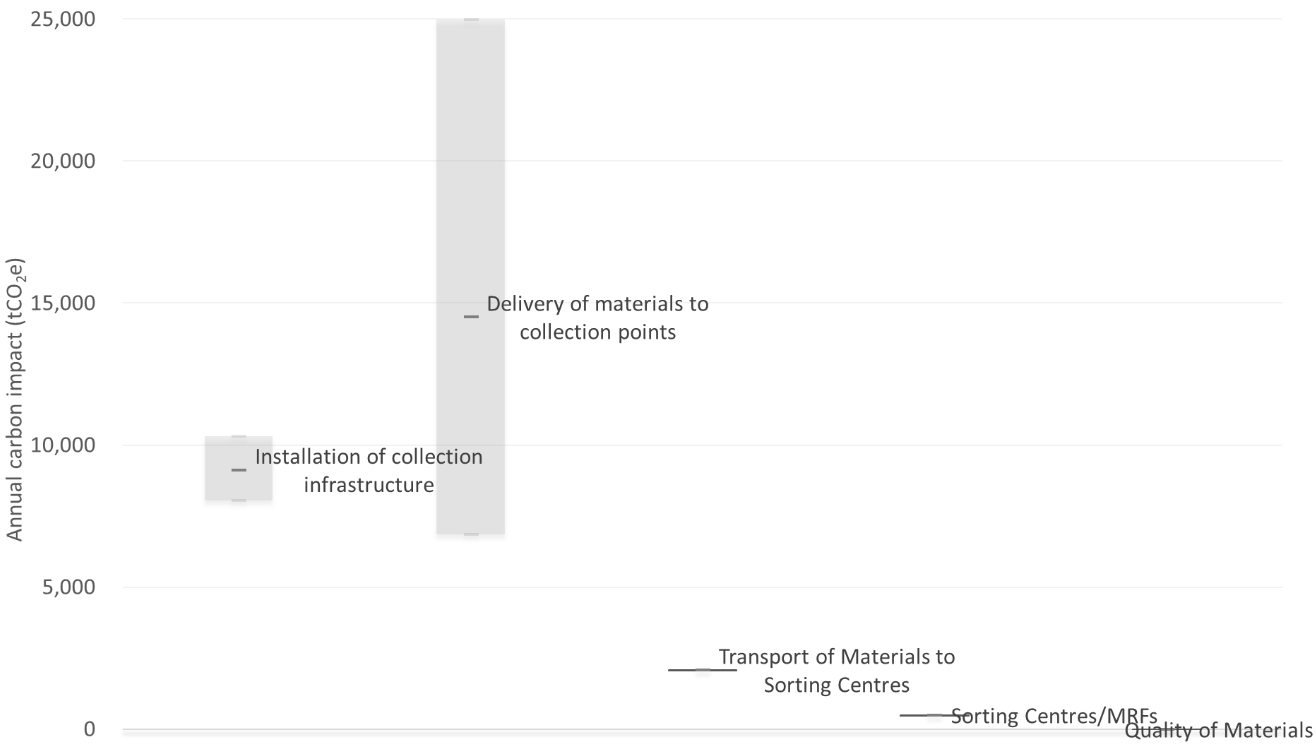

Figure 3-2
Conventional DRS – Breakdown of Carbon Impact by Element

The largest component of the carbon impact for the conventional DRS is associated with the delivery of materials to collection points. The carbon impact of the dedicated trips to RVMs and manual collection points account for between 39% and 66% of the estimated total carbon impact.

As containers will have to be stored at home uncrushed (to enable return to RVM or manual collection point, with latter then have to be processed by counting machine) these containers will be bulky in nature, and as such SLR considers that the assumptions applied in the carbon modelling are conservative; given the bulky nature of the containers (and the potentially limited storage space in some homes) trips might have to be more frequent and a higher number of dedicated trips may occur.

The second largest component of the carbon impact is the installation of the collection infrastructure. This carbon impact is a combination of the development of new floorspace and the electricity requirements of the 2,592 RVMs to be installed (the latter being the dominant impact).

The other components of the conventional DRS system result in relatively modest carbon impacts when compared to installation of collection infrastructure and delivery of materials to collection points.

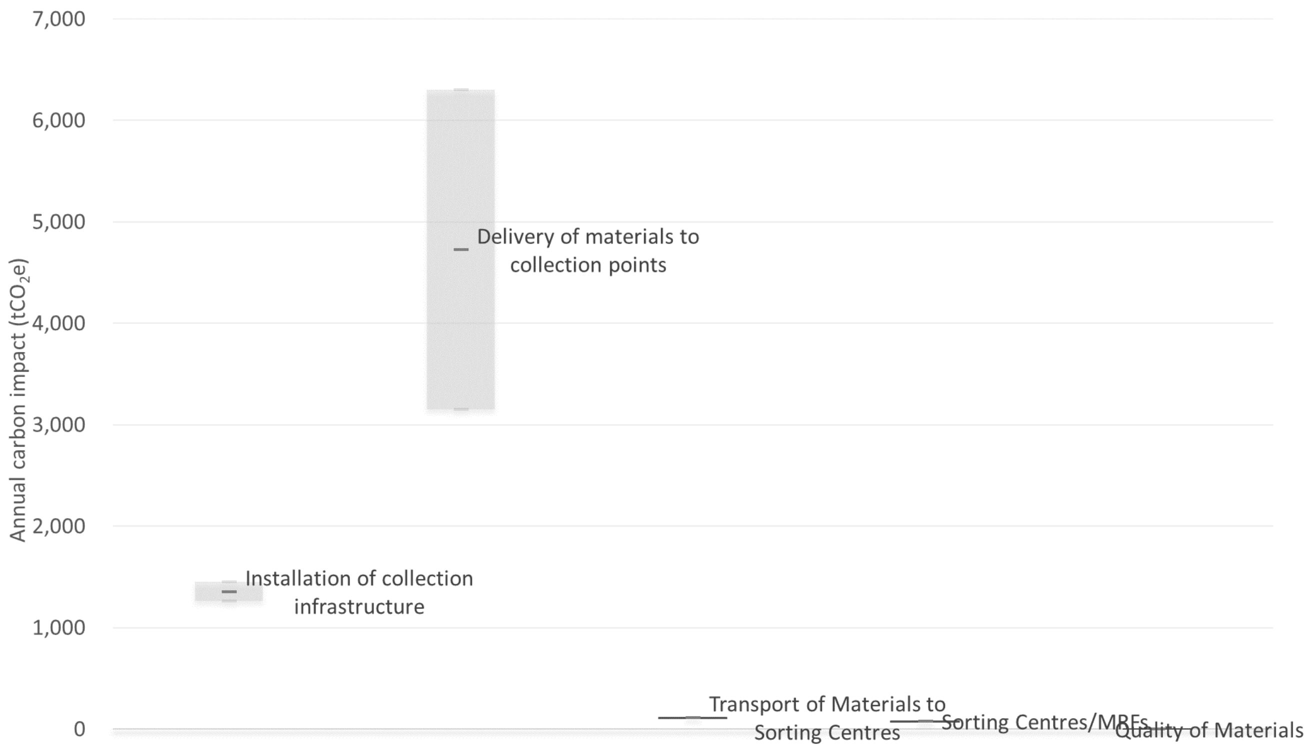

Figure 3-3
Smart DRS – Breakdown of Carbon Impact by Element

In the Smart DRS system, the carbon impact is also dominated (circa 68-79% of the total carbon impact) by the delivery of materials to collection points; this accounts for an assumed longer dedicated trip distance as the 500 RVMs will have a lower density than in the conventional DRS system.

3.3 Net Benefit of Smart DRS

When comparing the carbon impacts of a Smart DRS system to those of a conventional DRS (the baseline system assumed to be implemented), a Smart DRS system would deliver a net benefit of circa 20,000 tCO_2e per annum (with a net benefit range of between circa 13,000 and 30,000 tCO_2e per annum), as shown in Figure 3-4.

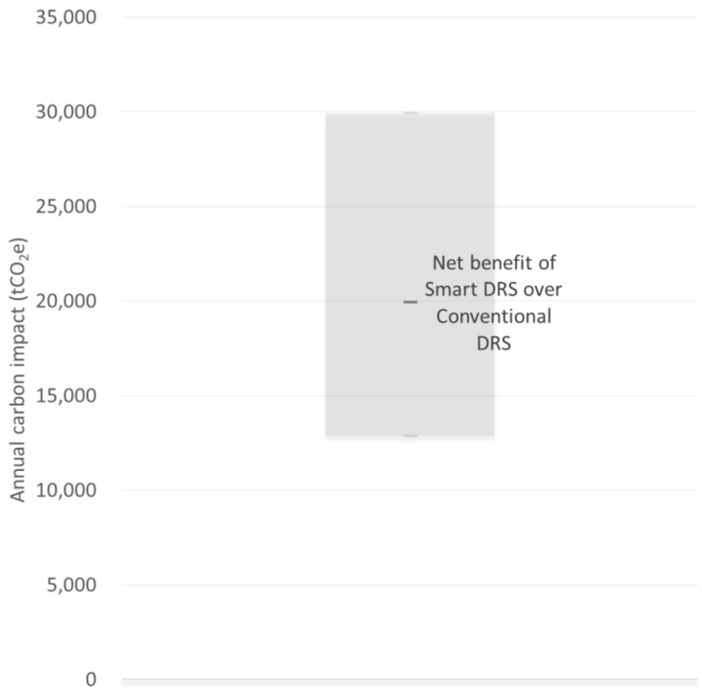

Figure 3-4
Net Benefit of Smart DRS Compared to Conventional DRS

This high level carbon impact analysis, which is conservative with respect to many of the assumptions applied, clearly demonstrates that the implementation of a Smart DRS system would have a lower environmental impact in terms of carbon emissions than implementation of a conventional DRS.

Conversion of the carbon saving of 20,000 tonnes of CO_2e pr annum into something more meaningful in the real world is the equivalent to:

- 9,996 tonnes of coal burned each year:
    - If the coal was stockpiled on the pitch at the Aviva Stadium in a pyramid style it would be 6.5m high.
- 46,304 barrels of oil consumed each year:
    - This is equivalent to approximately 200 oil tanker articulated trucks which if lined up nose to tail would stretch 3.2km across Dublin City from The Custom House on the River Liffey to the People's Garden in the Phoenix Park.

In addition to the carbon impact benefits of Smart DRS, the other key benefits of Smart DRS over conventional DRS should be noted (which will deliver additional carbon impact benefits), including (but not limited to):

- The ability of a Smart DRS as a flexible and adaptable system to access other material streams (such as tetra pak and juice cartons) and thus deliver a further carbon benefit (this assessment is therefore a conservative estimate of the true potential of Smart DRS);
- Smart DRS has the ability to mobilise quicker and get peak carbon benefits sooner. The mobilisation period for conventional DRS will be slower (and therefore achievement of carbon impacts delayed) due to the ramp up period for manufacture and installation of 2,500+ RVMs and also the development timescales required for sorting centre infrastructure (site identification, planning, environmental permit, construction, commissioning and testing.

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