ROAD TO A DEPOSIT RETURN SCHEME IN WALES: A BASELINE ANALYSIS

Source: LLP

Written by: Joan Wang (joanw0226@gmail.com)
Academic affiliation: Cardiff University School of Planning and Geography
Professional affiliation: Friends of the Earth Cymru
Special thanks to: Gareth Clubb, Michael Butterfield and Jemma Bere

Executive Summary

Unsustainable disposals of beverage containers such as litter and landfill pose a significant problem in Wales. Friends of the Earth Cymru (FoE Cymru) believes that enacting a deposit return scheme (DRS) in Wales would help eradicate this problem. Under a DRS, a consumer would pay a small deposit of 10p-20p when he/she buys a beverage, which can be redeemed when he/she returns the beverage container back to the system for reuse/recycling. This research for FoE Cymru provides a first look into some quantifiable benefits of DRS for Wales. Using municipal waste data from 2014, this research estimates that DRS (with a 95% return rate of containers) would reuse/recycle **144 kilotonnes** of beverage containers per year, generating an additional **£7.6 million** in material sales, **£13.8 million** of revenue from unclaimed deposits, and **£179 million** in reduction of litter costs. These results serve as a starting point for further efforts to bring DRS to Wales.

Introduction

Beverage containers such as beer cans and soft-drink bottles are a source of litter that remains indefinitely in the environment. With half of the Welsh population admitted to littering, the amount of beverage-related litter in Wales is undoubtedly significant[1]. These littered containers not only cause severe visual disamenity to local residents and visitors, they also pose several environmental problems. One method to reduce the amount of beverage containers left in the environment is a *deposit return scheme* (DRS), where "[consumers] pay the deposit when they purchase the beverage and receive it back when they return the container to one of the designated collection point"[2].

This method is far from an unprecedented idea. In fact, it has been well established and proven to succeed in 24 countries, half of which are European countries such as Belgium, Germany and Sweden[3]. In the United States, at least eight states have well-documented statistics showing reduction of beverage-related litter to be around 70-84% due to DRS[4].

Currently, there is no such scheme in the UK. Scotland, Northern Ireland and England have considered its adoption with various degrees of seriousness[5]. Wales, often the frontrunner in many environmental issues (e.g. introducing the carrier-bag charge in the UK), must now follow suit and treat DRS as a principal contender to tackle beverage-related litter. Towards this endeavour, an informal coalition of pro-DRS organisations has formed since September 2015 between Friends of the Earth Cymru (an environmental campaign organisation), Llangattock Litter Pickers (a volunteer group in Powys), Keep Wales Tidy (an anti-litter organization), and the Marine Conservation Society.

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[1] Beaufort Research. 2010. *Litter in Wales: Understanding littering and litterers* [Online]. Cardiff: Keep Wales Tidy. Available at: http://www.keepwalestidy.org/research/0415litter_perception_summary_report[1].pdf [Accessed: 6 January 2016]. p.4.
[2] Eunomia. 2015. *A Scottish Deposit Refund System: Final Report for Zero Waste Scotland* [Online]. Available at: http://www.eunomia.co.uk/reports-tools/a-scottish-deposit-refund-system/ [Accessed: 22 September 2015]. p.1.
[3] CRI. 2016a. *The Bottle Bill Resource Guide* [Online]. Available at: http://www.bottlebill.org/ [Accessed: 12 January 2016].
[4] CRI. 2016b. Litter studies in bottle bill states [Online]. Available at: http://www.bottlebill.org/about/benefits/litter/bbstates.htm [Accessed: 12 January 2016].
[5] KWT. 2015a. *Deposit Return Scheme: Keep Wales Tidy Action Paper* [Online]. Available at: http://www.keepwalestidy.org/research/5736kwt_action_paper_v1_-_drs.pdf [Accessed: 9 January 2016]. p.3.

Hosted by FoE Cymru, this three-month independent research project serves as a first attempt to quantify the potential benefits of a DRS in Wales. Firstly, this report identifies environmental problems associated with the disposal of beverage containers, and argues that DRS is a viable solution. Then, a *baseline analysis* is conducted to approximate the amount of beverage containers that could be captured by DRS, including an estimate of beverage-related litter in Wales. Lastly, based on methods employed in the Scottish feasibility report, the results of the baseline are used to infer some benefits of a DRS for Wales[6].

Below is a table of abbreviations used in this report (including references).

DRS	Deposit Return Scheme	MCS	Marine Conservation Society
KWT	Keep Wales Tidy	CRI	Container Recycling Institute
LLP	Llangattock Litter Pickers	WG	Welsh Government
FoE Cymru	Friends of the Earth Cymru		

Figure 1. Table of abbreviations. Source: author's own.

Overview of DRS

An environmental problem with implications in spatial planning

If consumed beverage containers are not properly reused or recycled, they are either sent to landfill or left as litter in the environment. And the latter two of these scenarios pose direct threats to the environment. Focusing on litter, a recent survey shows that **48%** of the Welsh public believe that beverage-related litter has the biggest negative impact on the local community compared to other litter types; **28%** with the second biggest impact[7]. This negative public perception is legitimized by recent quantitative litter data from several sources. Out of the litter collected by 37 community groups in September 2015, **50%** is beverage-related litter by volume[8]. In a rural setting, LLP has found beverage-related litter to comprise **74%** of total litter by volume, over four months of litter-picking in the winter of 2015[9]. Consequently, beverage-related litter has negative impacts for spatial-oriented sectors such as tourism and nature conservation, both of which are vital components of the Welsh economy[10]. As such, beverage-related litter accounts for a substantial amount of the **£70 million** in annual litter clean-up costs in Wales[11].

[6] Eunomia. 2015. p.10.
[7] KWT. 2015b. *Drink Related Litter: A report on the survey findings on the subject of drink related litter in Wales in September 2015* [Online]. Available at: http://www.keepwalestidy.org/login/kcfinder/upload/files/Drink%20Related%20Litter%20Report%202015.pdf [Accessed: 10 January 2016]. p.7.
[8] Ibid. p.9.
[9] Butterfield, M. 2015. *Stats for drink related litter for Llangattock - December 2015.* Email to J. Bere, G. Clubb and J. Wang. 17 December 2015.
[10] WG. 2016. *Visit Wales research: Latest Statistics* [Online]. Available at: http://gov.wales/topics/tourism/researchmain/latest-stats/?lang=en [Accessed 14 January 2016].
[11] KWT. 2015a. p.3.

Focusing on marine litter, as much as **17%** consists of beverage containers[12]. Marine litter can form enormous trash patches that threaten ecosystems. More specifically, plastic bottles are "some of the most obvious pieces of … beach litter" in the UK, endangering wildlife species when broken into microplastics[13]. In fact, plastic bottles are so abundant in marine litter that the European Commission has urged for measures like DRS to address this issue[14]. The unique trait of beverage containers is that they persist in the environment for a long time[15]. Therefore, beverage-related litter will continue to accumulate and alter the Welsh landscape as long as no effective reduction scheme is adopted. On the flip side, beverage-related litter is the only type of litter that carries significant material value if properly recycled. A solution like DRS could see to a drastic reduction in beverage-related litter as well as immediate revenue gains from the sale of recycled containers.

As shown above, the disposal of beverage containers is not a self-contained issue in waste management; it leaves tremendous impacts on other sectors. In Wales, *spatial planning* not only pertains to land development, it also coordinates "the spatial impacts of sectorial policies" by issuing guidance (TANs) for each sector[16]. The TAN on waste has declared that efficiently "managing waste as a resource" has clear benefits on other sectors[17]. Furthermore, the main waste strategy in Wales has ensured the integration between waste management and spatial planning, as required by the EU[18]. Indeed, in "Towards zero waste", the WG has cited reducing ecological footprint as a planning-oriented goal Wales must achieve by managing its waste[19]. More relevant to beverage packaging, the WG has advocated for "'closed loop' recycling whereby materials are re-used for their original purpose," along with principles such as minimising residual waste and eliminating landfill[20]. What other scheme embodies all of these principles better than DRS?

Workings of DRS

In the simplest terms, DRS adds a deposit to the prices of beverages, which consumers can get back once they return the beverage containers. Nonetheless, DRS is very much a governance system that requires much of horizontal coordination (involving multiple sectors such as packaging, manufacturing

[12] MCS. 2015a. *Have you got the bottle?* [Online]. Available at: http://www.mcsuk.org/what_we_do/Clean+seas+and+beaches/Litter+campaigns/Bottle+Deposit+System+for+Wales [Accessed: 6 January 2016].
[13] MCS. 2015b. *Marine Plastics Pollution Policy and Position Statement* [Online]. Available at http://www.mcsuk.org/downloads/pollution/PPPS%20Marine%20Plastics.pdf [Accessed: 10 January 2016]. p.3.
MCS. 2015c. *Pollution and litter problems* [Online]. Available at: http://www.mcsuk.org/what_we_do/Clean+seas+and+beaches/Pollution+and+litter+problems [Accessed: 10 January 2016].
[14] European Commission. n.d. *Integration of results from three Marine Litter Studies* [Online]. Available at: http://ec.europa.eu/environment/marine/pdf/Integration%20of%20results%20from%20three%20Marine%20Litter%20Studies.pdf [Accessed 14 January 2016]. p.1; p.7.
[15] Clubb, G. 2006. *Can and Bottle Litter: Position Paper* [Online]. Keep Wales Tidy. Available at: http://www.bottlebill.org/resources/publications.htm [Accessed: 6 January 2016]. p.13.
[16] Dühr, S. et al. 2010. *European Spatial Planning and Territorial Cooperation*. London; New York: Routledge. p.32.
WG. 2015c. *Technical Advice Note (TAN) 21: Waste (2014)* [Online]. Available at: http://gov.wales/topics/planning/policy/tans/?lang=en [Accessed: 1 February 2016].
[17] WG. 2015c. p.10.
[18] Dühr, S. et al. 2010. p.334.
WG. 2015b. Towards zero waste: The Summary of the Overarching Waste Strategy Document for Wales [Online]. Available at: http://gov.wales/docs/desh/publications/100621wastetowardssummaryen.pdf [Accessed: 9 January 2015].
[19] WG. 2015b. pp.1-2.
[20] Ibid. p.3.

and retail), vertical coordination (between central administration and local implementation) and geographical coordination (distribution and collection logistics)[21]. *Figure 2* is a comprehensive flowchart that illustrates the workings of DRS via financial and material flows.

Figure 2. Workings of DRS. Source: Eunomia[22].

The material flows in *Figure 2* form a closed loop, which demonstrates that a DRS would enable the complete re-use/recycling of beverage containers by the packaging industry. In order to achieve this closed-loop recycling, more *nodes* such as the collection, counting and sale of returned containers are added in the flow of beverage containers. These new nodes represent more areas of coordination between different actors in the system; and the costs of coordination are paid for predominantly by the packaging, beverage and retail industry (see financial flows in *Figure 2*). This conveys a significant

[21] Dühr, S. et al. 2010. p.32.
[22] Eunomia. 2015. p.3.

element of DRS: the principle of *extended producer responsibility* where producers are financially and/or physically responsible "for the treatment or disposal of post-consumer products"[23].

However, DRS does not solely rely on producers to compensate for the negative externality generated by beverage-related waste. The consumers must be incentivised by the deposit payment to return the containers. Hence, the most ingenious element of DRS is shifting the costs of container disposal from local authorities and taxpayers, to manufacturers and consumers[24]. Another feature of the scheme is the existence of a central management body that includes representatives from all relevant industries, but overseen by the government. In addition, the sales revenue from returned containers should stay within the DRS, "[contributing] to the performance of the system overall"[25].

Benefits of DRS

During a meeting with the aforementioned DRS coalition in September 2015, the special advisor of the Minister of Natural Resources expressed that evidence of public approval of DRS is needed to receive political backing. Below is a compilation of results from various surveys—including one in Wales, which indicates the **overwhelming popularity of DRS, both pre-adoption and post-adoption.**

Pre-DRS examples	Post-DRS examples
60% of Welsh public in favour of producer responsibility approach to beverage-related litter; out of them **81%** in favour of DRS in 2015 (KWT 2015b, p.12)	**84%** of people in Massachusetts support an expansion of existing bill in 2003 (CRI 2016c)
78.8% of Scots in favour in 2015 (Moore 2015, para.2)	**90%** of Oregonians in favour 4 years post-DRS (Clubb 2006, p.5)
81.2% of people in Tennessee either support the bill or strongly support it in 2008 (CRI 2016c)	**95%** of South Australians in favour (Clubb 2006, p.5)
75% of Americans supported a national bottle bill in 1993 (CRI 2016c)	**89%** of Dutch consumers in favour (Clubb 2006, p.5)

Figure 3. Public support for DRS from several surveys. Source: multiple sources[26].

As previously examined, the littered beverage containers pose a severe environmental and social problem to the Welsh people. Therefore, the main beneficial outcome of DRS is the overwhelming

[23] OECD. 2001. Extended Producer Responsibility: A Guidance Manual for Governments [eBook version]. Paris: OECD Publishing. Available at: http://dx.doi.org/10.1787/9789264189867-en [Accessed 12 January 2016].
[24] Clubb, G. 2006. p.2.
[25] Eunomia. 2015. p.21.
[26] KWT. 2015b. p.12.
Moore, D. 2015. *78% Of Scots In Favour Of Drinks Deposit scheme* [Online]. CIWM Journal. Available at: http://www.ciwm-journal.co.uk/78-of-scots-in-favour-of-drinks-deposit-scheme/ [Accessed: 10 January 2016].
CRI. 2016c. *Opinion Polls* [Online]. Available at: http://www.bottlebill.org/about/benefits/support-polls.htm [Accessed: 13 January 2016].
Clubb. 2006. p.5.

reduction of littered beverage containers. In the United States, at least eight states have well-documented statistics showing reduction of beverage-related litter to be around **70-84%** due to DRS[27]. To reframe the litter reduction in terms of an increase in recycling rates, an EU-wide study documents that European countries with a DRS have an average aluminium-can recycling rate of about **90%**, contrasted with a rough average of 50% in the non-DRS countries[28].

On top of the striking **reduction in litter and increase in recycling rates** evident in cases worldwide, there are many benefits associated with DRS[29]. Working alongside other recycling schemes, a DRS could be just the right scheme to help Wales increase its recycling rate from 54.3% in 2014 to the target of 70% by 2025, by ensuring a very high capture rate of recyclable materials[30]. Furthermore, containers recycled through the DRS stream will be reprocessed much better than those recycled through conventional streams "because of the high quality (low level of non-target materials) of the stream"[31]. To sum up, DRS gives more value for these materials and renders the reprocessing system more efficient. As a result, beverage packaging from virgin materials will decrease, **reducing energy consumption and greenhouse gas emissions** in the manufacturing industry. Some may argue that DRS would produce additional GHG emissions from backhauling returned containers. But compared to the current system where containers are transported to landfill or recycling centres, the difference in GHG emissions is virtually zero.

For local authorities, adding DRS to existing waste collection services would lead to significant **reduction in litter clean-up costs, as well as savings in kerbside collections and handling of materials**[32]. For example, costs of glass handling would decrease, as there would be less occurrence of broken glass in conventional waste streams[33].

Among the many other societal benefits, DRS could catalyse pro-environmental behavioural change, reduce violent crimes involving glass bottles, and produce up to **206 full time jobs** in Wales (4,300 jobs in the UK, pro-rated with Welsh population)[34].

Challenges of DRS

One challenge of adopting the DRS in Wales is sharing a border with England. Nevertheless, using appropriate container labeling and barcode scanners at the return of containers can help combat cross-

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[27] CRI. 2016b. Litter studies in bottle bill states [Online]. Available at: http://www.bottlebill.org/about/benefits/litter/bbstates.htm [Accessed: 12 January 2016].

[28] Schneider, J. et al. 2011. *A European refunding scheme for drinks containers* [Online]. DG External Policies, European Parliament. Available at: http://www.europarl.europa.eu/RegData/etudes/note/join/2011/457065/IPOL-AFET_NT(2011)457065_EN.pdf [Accessed: 10 February 2016]. p.18.

[29] Clubb, G. 2006. pp.8-9.
CRI. 2016a.
CRI. 2016b.

[30] WG. 2015b. pp.4-5.

[31] Eunomia. 2015. p.84.

[32] Eunomia. 2015. pp.65-69; p.72.

[33] KWT. 2015a. p.6.

[34] Ibid. p.5; p.2.
Hogg, D. 2011. *From waste to work: the potential for a deposit refund system to create jobs in the UK* [Online]. Campaign to Protect Rural England. Available at: http://www.cpre.org.uk/resources/energy-and-waste/litter-and-fly-tipping/item/2359-from-waste-to-work [Acessed 10 January 2016].

border and other forms of fraudulent use[35]. Please see the Scottish report for more information on potential legislative, financial and governance issues in implementing the DRS[36].

Framework & Methodology

Model logic & scope

The rest of this report focuses on the quantitative research undertaken to construct a mass flow baseline. Below I provide some important aspects of the methodology. All other research details are in the technical appendices of the final report presented to FoE Cymru.

The baseline analysis is based on the model presented in the Scottish DRS feasibility report[37]. The general logic for the baseline is:

(1) How many beverages of each packaging material are sold in Wales in a given year?
(2) Of this amount, how much is being recycled and sent to landfill (as residual waste) in each municipal waste stream?
(3) How much of each material is unaccounted for by (1) and (2), and thus becomes litter in the environment? (See equation below.)

(1) - (2) = (3)

This logic could be seen in *Figure 2*, where Eunomia illustrates the mass flows of DRS materials in local authorities' waste management system prior to the adoption of DRS. The temporal scope of the baseline is one year, and the geographical scope covers all local authorities in Wales. Note that a principal assumption is that within a given year, all sold beverages would be consumed and all packaging waste would enter into one of the waste streams. Thus, if some packaging waste is not in any waste streams, it is assumed to be beverage-related litter left in the environment, as represented by the red box in *Figure 4*.

[35] KWT. 2015a. p.5.
Eunomia. 2015. p.90.
[36] Ibid.
[37] Ibid. App. pp.10-22.

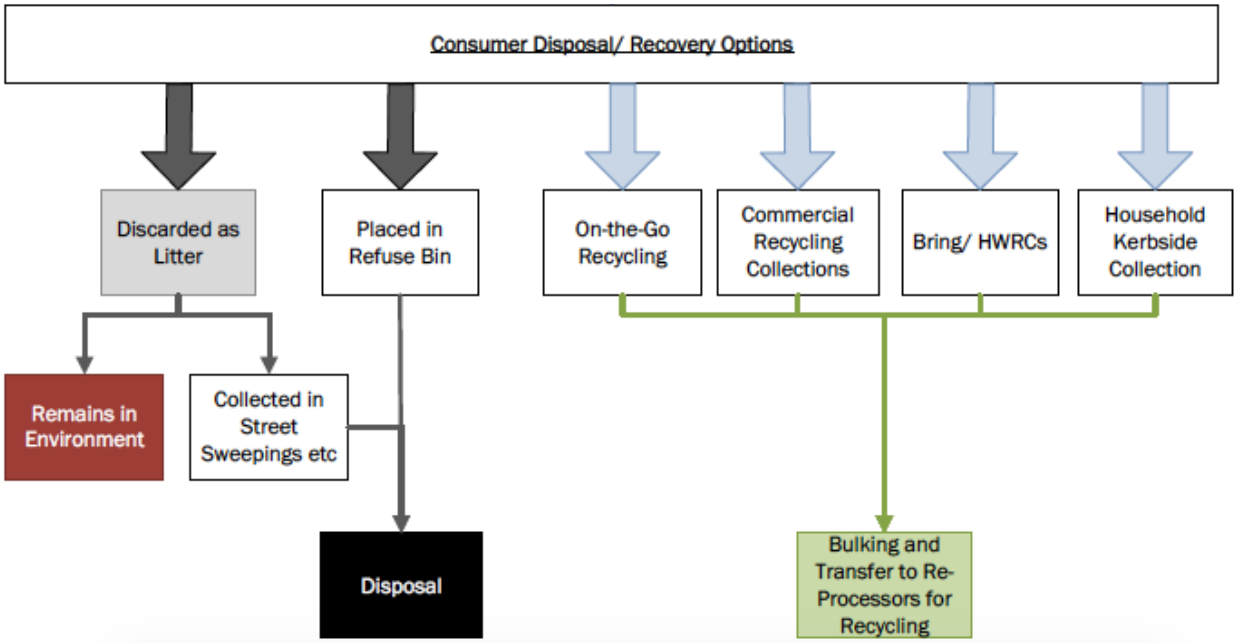

Figure 4. Mass flows of DRS materials in municipal waste management pre-DRS. Source: Eunomia[38].

Mass flow baseline

The mass flow baseline takes the form of a table (see *Figure 5*). The unit of measurement for material mass is kilotonnes. As shown in *Figure 4*, the specific waste streams (each with separate recycling and residual streams) that should be included in the baseline are:

- Household Kerbside
- Bring sites / Household Waste and Recycling Centres (abbreviated as HWRCs)
- Commercial
- Street Cleaning (black box in *Figure 4*). Note that Welsh local authorities do not tend to separate recyclable materials from their Street Cleaning collections, so all materials in Street Cleaning are recorded as residual waste[39].

And the categories of beverage containers are:

- Glass bottles (brown, green, blue, clear, etc.)
- Plastic bottles (PET and HDPE)
- Ferrous cans
- Aluminium cans
- Beverage cartons

[38] Eunomia. 2015. App. p.10.
[39] Bere, J. 2015. *Street cleansing segregation*. Email to M. Butterfield, G. Clubb and J. Wang. 19 November 2015.

The process of constructing the baseline consists of five main steps. The results of each step are color-coded in *Figure 5*.

1. Gathering data of containers sold on the market in 2014 for each DRS material.
2. Applying composition rates to municipal waste data to generate mass of each DRS material for all waste streams (specific time frame is April 2014 to March 2015).
3. Generate the total mass of DRS materials in each municipal waste stream.
4. Calculate the litter mass for each DRS material (in *Figure 5*, litter is the blue *minus* the green).
5. Calculate each waste stream's percent contribution of DRS material mass.
6. Calculate the recycling rate for each material type.

DRS Materials	Total Weight in Kilotonnes	Household Kerbside Recycling	Household Kerbside Residual	HWRCs Recycling	HWRCs Residual	Commercial Recycling	Street Cleaning Residual	Litter	Recycling Rate by Material Type
Glass Bottles									
Plastic Bottles									
Ferrous Cans									
Alum. Cans									
Beverage Cartons									
Total Mass									
Percent Contribution	**100**								

Figure 5. Sample table of mass flow baseline. Source: author's own.

The mass flow baseline essentially presents, among other things, the amount of DRS materials that are currently sitting in conventional waste streams and the amount of beverage-related litter pre-DRS. Then, different post-DRS scenarios of mass flows could be modeled based on hypothesised return rates of materials. Eunomia predicts that a **10p** deposit value per container would lead to a return rate of **85%**, whereas a **20p** deposit would lead to a **95%** return rate[40]. Low-return and high-return scenarios based on these predictions will be presented in the Results section.

Data collection

The data used to construct the mass flow baseline come from various sources, most of whom are the Welsh-equivalent of sources used by the Scottish report. If I cannot acquire the data, then as rule of thumb I obtain the Welsh data by applying the Welsh population rate on the Scottish or UK data. In *Figure 6*, I briefly present the data sources for this research. For more information, please see the appendices of the full FoE Cymru report.

[40] Eunomia. 2015. p.57.

All of the quantitative research (from data processing to modeling) was conducted in the Python programming language, using a data-analysis package called Pandas and an interface called iPython Notebook. Most raw data were downloaded to .csv files, which were then imported into iPython Notebook. Finally, the results of the research are exported back to .csv files for future use.

Data	Sources
Total Mass in Kilotonnes for each material	Sources from each material's industry and Eunomia (2015)
Municipal recycling and waste data	WasteDataFlow (2015)
Composition rates to separate materials in various streams	WRAP (2009; 2010)
Population for Wales, Scotland, and UK	Office of National Statistics (2015)
Supplementary data on beverage-related litter	Clubb (2012); Butterfield (2015) from LLP
Supplementary data for verification	Bere (2015) from KWT

Figure 6. Description of data and their sources. Source: author's own compilation[41].

Analysis of results

This section analyses the mass flow baseline along with DRS scenarios of low/high return rates. The results are interpreted contingent on the assumptions about the model and limits to the data. A comparison of recycling rates between pre-DRS and post-DRS scenarios is given, as well as the revenue gains from unclaimed deposits and sale of materials under DRS. One immediate observation is that the baseline failed to produce realistic estimates of containers in the Litter stream. As a result, I employed other sources to estimate the amount of beverage-related litter in Wales, and calculated savings in litter costs due to DRS.

[41] WasteDataFlow. 2015. *Data Manager* [Online]. Available at: http://81.201.130.52/login.aspx?ReturnUrl=%2fnews%2fwelcome.aspx [Accessed: 14 October 2015].
WRAP. 2009. *MRF Quality Assessment Study* [Online]. Available at: http://www2.wrap.org.uk/recycling_industry/publications/mrf_quality_study.html [Accessed: 3 January 2015].
WRAP. 2010. *The composition of municipal waste in Wales* [Online]. Available at: http://www.wrapcymru.org.uk/content/composition-municipal-solid-waste-wales-0 [Accessed 16 October 2015].
Office for National Statistics. 2015. *Population Estimates for UK, England and Wales, Scotland and Northern Ireland, Mid-2014* [Online]. Available at: http://www.ons.gov.uk/ons/publications/re-reference-tables.html?edition=tcm%3A77-368259 [Accessed: 14 January 2016].
Clubb. 2012. *Litter on rural Welsh roads: A case study from Penisa'r Waun*, trans. G Clubb. Gwerddon, Rhif 12 (Rhagfyr 2012), tt. 10-23. Available at: http://www.gwerddon.org/flipbook/rhif12/index.html#/10/zoomed [Accessed: 11 January 2016].
Butterfield. 2015.
Bere. 2015.

Mass flow baseline

DRS Materials	Total Weight in Thousand Tonnes	Household Kerbside Recycling	Household Kerbside Residual	HWRCs Recycling	HWRCs Residual	Commercial Recycling	Commercial Residual	Street Cleaning Residual	Litter	Recycling Rate
DRS Glass Bottles	95.29	43.68	8.83	7.68	1.13	6.22	1.49	1.38	24.89	0.60
DRS Plastic Bottles	42.98	18.79	6.54	3.30	0.64	0.35	1.61	1.43	10.32	0.52
DRS Ferrous Cans	3.61	2.10	0.67	1.52	0.54	0.71	0.53	0.37	-2.84	1.20
DRS Aluminium Cans	6.22	3.53	1.41	0.57	0.14	0.18	0.13	0.74	-0.48	0.69
DRS Beverage Cartons	2.87	0.45	1.60	0.11	0.07	0.08	0.19	0.09	0.29	0.22
Total	150.98	68.55	19.06	13.18	2.52	7.54	3.95	4.00	32.17	0.59
Percent Contribution	100.00	45.40	12.62	8.73	1.67	5.00	2.62	2.65	21.31	NaN

Figure 7. Mass flow baseline for Wales in 2014. Source: author's own.

In the current pre-DRS waste flows (i.e. the baseline in *Figure 7*), the recycling rate of all DRS materials is **59%**, slightly higher than the Scottish rate of 54%[42]. This is consistent with recent recycling trends in the UK[43]. Nonetheless, there are still **41%** of beverage containers—or **61.7 kilotonnes** of materials—out of the conventional recycling streams. This amount more than justifies the adoption of schemes like DRS to achieve a higher recovery rate[44].

Breaking it down by waste streams, household kerbside collections alone account for **45%** of DRS materials, compared to 23% in Scotland[45]. Moreover, the recycling rate of DRS materials in household streams is **78%**, compared to 47% for Scotland[46]. Other than the explanation that Welsh households recycle more, a portion of household-DRS materials could actually be from the commercial stream as some Welsh local authorities may not be able "to provide an accurate split between the household and non-household waste collected"[47]. Another noticeable aspect is the tremendously high recycling rate of DRS materials in the HWRCs stream (**84%**). But as Eunomia explains, it is mostly because HWRCs generally do not receive much residual waste[48].

Examining the baseline by each DRS material provides more illuminating information. Recycling rates by material are roughly consistent with UK-wide rates: for example, baseline rate for glass bottles is

[42] Eunomia. 2015. App. p.20.
[43] DEFRA. 2015. UK Statistics on Waste [Online]. Available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/487916/UK_Statistics_on_Waste_statistical_notice_15_12_2015_update_f2.pdf [Accessed: 14 January 2016]. p.3.
[44] Eunomia. 2015. App. p.20.
[45] Ibid. App. p.21.
[46] Ibid.
[47] StatsWales. 2015. *Waste generated (tonnes) by source and year* [Online]. Available at: https://statswales.wales.gov.uk/Catalogue/Environment-and-Countryside/Waste-Management/Local-Authority-Municipal-Waste/Annual/wastegenerated-by-source-year [Accessed: 14 January 2015].
[48] Eunomia. 2015. App. p.19.

60% whereas UK glass packaging rate is 68.3% in 2013[49]. However, the baseline still leaves **12.83 kilotonnes** of glass bottles in landfill, even given the wide awareness of the recyclability of glass. As a share of these glass bottles end up in landfill because they are broken, introducing a DRS could help people recognise the value in returning unbroken glass bottles[50]. Moving on, as one in two plastic bottles are thrown away, there are **10.22 kilotonnes** of plastic bottles in landfill, which is almost **310 million** PET bottles. Regarding beverage cartons, the baseline has shown very low recycling rates: in household kerbside, cartons in residual waste weight **3.5 times** more than cartons in recycling. However, there already exist technologies in the UK to pick out cartons from co-mingled materials and efficiently recycle them[51]. Therefore, this is an area where DRS could induce behavioural change in carton recycling, and drastically increase its recovery rate.

Drink cans (both ferrous and aluminium) have not been analysed because the baseline failed to produce a realistic estimate of the amount of drink cans littered in the environment (note the negative values). This result could be attributed to an overestimation in the amount of drink cans disposed in the conventional waste streams, caused by the imprecision of some of the composition rates (e.g. using composition rates that represent both food cans and drink cans). Additionally, Eunomia encountered the same issue and expressed uncertainty in the low number of cans placed on the market (estimated at a UK level), which would also contribute to the negative mass in littered cans[52].

Regardless of the data inconsistencies for drink cans, the baseline still puts forth accurate masses of DRS materials in conventional waste streams (green in *Figure 6*), given the quality of municipal data and composition rates. And overall, littered containers accounted for **21%** of all beverage containers in 2014, whereas municipal Street Cleaning picked up 10 times less than that. *Figure 8* and *Figure 9* illustrate the mass flows post-DRS based on low (85%) and high (95%) return rates of containers. With these scenarios, the next section presents some monetised benefits of DRS.

[49] DEFRA. 2015. p.13.
[50] KWT. 2015a. p.6.
[51] ACE UK. 2013. *How are beverage cartons recycled?* [Online]. Available at: http://www.ace-uk.co.uk/recycling/how-are-beverage-cartons-recycled [Accessed 14 January 2016].
[52] Eunomia. 2015. p.80.

DRS Materials	Total Weight in Thousand Tonnes	Household Kerbside Recycling	Household Kerbside Residual	HWRCs Recycling	HWRCs Residual	Commercial Recycling	Commercial Residual	Street Cleaning Residual	Litter	DRS Stream
DRS Glass Bottles	95.29	0.71	5.72	0.39	1.98	0.32	2.61	2.42	0.14	81.00
DRS Plastic Bottles	42.98	0.32	2.58	0.29	0.55	0.03	1.38	1.23	0.06	36.53
DRS Ferrous Cans	3.61	0.03	0.22	0.02	0.10	0.01	0.10	0.07	0.01	3.07
DRS Aluminium Cans	6.22	0.05	0.37	0.04	0.06	0.01	0.06	0.33	0.01	5.29
DRS Beverage Cartons	2.87	0.02	0.17	0.01	0.04	0.01	0.11	0.05	0.00	2.44
Total	150.98	1.13	9.06	0.72	2.67	0.41	4.19	4.24	0.23	128.33
Percent Contribution	100.00	0.75	6.00	0.48	1.77	0.27	2.77	2.81	0.15	85.00

Figure 8. Mass flows in DRS of low return rate (85%). Source: author's own.

DRS Materials	Total Weight in Thousand Tonnes	Household Kerbside Recycling	Household Kerbside Residual	HWRCs Recycling	HWRCs Residual	Commercial Recycling	Commercial Residual	Street Cleaning Residual	Litter	DRS Stream
DRS Glass Bottles	95.29	0.24	1.91	0.13	0.66	0.11	0.87	0.81	0.05	90.53
DRS Plastic Bottles	42.98	0.11	0.86	0.10	0.18	0.01	0.46	0.41	0.02	40.83
DRS Ferrous Cans	3.61	0.01	0.07	0.01	0.03	0.00	0.03	0.02	0.00	3.43
DRS Aluminium Cans	6.22	0.02	0.12	0.01	0.02	0.00	0.02	0.11	0.00	5.91
DRS Beverage Cartons	2.87	0.01	0.06	0.00	0.01	0.00	0.04	0.02	0.00	2.73
Total	150.98	0.38	3.02	0.24	0.89	0.14	1.40	1.41	0.08	143.43
Percent Contribution	100.00	0.25	2.00	0.16	0.59	0.09	0.92	0.94	0.05	95.00

Figure 9. Mass flows in DRS of high return rate (95%). Source: author's own.

DRS scenarios

Increase in recycling rates

Figure 10 demonstrates the drastic increase in recycling rates of containers in all categories post-DRS. The recycling rates under both DRS scenarios are slightly higher than the modelled return rate of containers through the DRS stream because a small amount of containers still enter the conventional recycling streams.

DRS Materials	Baseline Rate	Rate Under DRS - Low	Rate Under DRS - High
Glass Bottles	60%	86%	96%
Plastic Bottles	52%	86%	96%
Ferrous Cans	76%*	86%	96%
Aluminium Cans	71%*	86%	96%
Beverage Cartons	22%	86%	96%
Total	59%	86%	96%

Figure 10. Comparison of recycling rates of DRS materials between baseline and DRS scenarios. Source: author's own. *Note that the baseline did not produce realistic recycling rates for ferrous cans and aluminium cans. The baseline rates shown are recycling rates in the household kerbside stream.

Revenue from sale of materials

Assuming all plastic bottles recovered are PET, the total revenue from sales of recovered materials range from **£17.7 million** to **£19.5 million** per year, for Low and High scenarios respectively. As a mix of PET and HDPE bottles are expected in DRS, the total revenue per year will be higher in reality. Based on these estimates, DRS could gain an additional **£5.8 million** to **£7.6 million** per year in material revenue, compared to the baseline revenue of £11.9 million.

DRS Materials	Revenue per tonne	Material Mass in Tonnes (DRS - Low)	Revenue (DRS - Low)	Material Mass in Tonnes (DRS - High)	Revenue (DRS - High)
Glass Bottles	25	82410	£2,060,250	91000	£2,275,000
Plastic Bottles	300	37180	£11,154,000	41050	£12,315,000
Ferrous Cans	107	3130	£334,910	3450	£369,150
Aluminium Cans	768	5390	£4,139,520	5940	£4,561,920
Beverage Cartons	0	2480	£0	2740	£0
Total	n/a	130590	**£17,688,680**	144190	**£19,521,070**

Figure 11. Revenue from the sale of recovered materials under Low and High DRS scenarios. Source: author's own & Eunomia for Revenue per tonne[53].

Revenue from unclaimed deposits

Pro-rated from Scottish data, there are 1383 million beverage containers placed on the market in Wales in 2014[54]. Eunomia estimates that for a deposit value of 10p, 15% of the drink containers (in number)

[53] Eunomia. 2015. p.58.
[54] Ibid. App. p.12.

would not enter the DRS. Thus, using the equation below, this low-return DRS scenario would derive about **£20.7 million** of revenue from unclaimed deposits. For a higher deposit of 20p, Eunomia postulates that people are more likely to return the containers, thus leaving only 5% of the containers outside the DRS. This high-return DRS scenario would lead to **£13.8 million** of revenue from unclaimed deposits. It is widely regarded as good practice that the revenue from unclaimed deposits be transferred back to fund the DRS or distributed via an intermediary to environmental charities.

Revenue = Total number of drinks * Deposit value * Percentage unclaimed

Beverage-related litter

Estimation from baseline

The mass flow baseline estimates that there are **32.17 kilotonnes** of containers left as litter in the environment in Wales 2014. **24.89 kilotonnes** of the litter are glass containers, which amount to about **65 million** littered glass bottles. This could be an overestimation due to a number of reasons. For instance, a portion of glass bottles could have been sold in 2014 but not consumed, which the baseline model would have included in the litter stream.

Moving on to plastic bottles, the baseline estimates that there would be **10.32 kilotonnes** of plastic bottles in litter, equivalent to **312.7 million** PET bottles or **184 million** HDPE bottles. Skipping the negative values of ferrous-can and aluminium-can litter, the baseline estimates the number of littered beverage cartons to be about **13.8 million**. As all of these figures seem quite exaggerated, I employ three other methods to come up with more accurate estimations.

1% estimation from Eunomia

The Scottish report used a conservative 1% of the total material mass to estimate the amount of litter for each material[55]. The number of littered containers of this method are at least 10 times less than the estimation from the mass flow baseline (see *Figure 12*). Next, I will cross-reference with estimates from litter-picking case-studies.

[55] Eunomia. 2015. App. p.18.

DRS Material	Total Mass in Kilotonnes	Litter Mass in Tonnes (1%)	Number of containers in Litter (1%)
Glass Bottles	95.29	952.9	2.5 million
Plastic Bottles	42.98	429.8	13 million of PET or 7.7 million of HDPE
Ferrous Cans	3.61	36.1	1 million
Aluminium Cans	6.22	62.2	3.7 million
Beverage Cartons	2.87	28.7	1.4 million
Total	150.98	1509.8	21.6 million (with PET)

Figure 12. Estimation of beverage-related litter based on Eunomia's 1% method. Source: author's own.

Estimation from Penisa'r Waun

For 9 months between 2010 and 2011, a researcher collected 7.776 kilograms of litter by himself along 1.38 kilometres of a rural road in Gwynedd[56]. With 73.6% of the litter being beverage-related, on average there are 4.147 kilograms of beverage-related litter per kilometre.

If this rate is applied to the total highways distance in Wales (34,459km in 2014), an estimate of 142.9 tonnes of beverage-related litter exist in Wales in 9 months[57]. This amounts to about **190.5 tonnes** of beverage-related litter in one year, which is almost 10 times less than the figure using Eunomia's 1% method. This figure is arguably an underestimation of beverage-related litter in Wales, as the road from which the litter was picked is a very small rural road.

Estimation from LLP

LLP, an active community litter-picking group in Powys, has specific data on beverage-related litter between September and December 2015[58]. The average beverage-related litter per month is 50 kilograms over 70 miles of roadsides. This translates to 0.4438 kilograms per kilometre per month, which is about 5.326 kilograms per kilometre per year. Applying this rate to the total highways distance in Wales results in **183.5 tonnes** of beverage-related litter in Wales in one year.

This figure is consistent with results from the Penisa'r Waun study, which is understandable given the rural context of both studies. Nevertheless, LLP is one of the most active and consistent litter-picking groups (monthly collection since its inception in November of 2009). Therefore, further research with its data would give an accurate and updated situation on beverage-related litter in (rural) Wales.

[56] Clubb, G. 2012.
[57] WG. 2015a. *Road lengths and conditions* [Online]. Available at: http://gov.wales/statistics-and-research/road-lengths-conditions/?lang=en [Accessed: 11 January 2016].
[58] Butterfield, M. 2015.

Conclusion on litter mass

	Baseline	Eunomia's 1%	Penisa'r Waun	LLP
Beverage-related litter in 2014	32.17 kilotonnes	1510 tonnes	190.5 tonnes	183.5 tonnes

Figure 13. Summary of beverage-related litter from different methods of estimation. Source: author's own.

To conclude, this report uses four methods to estimate the mass of beverage-related litter in Wales in 2014: from its own baseline model, from the 1% estimation of Eunomia, from the Penisa'r Waun study and LLP. *Figure 13* provides displays the results from the aforementioned methods. Despite the comprehensive data given by Penisa'r Waun and LLP, they only pertain to beverage containers collected off of roadsides in rural areas, which exclude containers that end up in scenic areas, footpaths, the sea via rivers, etc. If a net neutral deposition on Welsh beaches is assumed (litter export to other beaches = import from those sources), then marine litter found on Welsh beaches should also be included in the litter mass. There are 6,437 litter items per kilometre along the Welsh coastline in 2014, out of which up to 17% is beverage-related[59]. This amounts to about 1.53 million beverage containers over all 1,400 kilometres of the Welsh coastline[60]. Using an average container weight of 96.8 grams, about **148.3 tonnes** of beverage containers are littered from the Welsh coastline in one year[61].

Adding the estimation from LLP, there are at least **331.8 tonnes** of beverage-related litter in Wales per year. This is still an underestimation because the litter clean-ups by LLP and MSC are still missing many types of places where litter populate, such as the urban centres. Therefore, it is safe to assume that the amount could be anywhere from **331.8 tonnes** to **1509.8 tonnes** (from Eunomia's conservative 1% method), but mostly likely to be even higher.

Reduction in costs of litter post-DRS

Pro-rated from Scottish data in 2013, total litter in Wales per year is about 15,611 tonnes[62]. In the baseline model, 1,510 tonnes of beverage-related litter (from Eunomia's 1% estimation) amount to 10% of the total litter. Assuming a linear relationship between litter weight and clean-up costs, it would cost **£7 million** per year to clean up the beverage-relate litter (total litter clean-up cost is estimated to be £70 million per year in Wales[63]).

On the other hand, the percentage of beverage-related litter out of overall litter (in weight) is much larger in the Penisa'r Waun and LLP studies (73.6%[64] and 45%[65], respectively). Using the LLP rate, as

[59] MCS. 2014. *Great British Beach Clean Report 2014* [Online]. Available at: http://www.mcsuk.org/downloads/pollution/beachwatch/latest2015/MCS_GBBC_2014_Report.pdf [Accessed: 14 January 2016]. p.4. MCS. 2015a.
[60] Visit Wales. n.d. Wales Coast Path guide [Online]. Available at: http://www.visitwales.com/things-to-do/activities/walking-hiking/wales-coast-path [Accessed: 14 January 2016].
[61] Eunomia. 2015. App. p.51.
[62] Ibid. App. p.62-63
[63] KWT. 2015b. p.3
[64] Clubb 2012.

much as **£31.5 million** could be contributed to cleaning up beverage-relate litter. Under DRS with a return rate of 95%, only 90 tonnes of beverage containers exist in litter (*Figure 9*), which would cost only **£360,000**. Therefore, the high-return DRS would save **£31.14 million** per year in the *direct* cost of beverage-related litter.

Pro-rated from Scottish data[66], the overall *indirect* costs of litter (property values, health, crime, visual disamenity) in Wales amount to at least £296.6 million per year. As 50% of litter is beverage-related by volume[67], the indirect cost of beverage-related litter in Wales per year is **£148.3 million**. Needless to say, this number would reduce significantly under a DRS.

In total, a high-return DRS scenario could reduce as much as **£179 million** per year in the direct and indirect costs of litter in Wales.

Conclusion

In line with the EU's new *circular economy strategy*, DRS incentivises the reuse of beverage-related containers within the market (producers and consumers) while creating manifold benefits for other sectors[68]. Reviewing both domestic and international literature, this report has underlined several of these benefits. But more importantly, the research has estimated some monetised outcomes of DRS where most beverage containers are reused and recycled instead of littered or thrown in landfill.

To summarise, municipal waste data are processed to produce a baseline that describes the current "end state" of beverage containers in the Welsh waste management system. Then, the same mass flows are estimated under the DRS scenario. Comparing the baseline figures to those in the high-return (95%) DRS scenario, this project estimates that DRS would reuse/recycle **144 kilotonnes** of beverage containers per year, generating an additional **£7.6 million** in material sales, **£13.8 million** of revenue from unclaimed deposits, and **£179 million** in reduction of litter costs.

Although the baseline contains unrealistic results for two types of beverage containers (ferrous an aluminium cans), this project has employed rigorous triangulation and cross-referencing of data and methods from other credible sources to ensure the accuracy of the rest of its analysis. In addition, the exploration of four different methods to estimate beverage-relate litter mass more or less demonstrates the difficulties involve in 'quantifying the litter problem.' Therefore, the results of this research should serve as a basis for larger feasibility studies in the near future.

Putting DRS on the Welsh political agenda requires the campaign efforts of FoE Cymru. Despite its small size, FoE Cymru has successfully lobbied for the plastic-bag charge and a GMO-free Wales along with other organisations. Due to resource constraints, FoE Cymru must utilise other channels to carry out its environmental campaigns. For example, this research project is the result of a partnership

[65] KWT. 2015b. p.9
[66] Eunomia. 2015. pp.82-83
[67] KWT. 2015b. p.9.
[68] European Commission. 2016. *Circular Economy Strategy* [Online]. Available at: http://ec.europa.eu/environment/circular-economy/index_en.htm [Accesed 15 January 2016].

between FoE Cymru and the PLANET Europe master programme. And the insights provided by this project are supplemented by expert knowledge from other organisations that collaborate with FoE Cymru. As a result, along with the pro-DRS coalition, FoE Cymru can help introduce a scheme that leads Wales into a litter-free circular-economy future.