Creating a world fit for the future

Waste Services Carbon Modelling

Report for Surrey County Council

DRAFT

Customer:

Surrey County Council (SCC)

Customer reference:

ED15762

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Executive summary

To be completed following client review of this DRAFT report.

Table of Contents

Glossary

Abbreviation	Definition
BEIS	Department for Business, Energy and Industrial Strategy
CAT	Carbon Assessment Tool
CO_2-eq	Carbon Dioxide equivalent
CRC	Community Recycling Centre
DD	Direct Delivery
DMR	Dry Mixed Recycling
EfW	Energy from Waste
GHG	Greenhouse Gas
MRF	Materials Recovery Facility
PAMS	Newspapers and Magazines
PTTs	Pots Tubs and Trays
SCC	Surrey County Council
TS	Transfer Station
WEEE	Waste Electronic and Electrical Equipment
WRAP	Waste and Resources Action Programme
WRATE	Waste and Resources Assessment Tool for the Environment

1 Background

Surrey County Council (SCC) is a county council in the South East of England, encompassing the 11 district and borough councils of: Elmbridge Borough Council, Epsom and Ewell Borough Council, Guildford Borough Council, Mole Valley District Council, Reigate and Banstead Borough Council, Runnymede Borough Council, Spelthorne Borough Council, Surrey Heath Borough Council, Tandridge District Council, Waverley Borough Council and Woking Borough Council.

Each council provides a comprehensive range of kerbside collection services for Dry Mixed Recycling (DMR), source segregated food waste, garden waste (charged opt-in service), charged bulky waste collections and residual waste. Although all these materials are collected at the kerbside by the councils, residents can also deposit these and other materials at one of fifteen Community Recycling Centres (CRCs) located across the County.

SCC's integrated waste management contract expires in September 2024 and SCC have commenced a programme to reprocure waste services within the county. The scope of services includes the operation of five waste transfer stations, fifteen community recycling centres and the transportation and treatment of all waste collected at those facilities. The 'Rethinking Waste' programme has as a principal objective, the re-procurement of waste services, however the scope and desired outcomes of the project go beyond that and are as follows:

- To ensure a circular economy model is adopted to minimise waste and maximise the value
  of resources
- To minimise the amount of waste produced
- To reduce the carbon impact of waste collection and disposal
- To reduce the illegal dumping of waste by fly tipping
- To increase the amount of waste that is recycled or reused
- To reduce the amount of waste sent to landfill
- To maximise the resource recovery of residual waste, and
- To ensure that service costs represent best value for money

SCC wishes to understand the scale and relative breakdown of greenhouse gas (GHG) emissions, (measured in CO_2-eq) arising from their existing waste contract services and has commissioned Ricardo Energy & Environment to complete a high-level carbon assessment. The system boundaries for this study consist of the activities within the management responsibility of SCC as the waste disposal authority, which include:

- the operation of the transfer stations
- the operation of CRCs
- the transport of waste and material streams
- processing and final treatment of the waste received at these sites.

In addition to the assessment, the team has identified the carbon emissions hotspots and recommended mitigation measures for the carbon intensity of the activities, which could form part of a future procurement. The model used to assess the emissions will be provided to SCC, so that it can be updated in the future.

2 Methodology

The methodology focused on developing a model that robustly and transparently quantifies the baseline carbon emissions from the defined waste services.

The model development phase involved the design, development and testing of an excel-based tool that calculates the carbon emissions of the transport and processing of waste, as well as carbon emissions arising from the operations of the transfer stations and CRCs within the control of SCC, based on input data provided by the council and a set of agreed assumptions.

2.1 Model

2.1.1 Development

Ricardo developed a bespoke model for SCC, referred to in this report as the Carbon Assessment Tool (CAT). The CAT has been built according to the following specifications, which were developed in liaison with SCC and according to the specific requirements. As mentioned above, the primary aim of the model is to allow SCC to assess the carbon emissions arising from their current waste contract services. SCC should be provided with the functionality to update the model as and when required, with the latest actual data available to them. The following list sets out the key requirements for the design of the model:

A. The model should accept input data such as quantity of waste, distances travelled, and vehicles used at the level of detail that is readily available to SCC. This input data should be easy to update.
B. The model should use evidence-based assumptions and include references. These references should be easy to update, such as the origin of the carbon factors to allow for these updates to be made.
C. The model should calculate the emissions related to the transport and processing (recycling, treatment and disposal) of the following materials:
    i. Collected at kerbside:
        a) Garden waste
        b) Food waste
        c) Residual (black bag) waste
        d) Kerbside commingled dry recycling (further broken down into individual materials)
    ii. Collected in CRCs:
        a) Batteries and accumulators wastes
        b) Chemical wastes
        c) Discarded equipment (excluding discarded vehicles, batteries and accumulators wastes)
        d) Glass wastes
        e) Household and similar wastes
        f) Metallic wastes, ferrous
        g) Metallic wastes, mixed ferrous and non-ferrous

h) Mineral waste from construction and demolition
i) Other mineral wastes
j) Paper and cardboard wastes
k) Rubber wastes
l) Textile wastes
m) Used oils
n) Vegetal wastes
o) Wood wastes
p) Plastic wastes

The model should calculate the quantity of relative carbon emissions attributable to the material streams managed, by associated process and the quantity of relative carbon emissions for the transport of the material streams. It should also present the emissions in graphs that facilitate the identification of the emissions hotspots in terms of processes and materials.

2.1.2 Assumptions

The model contains several assumptions that have been used to complete the calculations. Appendix A1 provides these assumptions in full detail, Table 1 highlights the key assumptions used.

Table 1: Key Modelling Assumptions

Item	Assumption	Function	Source
Residual waste destination	All residual waste assumed to be sent to EfW plants located within 100 miles from the transfer station or CRC.	Used to calculate emissions from transporting residual waste to the final destination and for the residual waste treatment solution.	Agreed in discussion with SCC
Final destinations post-MRF	For the distances from the MRFs to the final destinations, the destination where most of the tonnage was sent on average between October 2020 and June 2021 was selected as the sole destination.	Used to calculate emissions from transporting recyclables to their final destination.	DMR Destination List file provided by SCC
Trips	The trips to the facilities are assumed to be one-way for shipping and round trips for road transport.	Used to calculate transport emissions.	Assumption based on previous experience
DD & TS Distances	A weighted average was used for the distances where multiple destinations exist.	Used to calculate DD & TS transport emissions.	Agreed in discussion with SCC
CRC Distances	Materials from CRCs sent to transfer stations were assumed to travel 50 miles to their final destination	Used to calculate some of the CRC transport emissions.	Agreed in discussion with SCC

Item	Assumption	Function	Source
Operations	Transfer stations and CRC fuel consumption in operations is based on data from WRATE.	Emissions from operations	WRATE
Operations	Where emissions were reported for CRCs and transfer stations as one value, the average emission factor (tonnes CO_2-eq/tonne waste) was calculated for CRCs and applied to these values. These emissions were then deducted from the total emissions to calculate the emissions from transfer stations.	Emissions from operations	Data provided by Suez
Material Bulk Densities	WRAP's bulk density report, WRAP's Kerbside Analyser Tool (KAT), online sources (CRC materials)	Used to calculate the volume taken up by the waste quantities, by material, and thus the number of vehicle loads required.	WRAP
Vehicle Specifications	WRAP's Kerbside Analysis Tool and Department of Transport	Used to calculate fuel consumption, as well as number of vehicle loads.	Department of Transport
Fuel Emission Factors	UK Government Emission Factors	Used to calculate emissions from fuel consumption.	UK Government
Material Processing Emission Factors	Scottish Carbon Metric Note: this includes emissions from collection, transport, treatment and offsets, known as 'avoided emissions'.	Used to calculate emissions from waste processing.	Zero Waste Scotland
Electricity Grid Emission Factors	BEIS Factors	Used to calculate emissions from electric vehicles (in the future).	BEIS

2.1.3 Transport

The operational boundaries of SCC include the bulk transport of materials collected in the five transfer stations and fifteen CRCs to their final treatment destinations. Using the inputs, as outlined in Appendix 0, the model calculates the total mileage travelled for the transfer of each material collected at kerbside, from each transfer station and CRC, the total fuel consumption and the resulting carbon emissions. The Tool then displays results in tables and charts, as shown in section 3.

2.1.4 Operations

The operation of the five transfer stations and fifteen CRCs is within the scope of services provided by SCC. To account for the emissions from the operation of these sites, the model uses the annual electricity and fuel consumption. The results are presented in totals and by material stream for each facility. The Tool then displays results in tables and charts, as shown in section 3. The calculation is presented in detail in Appendix 0. For the results presented in section 3, emissions provided by the sites' operator are used instead of electricity and fuels consumption.

2.1.5 Waste Processing Emissions

Waste processing emissions relate to the energy and fuels used to handle, sort and process the materials for recycling and treatment purposes i.e. post collection treatments such as MRFs, EfW plants, composting and landfill sites. Emissions primarily originate from fuels such as diesel and burning oil used by plant and equipment on site (scope 1 emissions) and from the import of electricity purchased from the national grid (scope 2 emissions). The Scottish Carbon Metric factors used to calculate processing emissions for each material include 'avoided emissions' and thus result in negative emissions for many materials. From a carbon accounting perspective, these avoided emissions would not be able to be counted in SCC's carbon footprint calculation, as they would form part of SCC's Scope 3 emissions. They have been used in this project to provide a high-level perspective of the contribution recycling makes in reducing the need for raw materials and energy to manufacture products from scratch.

Ricardo's CAT calculates waste processing emissions based on the final destination the user has selected. The calculation is presented in detail in Appendix 0. The Tool then displays results in tables and charts, as shown in section 3.

3 Results

The CAT model provides two forms of outputs: total emissions and emissions per tonne of waste. The total emissions section provides an overview for SCC to examine which components are most responsible for SCC's overall carbon footprint (hotspots), within the scope of this project. Whereas the emissions per tonne section allows SCC to compare materials on a like-for-like basis to determine which materials have larger footprints.

3.1.1 Tonnes Modelled

The tonnes entered into the model are shown in Table 2 and Table 4 below. These quantities are presented to provide context to the results in the following sections. In addition, Table 3 presents the composition of the kerbside collected materials. Residual waste makes up 43 per cent of the total, while recycling contamination averages 3 per cent of the total, or 11 per cent of the dry recyclable stream.

Table 2: Kerbside Collected Tonnes Modelled

Waste Stream	Elmbridge BC	Epsom & Ewell BC	Guildford BC	Mole Valley DC	Reigate & Banstead BC	Runnymede BC	Spelthorne BC	Surrey Heath BC	Tandridge DC	Waverley BC	Woking BC	Total
Mixed Paper incl PAMS	3,599	2,455	6,607	3,017	2,071	2,623	3,304	3,281	4,464	4,641	2,116	**38,178**
Card	3,961	1,979	1,118	2,471	5,482	1,686	1,661	2,241	608	2,670	2,378	**26,256**
Mixed Glass	3,870	2,240	4,167	2,240	5,926	2,048	2,365	2,060	3,103	4,457	2,181	**34,657**
Steel Cans	550	137	443	349	342	183	362	213	293	342	357	**3,571**
Aluminium cans	302	93	247	209	386	131	228	141	166	198	207	**2,308**
PTTs	209	167	299	121	300	192	248	227	214	318	142	**2,436**
Plastic bottles	451	219	460	236	450	289	384	312	299	372	319	**3,792**
Plastic films	-	-	152	-	-	-	-	-	101	-	-	**253**
Mixed Plastic	809	410	593	337	705	449	467	562	426	722	573	**6,052**
Recycling Contamination	1,588	1,219	2,513	932	1,217	687	665	1,487	1,644	939	988	**13,879**
Garden waste	12,812	5,120	12,026	7,967	8,226	3,635	4,253	6,078	5,947	7,363	7,906	**81,332**
Food waste	5,429	2,641	5,104	3,232	5,267	2,751	2,817	3,916	3,471	4,538	4,283	**43,447**
Residual waste	23,881	14,521	21,955	13,884	24,856	15,616	18,017	12,755	12,375	19,352	16,637	**193,850**
Total	**57,462**	**31,199**	**55,685**	**34,995**	**55,227**	**30,290**	**34,771**	**33,273**	**33,111**	**45,911**	**38,087**	**450,012**

Table 3: Composition of kerbside collected tonnes

Waste Stream	Elmbridge BC	Epsom & Ewell BC	Guildford BC	Mole Valley DC	Reigate & Banstead BC	Runnymede BC	Spelthorne BC	Surrey Heath BC	Tandridge DC	Waverley BC	Woking BC	Total
Mixed Paper incl PAMS	6%	8%	12%	9%	4%	9%	10%	10%	13%	10%	6%	**8%**
Card	7%	6%	2%	7%	10%	6%	5%	7%	2%	6%	6%	**6%**
Mixed Glass	7%	7%	7%	6%	11%	7%	7%	6%	9%	10%	6%	**8%**
Steel Cans	1%	0%	1%	1%	1%	1%	1%	1%	1%	1%	1%	**1%**
Aluminium cans	1%	0%	0%	1%	1%	0%	1%	0%	1%	0%	1%	**1%**
PTTs	0%	1%	1%	0%	1%	1%	1%	1%	1%	1%	0%	**1%**

Waste Stream	Elmbridge BC	Epsom & Ewell BC	Guildford BC	Mole Valley DC	Reigate & Banstead BC	Runnymede BC	Spelthorne BC	Surrey Heath BC	Tandridge DC	Waverley BC	Woking BC	Total
Plastic bottles	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	**1%**
Plastic films	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	**0%**
Mixed Plastic	1%	1%	1%	1%	1%	1%	1%	2%	1%	2%	2%	**1%**
Recycling Contamination	3%	4%	5%	3%	2%	2%	2%	4%	5%	2%	3%	**3%**
Garden waste	22%	16%	22%	23%	15%	12%	12%	18%	18%	16%	21%	**18%**
Food waste	9%	8%	9%	9%	10%	9%	8%	12%	10%	10%	11%	**10%**
Residual waste	42%	47%	39%	40%	45%	52%	52%	38%	37%	42%	44%	**43%**
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Table 4: CRC Tonnages Modelled

Waste Stream	Bond Road CRC	Bourne Mill CRC	Chaldon Road CRC	Lyne Lane CRC	Martyrs Lane CRC	Nanhurst CRC	Ranmore Road CRC	Swift Lane CRC	Wilton Road CRC	Witley CRC	Charlton Lane CRC	Earlswood CRC	Epsom CRC	Leatherhead CRC	Slyfield CRC	Total
Batteries and accumulators wastes	0	11	3	12	28	2	4	3	7	25	37	32	22	26	17	**227**
Chemical wastes	0	4	2	0	0	0	0	0	0	4	1	-	1	4	7	**24**
Discarded equipment (excluding discarded vehicles, batteries and accumulators wastes)	21	234	43	180	477	23	12	20	243	361	615	594	408	462	837	**4,527**
Glass wastes	-	-	-	-	-	-	-	-	-	-	-	-	1	0	0	**2**

Waste Stream	Bond Road CRC	Bour-ne Mill CRC	Chal-don Road CRC	Lyne Lane CRC	Mar-tyrs Lane CRC	Nan-hur-st CRC	Ran-mo-re Ro-ad CRC	Swift Lane CRC	Wilton Road CRC	Witley CRC	Charl-ton Lane CRC	Earls-wood CRC	Ep-som CRC	Lea-ther-head CRC	Sly-field CRC	Total
Household and similar wastes	11	871	608	1,523	2,279	1	2	14	1,828	1,783	3,200	2,779	1,519	2,321	1,518	**20,257**
Metallic wastes, ferrous	2	12	4	10	30	-	1	2	13	15	12	16	8	14	6	**145**
Metallic wastes, mixed ferrous and non-ferrous	14	298	105	306	713	53	33	27	418	476	798	787	353	612	370	**5,363**
Mineral waste from construction and demolition	-	-	-	-	14	-	-	-	7	22	26	26	46	48	33	**223**
Other mineral wastes	-	-	-	-	64	-	-	-	-	49	-	1	93	119	3	**329**
Paper and cardboard wastes	17	236	102	335	506	59	35	42	375	418	829	484	259	581	338	**4,615**
Rubber wastes	-	-	-	0	1	-	-	-	1	3	28	22	3	6	14	**79**
Textile wastes	4	50	22	45	80	15	7	9	62	86	115	116	81	126	58	**875**
Used oils	1	11	4	11	15	2	1	1	10	15	14	20	8	10	6	**128**
Vegetal wastes	103	1,224	430	1,446	2,113	328	224	347	1,989	2,151	2,132	2,260	1,400	1,975	861	**18,982**

Waste Stream	Bond Road CRC	Bourne Mill CRC	Chaldon Road CRC	Lyne Lane CRC	Martyrs Lane CRC	Nanhurst CRC	Ranmore Road CRC	Swift Lane CRC	Wilton Road CRC	Witley CRC	Charlton Lane CRC	Earlswood CRC	Epsom CRC	Leatherhead CRC	Slyfield CRC	Total
Wood wastes	34	683	361	884	1,896	122	83	104	1,170	1,228	2,369	2,008	1,365	1,715	1,048	**15,070**
Plastic wastes	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	**0**
Mineral waste from construction and demolition	-	-	-	-	271	-	-	-	135	206	300	264	154	251	171	**1,753**
Total	**207**	**3,634**	**1,682**	**4,752**	**8,487**	**605**	**401**	**569**	**6,259**	**6,842**	**10,474**	**9,407**	**5,721**	**8,272**	**5,287**	**72,599**

3.1.2 Overall Emissions

Figure 1 provides an overview of the total GHG (measured in CO_2-eq) emissions arising from the waste management services provided by SCC. Burdens, or emissions, are presented in blue as positive values, while avoided emissions, or gains, are presented in green as negative values. The transfer emissions amount to approximately 17,000 tonnes CO_2-eq, largely due to the export of materials. The CRC and transfer station operations amount to 1,000 tonnes CO_2-eq, while the treatment of the materials collected at kerbside and in the CRCs amount to approximately -39,000 tonnes CO_2-eq. Apart from the residual waste, the recycling contamination and the chemical wastes processing, the other materials provide savings, as recycling results in avoided emissions calculated from the avoided extraction and manufacturing of raw materials into new products. These emissions total -21,000 tonnes CO_2-eq, which is equivalent to diverting 46,000 tonnes of household waste from landfill.

Figure 1: Total emissions, tonnes CO_2-eq

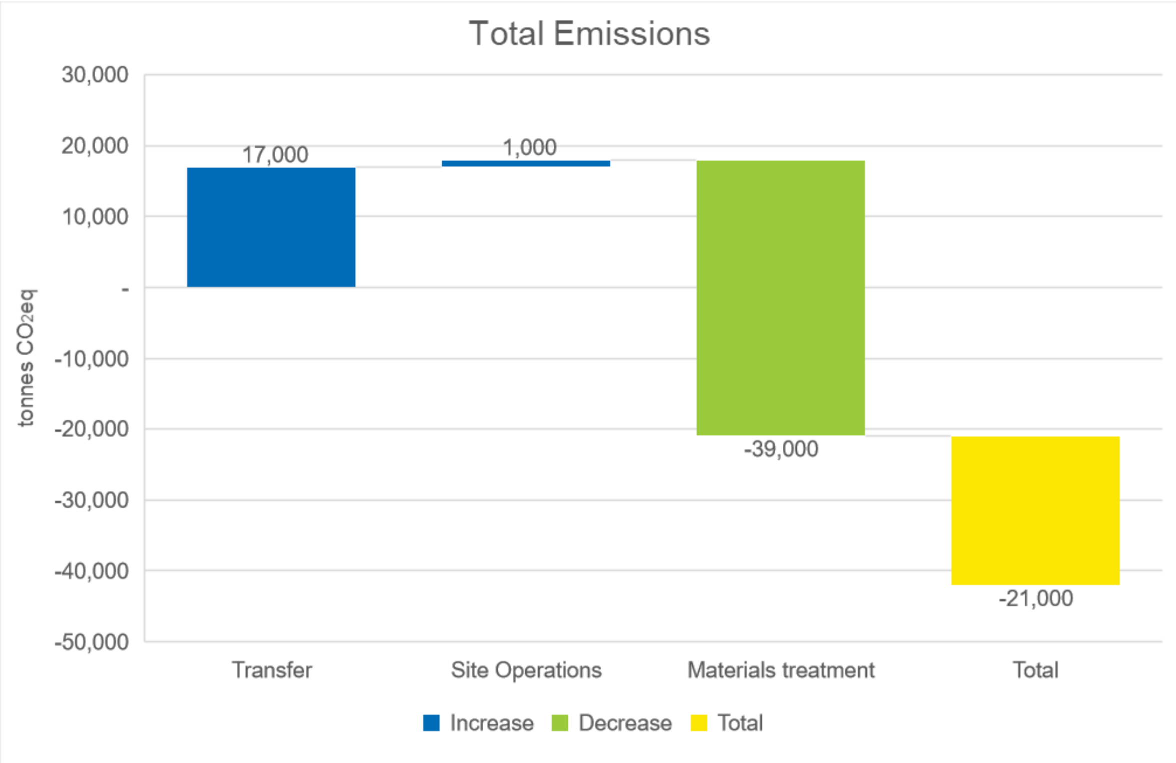


Figure 2 provides an overview of the emissions by kerbside collected material. Management of residual waste and recycling contamination shows a significant positive (detrimental) and high level of emissions (81,415 tonnes CO_2-eq), which is due to the use of EfW and landfill, as 6.4 per cent of the kerbside collected residual waste is landfilled. There are also positive (detrimental) emission values from the transfer of kerbside collected paper and card, due to the shipping of these materials to Turkey, India and Malaysia. These emissions amount to almost 10,000 tonnes CO_2-eq. However, these emissions are counterbalanced by the savings from recycling[1], in particular the recycling of paper, card, glass and metals.

[1] Materials treatment/ Processing includes recycling.

Figure 2: Kerbside collected materials emissions, tonnes CO_2-eq

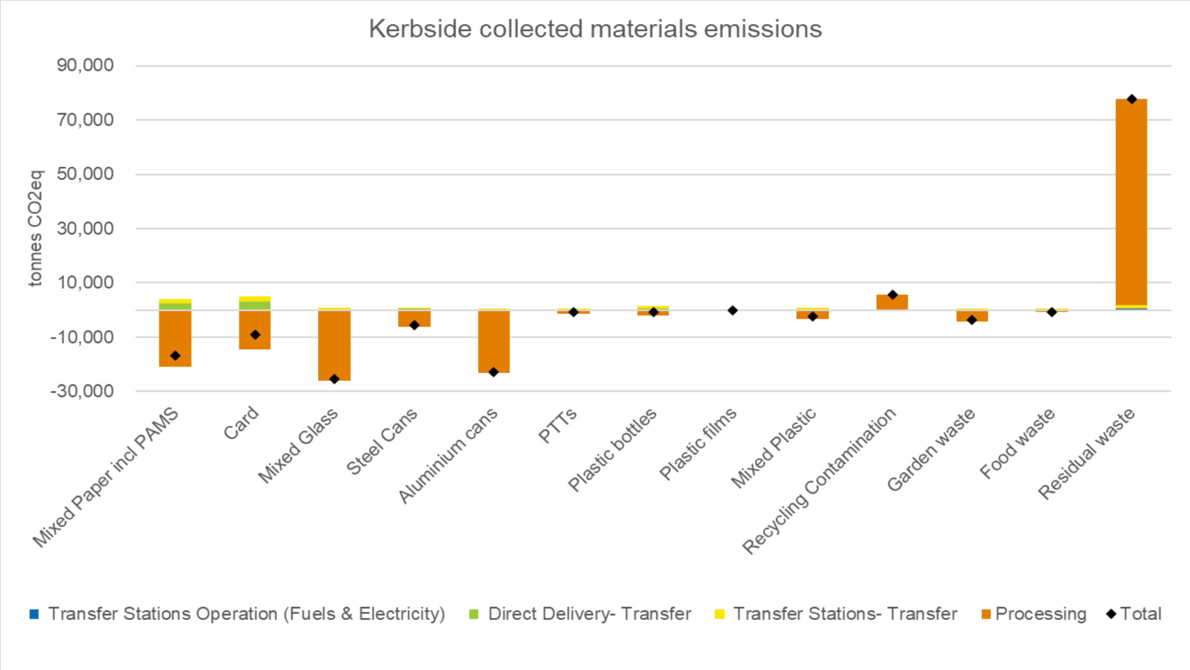
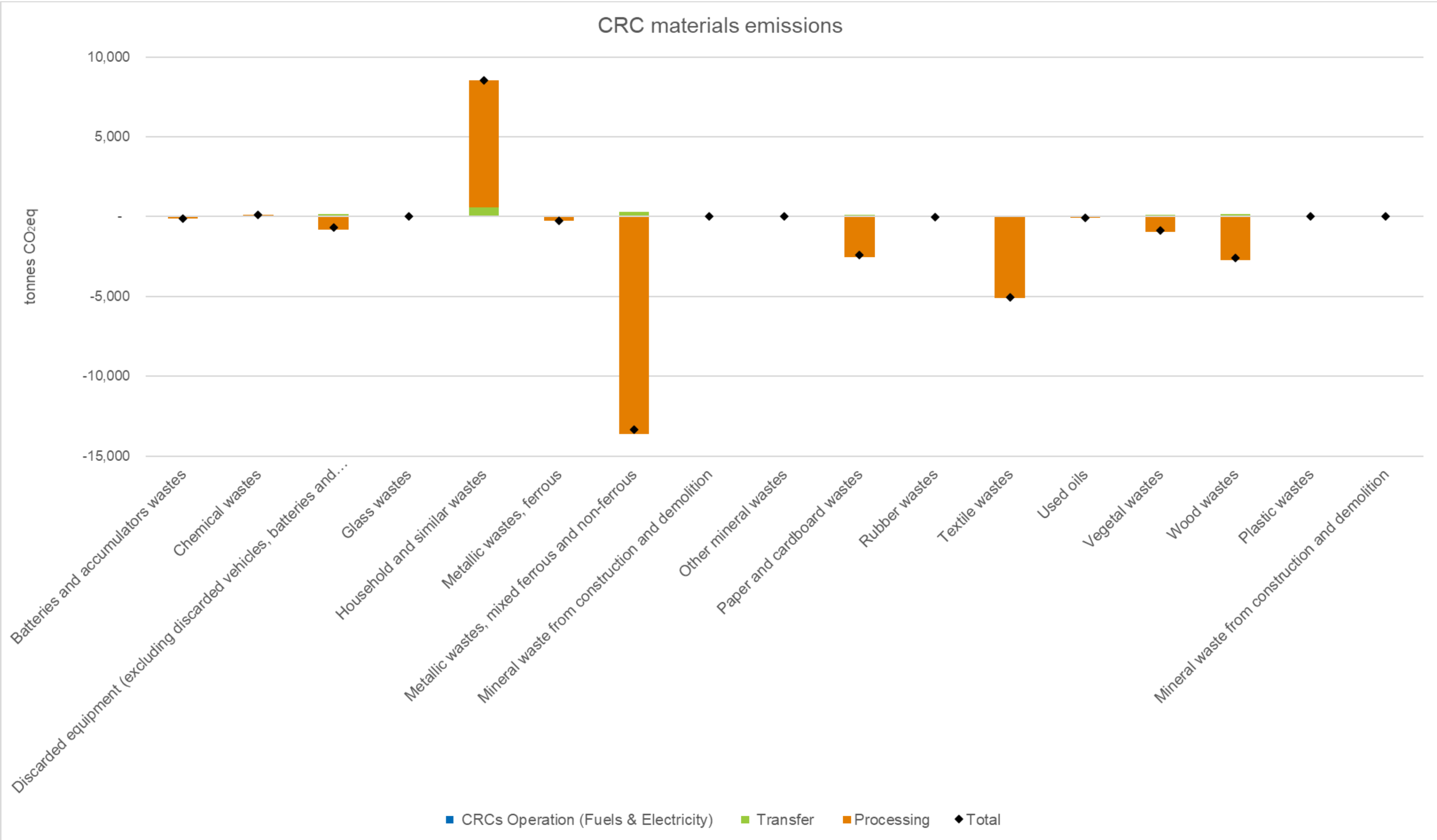


Figure 3 presents the emissions from each material type collected at the CRCs. The most predominant materials are the household and similar wastes, mentioned as ‘residual waste from CRCs’ from this point onwards, mixed metals, paper and card, textiles, vegetal and wood wastes due to their tonnages.

Figure 3: CRC materials emissions, tonnes CO_2-eq



3.1.3 Emissions per tonne

In order to gain a better understanding of the emissions hotspots and the most impactful materials and processes, it is important to examine the emissions per tonne. Figure 4 and Figure 5**Error! Reference source not found.** present the processing and transfer emissions for the kerbside collected materials. In Figure 4**Error! Reference source not found.**, it can be seen that the largest savings occur from recycling metals, in particular aluminium cans, which saves almost 10,000 kg CO_2-eq per tonne managed, while recycling contamination and residual waste generate the most emissions per tonne. It is worth noting that the emissions from food and garden waste are smaller than 100 kg CO_2-eq/ tonne and hence, not visible in the graph. Conversely, Figure 5 shows that the transfer of plastic bottles results in the highest emissions per tonne. This occurs because plastic bottles have low bulk density and the material is usually transported over large road distances within the UK, as seen in Table 5. The same applies to PTTs and steel cans, which have the second highest emissions. Plastic films are also transported over long distances within the country, but due to their low volume, their impact is not equally significant. Conversely, food, garden and residual waste streams have the lowest transport emissions, because much is directly delivered to the processing facilities and the rest travels relatively short distances.

It should be noted that exported materials (paper, card, aluminium cans) do not have the highest emissions, due to their density (paper in particular) and the large tonnages that cargo ships can transfer. Even though shipping is fuel intensive, the allocation of the emissions to each tonne transferred results in lower emissions when bulk transfer and longer distances are considered. By combining the results from Figure 5 and Table 5, it is evident that the transport mode is not the only factor for high transport emissions. It appears that transfer emissions depend more on the mileage rather than the means of transport, but also on the physical characteristics of the material, as the more bulky the waste stream, the more trips that are required.

Figure 4: Processing emissions for kerbside collected materials, kg CO2-eq/ tonne

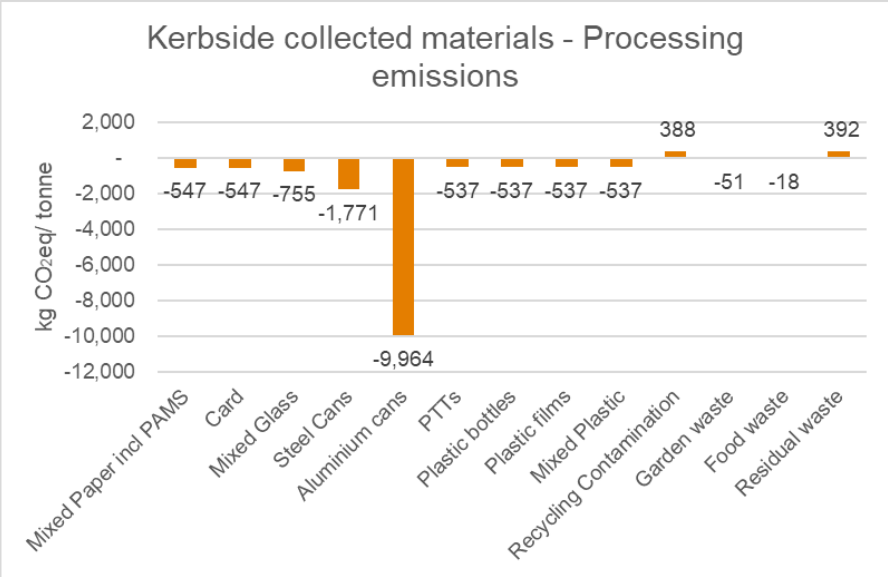


Figure 5: Transfer emissions for kerbside collected materials, kg CO2-eq/ tonne

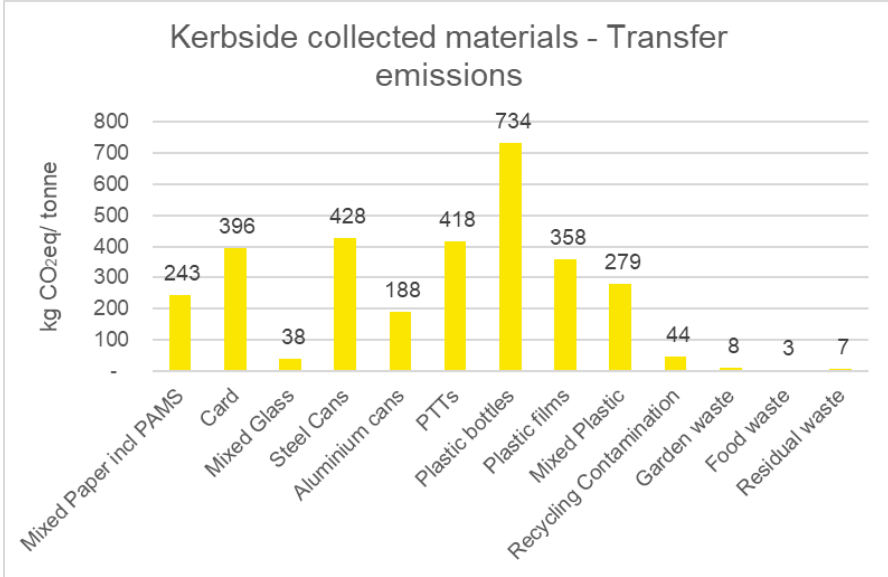


Table 5: Average mileage and percentage of shipping per material

	Average mileage (miles/ tonne)	% Shipped abroad
Mixed Paper incl PAMS	16	38%
Card	45	92%
Mixed Glass	13	0%
Steel Cans	141	0%
Aluminium cans	47	20%
PTTs	148	0%
Plastic bottles	246	0%

	Average mileage (miles/ tonne)	% Shipped abroad
Plastic films	319	0%
Mixed Plastic	92	0%
Recycling Contamination	15	0%
Garden waste	4	0%
Food waste	1	0%
Residual waste	4	0%

Figure 6 presents the emissions per tonne of waste from CRCs, which are largely dominated by the processing emissions. Chemical wastes, along with mineral waste from construction and demolition, are the only materials for which recycling results in additional emissions. For mineral waste from construction and demolition, this can be attributed to the recycling process and especially the washing stage and fuel demand. On the contrary, textile wastes achieve the largest savings, together with metals, due to the avoided emissions from the production of virgin materials, which are energy and material intensive.

Figure 6: Emissions per tonne for CRC materials

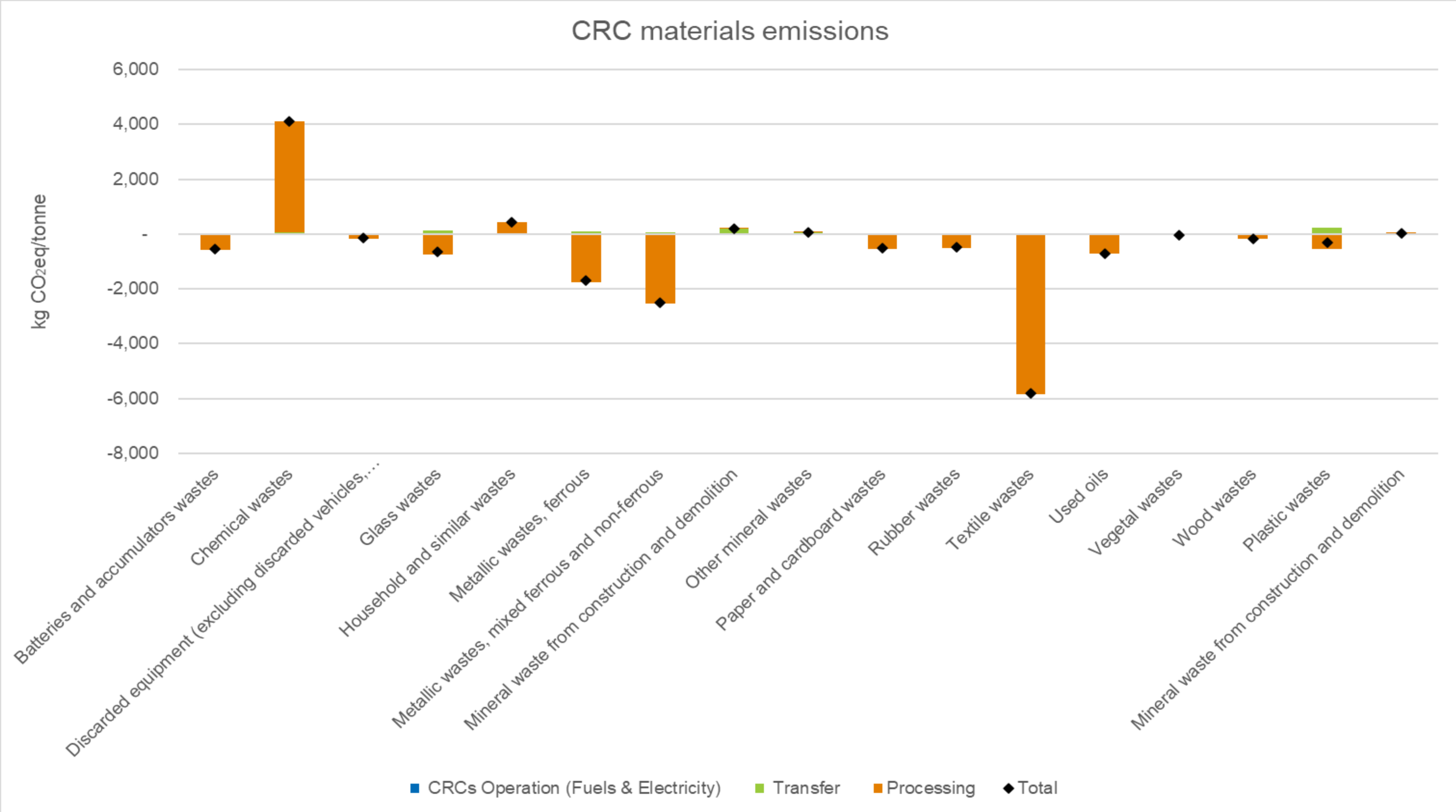
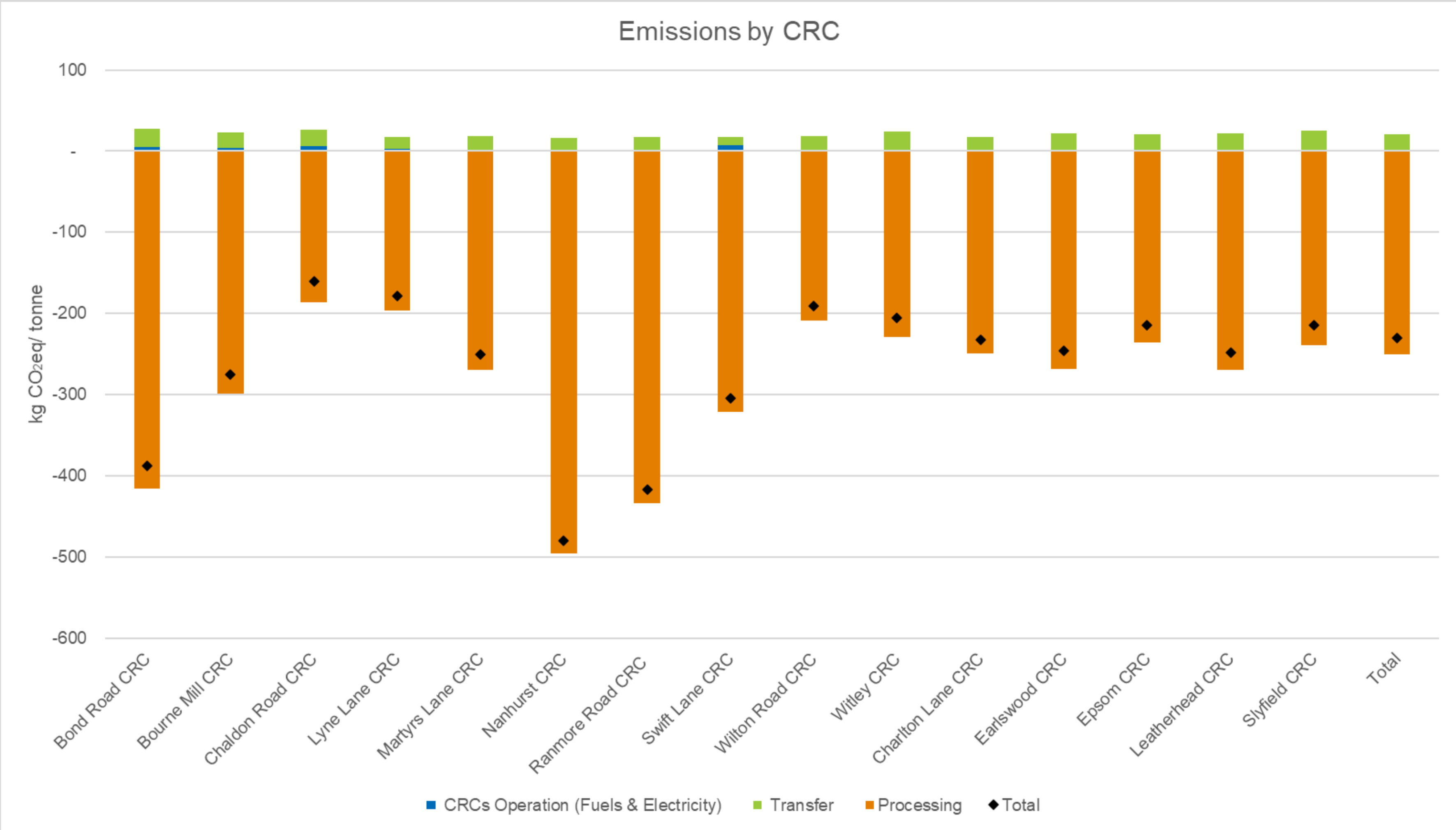


Figure 7 presents the emissions per tonne for each CRC. The results are driven by the composition of materials handled at the facilities. CRCs with large amounts of household and similar wastes, or residual waste, that is sent mostly to EfW plants will have an overall higher emission factor. This is because residual waste tonnages lead to higher emissions because the emission factor for EfW or landfill has a positive value of 388 kg CO_2-eq per tonne. While CRCs with high recyclables tonnages will have lower emissions, since the emission factors include avoided emissions, The Nanhurst CRC is the site with the lowest emissions per tonne because there was only one tonne of household and similar wastes collected. On the contrary, the Chaldon Road CRC had the highest emissions per tonne because household and similar wastes made up more than a third of the waste on site.

Figure 7: Emissions per tonne by CRC



4 Recommendations for reducing the GHG emissions generated from waste management activities

Section 3 gives an overview of the processes and materials that contribute most to the carbon emissions associated with the waste services SCC provides. Ricardo suggests the following measures to reduce the carbon intensity of waste management activities:

1. For the kerbside collected materials:
   a. Minimise landfilling of residual waste, as currently 6.4 per cent of kerbside collected residual waste and 8.8 per cent of residual waste from CRCs is landfilled (6.7 per cent of total residual waste, 2.7 per cent of total waste arisings).
   b. Reduce the residual waste tonnages or divert to recycling to minimise the emissions associated with sending these materials to EfW facilities, as residual waste account for 43 per cent of the waste collected at kerbside within the boundaries of SCC. Encouraging citizens to increase source segregation and informing them of the environmental and financial benefits of recycling would help SCC and its WCAs increase recycling rates and reduce residual waste tonnages.
   c. Minimise recycling contamination and ensure that any non-targeted materials that are collected are recycled and not disposed of. The first part of this measure can be achieved in conjunction with the measure above. However, it relies on close liaison with MRF operators and agreement around their sorting configurations and outputs.
   d. Investigate ways to reduce emissions from the transfer and transport of recyclable materials. If reprocessing facilities close to Surrey are not available, ensuring that better planning of trips is considered to make use of empty vehicles on the 'return' or 'onward' journey, which could cut associated road emissions by almost half. In practice this means making full use of 'round trips', ensuring that vehicles are not returning empty.
   e. Ensure that as much material as possible is recycled within the UK. It is not known whether SCC can directly influence this decision, as the dry recyclable materials are first sent to MRFs, but as seen in Figure 1, transport emissions account for the largest part of the total emissions.
2. For the CRCs:
   a. Reduce the residual waste from CRCs tonnages or divert to recycling to minimise the emissions associated with sending these materials to EfW facilities and landfill. This can be achieved either in combination with measure 1b above or by undertaking more separation onsite at each CRC.
   b. Investigate ways to reduce emissions from the transfer and transport of recyclable materials. If reprocessing facilities close to Surrey are not available, ensuring that better planning of trips is considered to make use of empty vehicles on the 'return' or 'onward' journey, will result in cutting road emissions by almost half. In practice this means making full use of 'round trips', ensuring that vehicles are not returning empty.

5 Conclusions

SCC's carbon footprint for the material streams managed amounts to a total of -20,837 tonnes CO_2-eq, which includes avoided emissions accrued from the contribution of recycling activity. Of this total figure, the majority (17,388 tonnes CO_2-eq) of the emissions arise from transport, as transport activities, including shipping of waste outside of the UK, are fuel-intensive. The remainder (-39,143 tonnes CO_2-eq) of emissions are generated from processing the materials, with site operations accounting for 918 tonnes CO_2-eq. It is worth highlighting that both the processing emissions and the total emissions have negative values, since the recycling of the materials result in higher 'avoided emissions' than those generated through transport and processing activity.

For recycling from kerbside collections, the materials that result in the largest gains through 'avoided emissions' are aluminium and steel cans, glass and paper. The materials that result in GHG emission burdens are residual waste, due to the emissions from EfW and plastic bottles, due to the emissions from transport.

For CRCs, the materials that result in the largest gains (avoided emissions) are textiles, metals and used oils, while the materials that result in GHG emission burdens are chemical wastes, residual waste and construction and demolition waste, due to their processing emissions.

The carbon intensity of the waste management activities included in this analysis can be reduced by reducing landfilling, diverting residual waste, rationalising the transport of bulk recyclable materials to processing facilities and avoiding the generation of the waste streams with the highest emission factors.

It should be noted that, in order to undertake this analysis, Ricardo applied assumptions where uncertainties arose or where data was missing. It is advised that SCC satisfies itself that these assumptions are reasonable and appropriate.

A1 Model description

A1.1 Transport

Ricardo has designed the CAT to calculate transport emissions using the following process:

1. The user enters information on the following items for each waste stream:
    a. Waste / material quantities (tonnes)
    b. Waste streams sent from the councils to transfer stations, tonnages in transfer stations and transfer station used by each council (if applicable)
    c. Recycling composition
    d. Waste / material destinations (primary, secondary, tertiary, and final destinations), in three different tabs, depending on the source (Direct Delivery, Transfer Station or CRC).
    e. Vehicles used for each section of the journey, in three different tabs, depending on the source (Direct Delivery, Transfer Station or CRC).
    f. One-way distances for each section of the journey (including the functionality to select whether the trip is one-way or a round-trip), in three different tabs, depending on the source (Direct Delivery, Transfer Station or CRC).
2. [Optional] The user modifies assumptions:
    a. Vehicle specifications (including capacity in tonnes, volume and fuel efficiency)
    b. Material bulk densities, to take account of material volumes
    c. Fuel emission factors, to calculate CO_2-eq emissions
3. The model computes the following calculations for each waste stream:
    a. The tonnages of DMR collected at kerbside and handled in transfer stations.
    b. The number of trips required to transport the materials to their destinations, using trip data, the waste quantity data, bulk density assumptions, vehicle selection data and vehicle specification assumptions, in three different tabs, depending on the source (Direct Delivery, Transfer Station or CRC).

       Note: the model calculates the number of trips required on a weight and volume basis and selects the higher value, as the vehicle could be limited by weight (for more dense waste streams) or volume (for less dense waste streams).

    c. The total mileage travelled in each section of the journey, using the number of trips and the distance data, in three different tabs, depending on the source (Direct Delivery, Transfer Station or CRC).
    d. The total fuel consumption for each section of the journey from the three sources, using the total mileage calculation and the vehicle specification assumptions.
    e. The total carbon emissions from the fuels using the total fuel consumption and the emission factor assumptions.

A1.2 Operations

To account for the emissions from the operation of the transfer stations and CRCs, the model follows this process:

1. [Optional] In the “Lists” tab, Table 2d, the user specifies if the operation of the transfer station is within the scope of services.
2. The user enters information on the following items:
    a. The annual electricity consumption in the CRCs and transfer stations.
    b. The type of fuel used in these sites.
    c. The annual fuel consumption in these sites.
3. [Optional] The user modifies assumptions:
    a. Fuel emission factors, to calculate CO_2-eq emissions
4. The model computes the following calculations:
    a. Emissions from electricity and fuel consumption per CRC and per material.
    b. Emissions from electricity and fuel consumption per transfer station and per material.

A1.3 Waste Processing Emissions

Ricardo’s CAT calculates waste processing emissions using the following process:

1. The user enters information on the following items for each waste stream:
    a. Waste / material quantities (tonnes)
    b. Waste streams sent from the councils to transfer stations, tonnages in transfer stations and transfer station used by each council (if applicable)
    c. Recycling composition
    d. Waste / material destinations (primary, secondary, tertiary, and final destinations), in three different tabs, depending on the source (Direct Delivery, Transfer Station or CRC).
2. [Optional] The user modifies assumptions:
    a. Material processing emissions factors
3. The model computes the following calculations:
    a. The carbon emissions for each material going to each type of destination.

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