Energy Audit of the Kerbside Recycling Services

The London Borough of Camden

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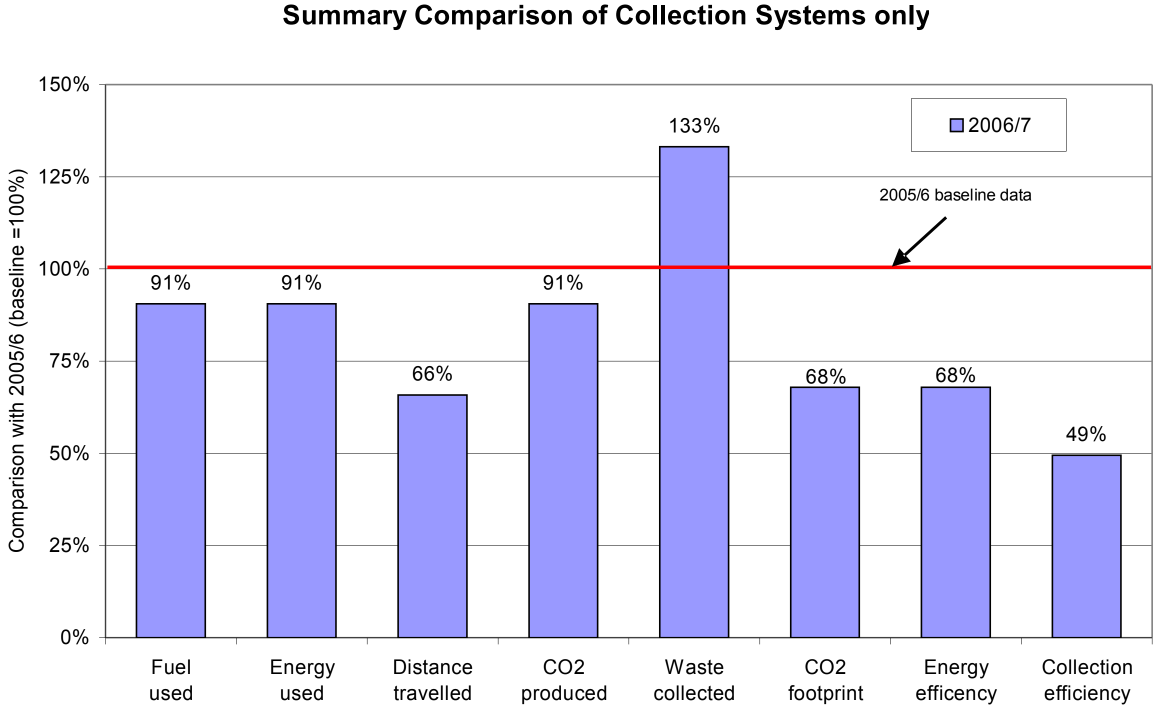
Summary

The London Borough of Camden (LBC) require an energy audit to be undertaken of their current (2006/7) co-mingled weekly doorstep collection service for dry recyclables, that are transported for sorting to a materials recycling facility (MRF)., with the previous (2005/6) system of kerbside sorting on the collection vehicles. The energy audit compares the environmental impacts of both systems.

The energy audit compares the overall energy, carbon dioxide based carbon foot print and the efficiency of collection as measured by distance covered against and functional unit of tonne of dry recyclable collected.

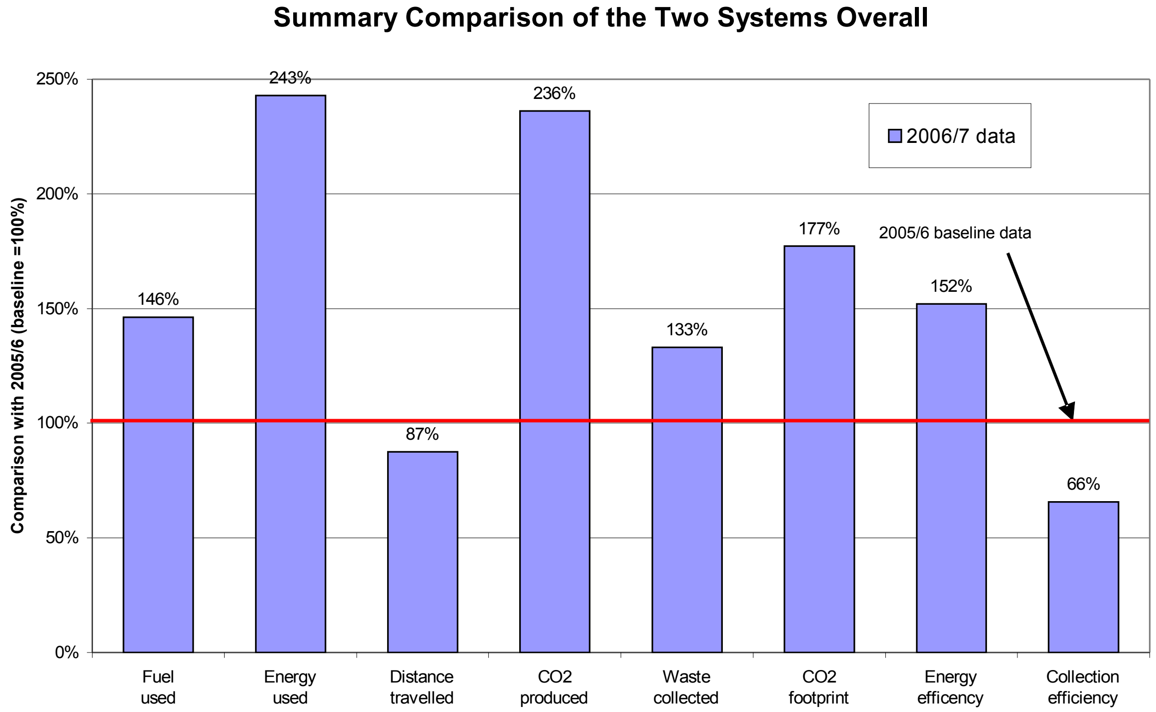
The comparison between collection systems up to the waste transfer station shows lower impacts for the co-mingled collection system, with a lower absolute distance that waste collection vehicles have to travel.

Figure S1



The comparison examines the impact on the bulk transport to the MRF and the MRF operations. The effect of this is to double the original impact of the co-mingled collection. The further impact of the transport of recyclate from the MRF in comparison to the source segregated recyclate directly from the transfer stations to an arbitrary position taken as the M25 is of a similar magnitude. The overall effect of the MRF is to increase the carbon footprint from 68% of the former system at collection to the transfer station to 177% after the MRF and delivery as far as the M25.

Figure S2



The overall carbon footprint of the two systems co-mingled collection and kerbside sorted waste are 37.43 kgCO_2/tonne and 21.11 kgCO_2/tonne respectively.

The evaluation also considered the composition of the recyclate. This showed that the increase on overall quantity of recyclate was a direct result of the expansion of the collection to include more types of paper and card and plastic containers. The largest component remained paper, which with the card made 69% of the total weight collected in 2006/7, in comparison with 67% paper in the last year of the previous system in 2005/6.

Health and safety hazards were evaluated based upon the changes in operations. The number of hazards with significant risk was reduced from 14 to 10. The reduction in the number of operatives who were then exposed to the hazards resulted in an overall risk of 58% of the previous system.

BVI 90b customer satisfaction with recycling had increased from 52% to 62%, with satisfaction of associated activities such as doorstep recycling and containers at similar levels.

External costs relating to congestion, infrastructure, noise, accidents and carbon dioxide emissions for the co-mingled collection and the kerbside sorted recycling services were £12.46 per tonne of recyclate and £15.28 per tonne of recyclate respectively.

Conclusions

The carbon footprint of the collection service within the Borough is 32% smaller for the co-mingled service.

This advantage is reduced to 19% when the transport to the MRF is added.

The carbon footprint of the MRF treatment is as much as the collection and bulk transport combined.

The carbon footprint of the co-mingled collection system, transfer and MRF is 77% greater than for the kerbside sorted waste collection.

Only when very long transport distances are used for the kerbside sorted materials is the additional energy in the MRF cancelled out.

The introduction of the co-mingled scheme has been successful in stimulating additional recycling of material classes of plastics, card and mixed paper.

The health and safety overall risk factor is improved with current co-mingled system.

Customer satisfaction has improved significantly.

External costs of collection on infrastructure, congestion, noise and carbon dioxide are reduced per tonne collected.

Recommendations

More information should be supplied on the energy use in the waste transfer stations for the differences in bulking up and loading recyclate.

The collection options for diverting the still dominant quantity of newspaper and magazines directly to reprocesses instead of incurring energy costs in transport and MRF represents an obvious option to reduce the carbon footprint of the recycling operation.

Further investigation of the processing required to avoid high energy MRF sorting of the paper waste stream is required.

Contracts that encourage the use of green tariff electricity use at the MRF will substantially reduce the carbon dioxide emission from this element of the collection and recycling process.

Contents

1 Introduction

1.1 Background

The London Borough of Camden has challenging statutory Government targets for household waste recycling of 30% for 2007/8 and 35% for 2010. The landfill directive has also set national targets to reduce biodegradable waste going to landfill by 75% of that produced in 1995. The pressure is on to make recycling services as efficient as possible, yet fit for purpose. Camden's recycling rate for 2006/07 was 28.14%.

The London Borough of Camden (LBC) required an energy audit to be undertaken of their kerbside recycling services. Camden recently introduced a co-mingled weekly doorstep collection service for dry recyclables to replace the existing process of kerbside sorting by the collection vehicles. The audit will compare the environmental impacts of both services.

Before March 2006 the council operated a kerbside separated recycling collection but due to increasing demand from residents for card and plastic recycling this was changed to the co-mingled dry recyclables service with MRF separation that operates today[1]. Camden provides 59,000 kerbside households with weekly collections of aerosols, cardboard, glass bottles and jars, mixed cans, paper, plastic bottles and Yellow Pages. The materials are collected co-mingled (mixed together), by the Council's contractor Veolia Environmental Services, in a single compartment compaction vehicle.

Obstacles to recycling[2] include: lack of "ownership", constraints of lifestyle and service provision, lack of time, insufficient space for separation and knowledge/ awareness on what to recycle. The provision of a single mixed dry recyclables collection has the potential to address these constraints by simplification and space requirement reduction for the householder. The Borough then takes on the responsibility of separating and recycling or recovering the different components. It is therefore important that the benefits to the council and the council taxpayer are demonstrated.

1.2 Scope

The scope of the investigation was to provide a comparison of the energy use in the collection and recycling of kerbside recycling operations provided by LBC.

Energy comparison is collected by interrogation of the LBC database on the waste management service and quantities of recyclate that were collected. Information on fuel consumption and vehicle payloads was obtained from the contractors. Further information was collected from the contractors on the energy and fuels used in the waste transfer facilities and the materials recycling facility (MRF).

Two 12 month periods would be used to compare the energy use and operational issues.

The previous system was compared over the period April 2005 to March 2006. In order to avoid bedding in periods it was decided that the initial bedding in period for the new system would be avoided if possible. The period from August 2006 to July 2007 was selected. Where data relating to the two start years was unavailable then comparable information relating to round distances and fuel consumption was used to estimate the consumption for each system. This was more of a problem with the previous system as the historical data contained more gaps.

Carbon footprint for comparison of the services was also calculated but limited to the release of carbon dioxide from scope 1 direct fuel consumption and scope 2 indirect release of carbon dioxide in power generation for electricity consumed in the processes.

1.3 Description of services

The two services that are to be compared are summarised with vehicles etc and rounds. The previous service was operated by Veolia from 2003 to 2006. The new co-mingled service started in April 2006, again with Veolia as the contractor.

The previous system sorted the recyclate at the kerbside, delivered it to a waste transfer station where the recyclate was dispatched to the recycling reprocessor. The new system collects mixed dry

[1] http://www.camden.gov.uk/ccm/navigation/environment/recycling-and-waste/

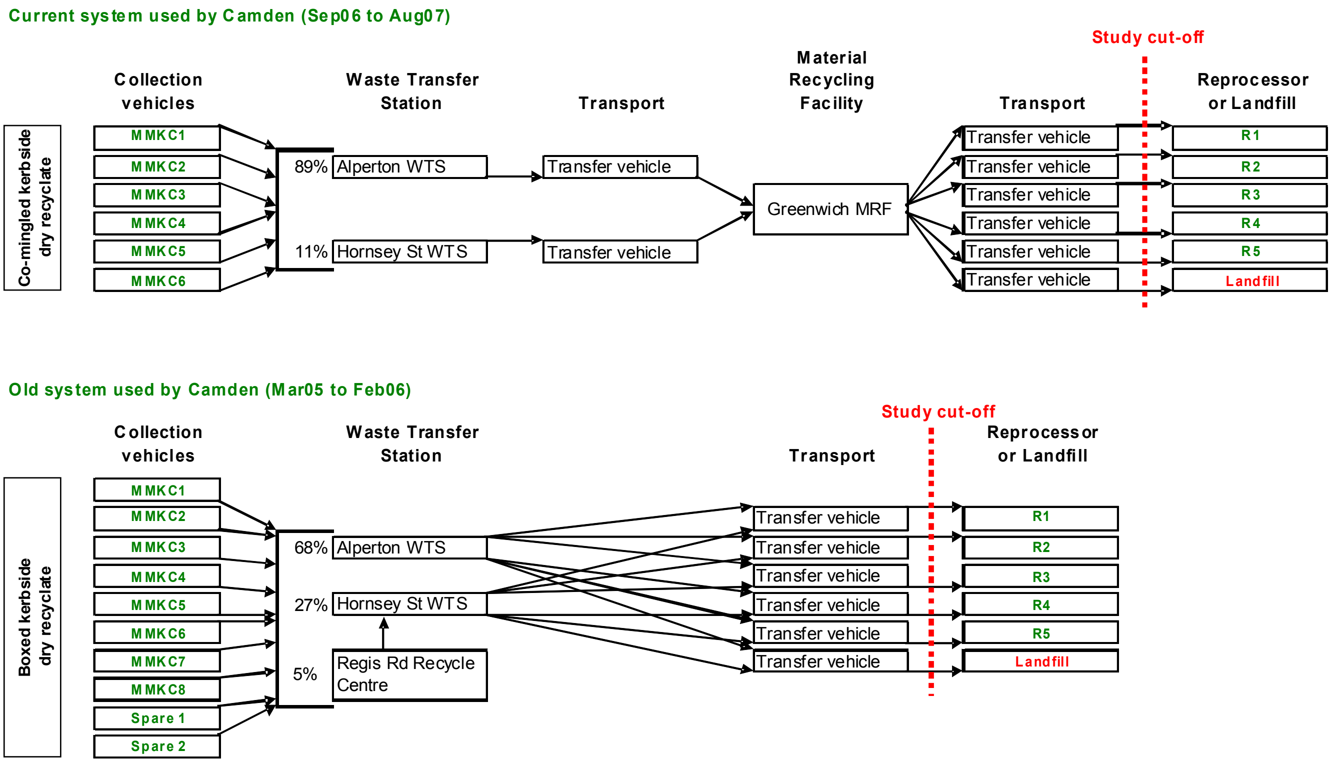
[2]

recyclables and transports these to the waste transfer station where it is bulked for transportation to a MRF for sorting into separate recyclates. The materials have been going to the Veolia operated MRF in Greenwich since September 2006.

Table 1 Main Characteristic of the Collection Systems

Year	Previous system 2005/6	Present system 2006/7
System	Sort on kerbside	Co-mingled kerbside
Presentation	Single box	Single bag
Vehicles	8 (+ 2 spare)	6
Vehicle payload	2-3 tonnes	6-7 tonnes
Collection rounds	8	6
Working method	1 vehicle per round	All vehicles on each round
Manning	Driver + 2	Driver + 2
Delivery	Transfer stations	Transfer stations
Bulking/ transfer	-	Yes
Sorting	On vehicle	MRF

Figure 1 Flow diagrams for the two collection systems



2 Analysis of Fuel used in Kerbside recycling service Collection

The distances covered are made up of the round collection plus delivery to the waste transfer station and return to the round. Thus for a constant waste amount there is a constant collection element irrespective of vehicle capacity and a carriage element that is dependant on the vehicle payload.

Similarly the time that the crew spend riding in the vehicle is affected only by the duration and frequency of visits to the transfer station.

The introduction of a different collection regime can change the overall percentage and therefore quantity of recyclate collected. This additional quantity again will only affect the number of loads that are delivered to the transfer station.

Energy and carbon dioxide release was calculated using calorific value of the fuel that was consumed and carbon dioxide factors from the DEFRA. Guidelines for Company Reporting on Greenhouse Gas Emissions[3].

2.1 Collection systems

As part of continuous improvement the collection system has seen changes between years as collection systems were trialled before full procurement. For 2005/6 a pilot comingled collection was tried on round 4.

2.1.1 Previous System

The information on vehicle fuel usage was slow to arrive for the earlier system. It may be possible to estimate the distances covered by this fleet based upon the payloads and overall dry recyclables collected under the new system for which there is data.

The distances covered by each vehicle in the fleet within the year were obtained for 2005/6. Detailed fuel consumption was not available for this particular year. Therefore distance and fuel consumption for 2004/5 was obtained. This was on an individual vehicle basis so that average fuel consumption for each vehicle could be used to estimate the fuel consumption. It is reasoned that as the rounds were very similar, the drive cycle is unchanged between years.

Round 4 of the 2005/6 year in formation was available for the collected volumes of recyclate including the comingled dry recyclables the was also no information on vehicle distances or fuel use The volume of the waste in this round was equivalent 20 % of the kerbside sorted recyclate that was collected. (Appendix 3). To ignore this would have a significant effect on the perceived absolute change in fuel and energy consumption between the two systems. The fuel consumption and distances were estimated with the inclusion of round 4 based on the collection efficacy ratios from the completed kerbside sorted rounds.

The fuel consumption and annual distance for 2005/6 round are shown in table 1.

2.1.2 Current System

The information on fuel use in the co-mingled fleet of vehicles was supplied by the contractor on average monthly basis. This gives the fuel consumption and distanced covered over a 12 month period

[3] DEFRA Guidelines for Company Reporting on Greenhouse Gas Emissions July 2005

Table 1 Comparison of distances fuel consumption and staff

System	Year	Distance per year (km)	Fuel Used per year (litres)	Total working days per year	Days in alternative vehicle	Average distance travelled per working day (km/day)	Average fuel used per working day (l/day)	Average hours worked per day	No of crew
2	2006/7	82,344	38,340	1,560	32	323	151	40.0	18
1	2005/6	125,086	42,338	2,080	198	423	163	61.5	24

2.2 Efficiency of Collection, Quantity and Types of Materials

Efficiency of collection can be compared by examining the number of staff involved, the distances covered and the quantities of recyclate that are collected and recycled. Table 1 shows the difference between the two collection systems.

The average hours that vehicles are operating in the streets is also reduced by 35%.

The co-mingled collection was devised to collect a larger range of recyclate and to encourage the setting out of materials for collection. Consequently the quantities of recyclate that were collected by the two systems differed. When comparing the energy efficiency of collection or the carbon footprint this is calculated on the basis of a functional unit of 1 tonne of recyclate that is collected.

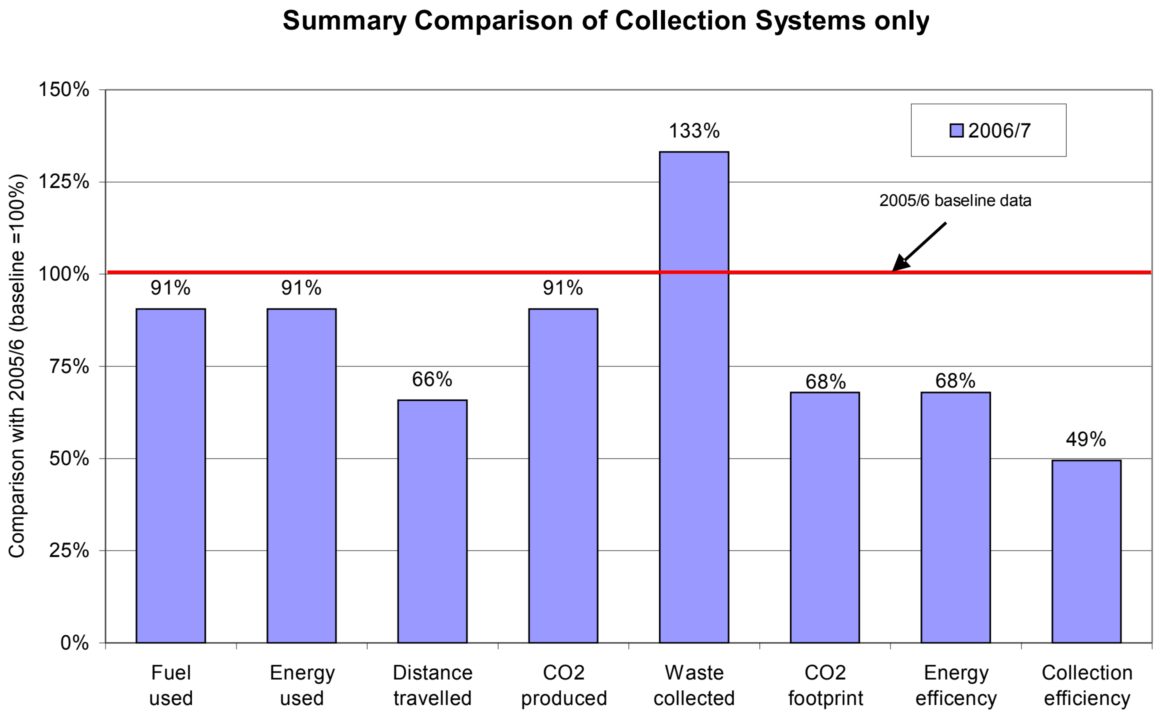
A further indicator of efficiency is the distances travelled by the collection vehicles per tonne of recyclate that is collected.

Efficiency of collection can be defined in terms of distance travelled per tonne of recyclate collected. This shows a 50% reduction in collection from 20.48 to 10.12 km per tonne of dry recyclables collected.

Table 2 Efficiency of Collection

System	Year	Fuel used	Energy used	Distance travelled	CO_2 produced	Waste collected	CO_2 footprint	Energy efficiency	Collection efficiency
		litres	GJ	km	kg	tonnes	kg/tonne	MJ/tonne	km/tonne
2	2006/7	38,340	1,457	82,344	100,834	8,137	12.39	179	10.12
1	2005/6	42,338	1,609	125,086	111,348	6,109	18.23	263	20.48

Figure 2



The fuel used releases carbon dioxide. This is a function of the fuel efficiency of the collection vehicle. The efficiency of transport is improved by larger payloads and newer vehicle engine specification. The carbon footprint per tonne of recyclate was calculated for each system. The relative amounts are shown in figure 2. This shows a 32 % decrease in carbon dioxide emissions in the Borough per tonne collected.

Table 2 also shows that the fuel quantities used were 9% lower with the quantity of recyclate collected increasing by 33%. From this table it can be seen that the overall distance travelled by refuse collection vehicles in the Borough is reduced from 125,089km (101,212km excluding round 4) to 82,344km. Therefore the distance that the refuse vehicles were on the roads in the Borough was reduced in absolute terms by 34%. The other waste distance is that of the vehicles delivering recyclate to the recycler from the waste transfer station or bulk hauling the recyclate from the transfer station to the MRF. The make-up of values of km per tonne recycled can be seen in figures 3 and 4

Figure 3

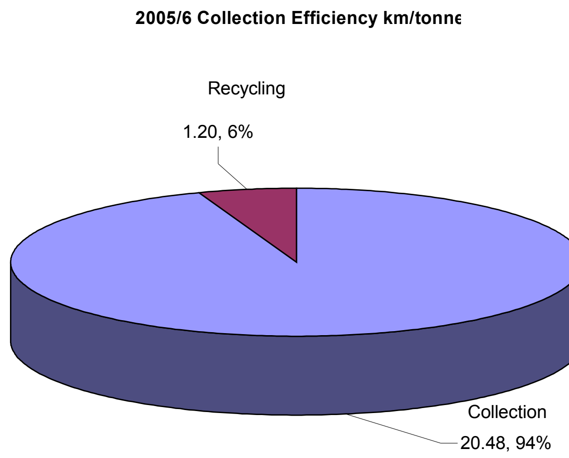
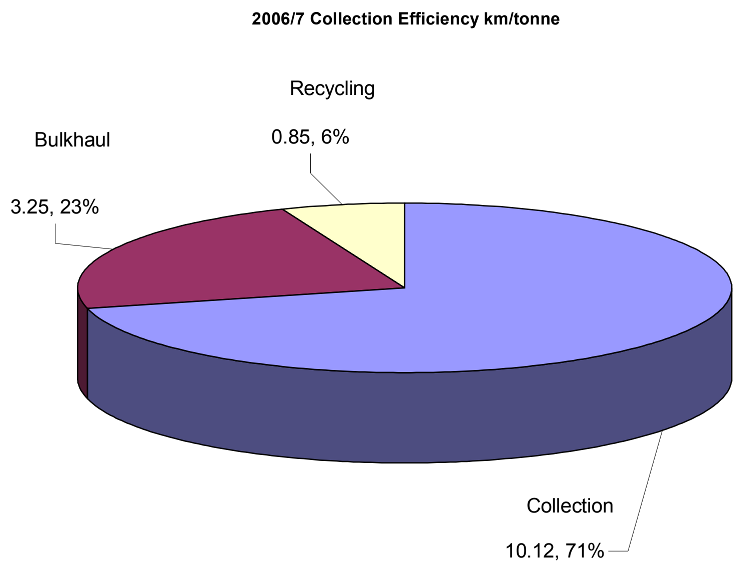


Figure 4



3 Energy Use in the MRF and Transfer Station

The collected recyclate is delivered by the collection vehicles from either system. The degree of treatment then differs between the two collection systems:

System 1 - Former system

Kerbside sorted material is deposited into bunkers and bulked up for collection by the recyclate vehicle. One of the three large bunkers for paper at the Alperton waste transfer station was covered. The materials from the bunkers were loaded by wheeled loader into open topped transport skips for transfer to the recycler.

System 2 - Current system

Co-mingled materials are deposited in a number of similar bunkers and bulked up for onward carriage to the MRF. At the Hornsey Street site in Islington, all transfer and bulking is carried out under cover. An 80m^3 bulker is loaded with the co-mingled materials for onward transport to the MRF.

Energy consuming items at the transfer station include

- Lighting, office & weighbridge
- Mobile plant

Three transfer stations are used:

- The London Waste facility at Hornsey Street, Islington.
- The Veolia facility at Marsh Lane, Alperton.
- The recyclate from the Regis Road Recycling Centre is delivered to Hornsey Street, Islington.

The transfer stations receive recyclate from other London Boroughs. The energy usage that was allocated to LBC was based upon the overall energy consumption and the fraction of the annual throughput that is collected from LBC. There are several variables that will affect these proportions including:

- Changes in the overall quantity of waste collected
- Changes in sorting regimes for other Boroughs
- The combined error of data from two sites

The quantities of recyclate collected by each system were derived from the vehicle collection round data. Information on the overall number and weights of deliveries to the Alperton and Hornsey Street transfer stations were extracted from LBC records. The quantities of different recyclate were derived from LBC records and records supplied by Veolia for the respective years. This data is included at appendix 3. Information on fuel consumption at the transfer station per unit tonne of recyclate delivered was received from Veolia for the Alperton site. The fuel and electricity consumption are shown in table 3.

Table 3 Energy Consumption at Waste Transfer

Previous system - Mar 05 to Feb 06

Red Diesel consumption activities

	Loading lorries for onward journey	Other (please specify)	Red Diesel consumption (litres/tonne of through put material)
Paper	Yes	-	0.51
Glass	Yes	-	0.51
Metal	Yes	-	0.51

Electrical consumption activities

	Compactors	Other (please specify)	Electrical consumption (kWh/tonne of through put material)
Paper	No	office & w'bridge	1.39
Glass	No		1.39
Metal	No		1.39

Current system - Sept 06 to Aug 07

Red Diesel consumption activities

	Loading lorries for onward journey	Other (please specify)	Red Diesel consumption (litres/tonne of through put material)
Co-mingled	Yes	-	0.47

Electrical consumption activities

	Compactors	Other (please specify)	Electrical consumption (kWh/tonne of through put material)
Co-mingled	No	office & w'bridge	1

2. Staff hours (operatives only, not management/ office staff) used in the above activities	**0.05**	hours/tonne of through put material

3. Transport from waste transfer station to MRF @ Greenwich

Camden dry recyclate (kerbside) tonnage managed per month	**600.61**	tonnes/month
Round trip distance	**41**	km
Type of lorry used (inc payload)	**44t artic bulker - 19t payload**	
Fuel consumption		litres per round trip
Time taken per trip	**4.5**	hours per round trip

Data on energy consumption at the Hornsey Street facility was not available, so it was assumed that this would be of a similar order per unit of recyclate. The energy and carbon footprint of the waste transfer operations are shown in table 4

Table 4 Energy and Carbon Footprint of the Waste Transfer Operations

System 2 Waste transfer

Source	Year	Fuel used	Energy used	CO_2 produced	Waste collected	CO_2 footprint	Energy efficiency
		litres	GJ	kg	tonnes	kg/tonne	MJ/tonne
electricity kwh*	2006/7	8,137*	29	3,499	8137	0.43	4
fuel oil	2006/7	3,824	145	10,249	8137	1.26	18
total transfer	2006/7	3,824	175	13,748	8137	1.69	21

System 1 Waste transfer

Source	Year	Fuel used	Energy used	CO_2 produced	Waste collected	CO_2 footprint	Energy efficiency
		litres	GJ	kg	tonnes	kg/tonne	MJ/tonne
electricity kwh*	2005/6	8,491*	31	3,651	6109	0.60	5
fuel oil	2005/6	3,115	118	8,194	6109	1.34	19
total transfer	2005/6	3,115	149	11,845	6109	1.94	24

3.1 Bulk Transport to MRF

The transport of the materials from the bulking operation at the transfer stations introduces an additional transport operation for the co-mingled material. The fuel usage in carriage for the recyclate to the MRF is based upon the payload of the vehicle, typical fuel consumption and the distance travelled adjusted for the average speed 14.5 km/hr. At this speed the carbon dioxide emissions are double those at normal drive cycle speeds[4]. The distance between the transfer stations and the MRF were obtained from route finder information[5].

A typical payload was used to calculate the number of annual round trips and from this the distances covered. Information from Alperton waste transfer station, which represents operations for the major of the co-mingled material, which uses 80 m^3 bulkers.

The relative quantities of recyclate from each transfer station was used in the calculation to allocate fuel consumption and distances from the two transfer stations. An aggregate figure for fuel consumption and emissions per unit of recyclate collected in the LBC was calculated. Typical urban drive cycle information was used for a fuel consumption rate and compared with the journey times from the waste transfer station to the MRF. The emission was taken as twice the normal rate for a heavy goods vehicle on urban roads.

The energy use and emissions were estimated for the functional unit of 1 tonne of recyclate.

[4] Piecyk, M.. McKinnon A. Internalising the External Costs of Road Freight Transport in the UK, Heriot-Watt University November 2007

[5] The Automobile Association

Table 5 Distances and fuel consumption for bulk haulage to the MRF

Location	Fuel used	Energy used	Distance travelled	CO_2 produced	Waste collected	CO_2 footprint	Energy efficiency	Waste 'miles'	Collection efficiency
	litres	GJ	km	kg	tonnes	kg/tonne	MJ/tonne	tonne km	km/tonne
Alperton	14,703	559	24,505	39,404	7,207	5.47	77.5	232,796	3.40
Islington	1,174	45	1,957	3,147	930	3.39	48.0	18,590	2.11
Total	15,877	603	26,462	42,551	8,137	5.23	74.1	251,387	3.25

The overall operation of recycling involves the transport of the separated recyclate to the processor. There is an arbitrary effect of the location of the processor relative to the location of the MRF.

For a processor that is located south of the Thames the movement of the recyclate will be towards the processor therefore there would be negligible effect. However for a recycling outlet north of London any transport to the MRF would give an increase in the carbon dioxide emission.

3.2 The Materials Recycling Facility

The MRF receives the LBC recyclate as a single co-mingled stream. Recyclate from several Boroughs is recycled at the facility. Information on the overall energy consumption by the MRF was supplied by the operators.

The overall recyclate quantities recycled in the year were compared against the overall costs of energy supply. At the MRF mobile plant and fixed machinery were identified as energy users. The two fuels used were therefore electricity and diesel fuel. Information was obtained from Veolia for the consumption of these fuels per tonne of co-mingled recyclate received.

Table 6 MRF electricity and fuel consumption

Fuel Type	Annual fuel consumption per tonne of feedstock (MRF input) material 01 Sep 2006 to 31 Aug 2007	
Electricity	30	kWh/tonne of feedstock
Red diesel	1.73	litres/tonne of feedstock

Whereas the quantities of fuel oil use in the collection rounds could be verified against typical fuel consumption and differences in vehicle capacity. Little publicly available data on MRFs is available. The MRFs also vary in the degree of complexity and processing power consumption. There are few benchmarks for these processes. The electricity and fuel used at the MRF introduces additional carbon dioxide emissions for the present collection and recycling system.

Table 7 Energy and Emissions from MRF

System 2 MRF

Source	Year	Fuel used	Energy used	CO_2 produced	Waste collected	CO_2 footprint	Energy efficiency
		litres	GJ	kg	tonnes	kg/tonne	MJ/tonne
electricity kwh*	2006/7	244,104*	879	104,965	8,137	12.90	108
fuel oil	2006/7	14,077	535	37,022	8,137	4.55	66
total MRF	2006/7	14,077	1,414	141,987	8,137	17.45	174

Subtotals to the MRF

System	Year	Fuel used	Energ y used	Distance travelled	CO_2 produced	Waste collecte d	CO_2 footprint	Energy efficiency	Collection efficiency
		litres	GJ	km	kg	tonnes	kg/tonne	MJ/tonne	km/tonne
2	2006/7	58041	2235	108,806	157133	8,137	19.31	275	13.37
1	2005/6	45,453	1758	125,086	123192	6,109	20.17	288	20.48

Sub Totals to the MRF Output

System	Year	Fuel used	Energy used	Distance travelled	CO_2 produced	Waste collected	CO_2 footprint	Energy efficiency	Collection efficiency
		litres	GJ	km	kg	tonnes	kg/tonne	MJ/tonne	km/tonne
2	2006/7	72,118	3,649	108,806	299,119	8,137	36.76	448	13.37
1	2005/6	48,568	1,758	125,086	123,192	6,109	20.17	288	20.48

Table 7 above shows that the cumulative carbon dioxide release from the current collection and the bulk haulage to the MRF is less than that for the kerbside sorted collection 2005/6 by 35%. The additional releases as a result of the MRF process give a carbon footprint that is 82% more than the kerbside sorted recyclate collection. The energy consumption per tonne is 54% higher as a result of the co-mingled service with MRF. Percentages differences for energy and carbon dioxide diverge as a result of the use of electrical power at the MRF.

3.3 Transport of Recyclate after Sorting

For the previous kerbside sorted system, segregated materials were held in bunkers and accumulated until there was sufficient for a load, then it was sent direct to the reprocessor or recycler. In the case of the co-mingled MRF system, the separated materials are bulked and loaded for transport to recyclers. The two systems are shown at figure 1.

The distance and transport to the reprocessor is dependent on contracts and the location of the reprocessor. A number of reprocessing sites and can be used for each of the recyclate streams.

In order to bring into the analysis a stability of comparison it was decided to assume that all recyclates are to be transported as far as the M25 ring motorway. This can be applied to the waste transfer stations for the former kerbside sorted collection system and the MRF for the present co-mingled collection system.

The relative distances of the MRF and the transfer stations were estimated from maps and the fuel use and efficiency of the systems compared.

Table 8 Carbon Dioxide and efficiency comparison of transfer of recyclate to the M25

System	Year	Fuel used	Energy used	Distance travelled	CO_2 produced	Waste collected	CO_2 footprint	Energy efficiency	Collection efficiency
		litres	GJ	km	kg	tonnes	kg/tonne	MJ/tonne	km/tonne
2	2006/7	2083	79	6944	5478	8,137	0.67	10	0.85
1	2005/6	2192	83	7306	5788	6,109	0.95	14	1.20

Comparison of the carbon footprint indicates that there is a 30% improvement in the carbon dioxide emission and efficiency as a result of the proximity of the MRF to the M25. This can be seen from table 8

The influence that the distance to the reprocessor can have on the energy used and the efficiency can be demonstrated if the transport to the two differing reprocessor locations for paper are examined. The example of paper is justified on the basis that paper constitutes 67% of the collection quantity.

At the time of the first collection system the recyclate was transferred for reprocessing at Ellesmere Port. The paper recyclate from the MRF is sent to reprocessing in Kent. In order to gain an understanding of the sensitivity of the overall carbon footprint to recyclate transport to reprocessor the two systems were compared. The addition that this has on the overall foot print and efficiency is demonstrated in table 9.

Table 9 Carbon Dioxide and Energy Efficiency for Collection Processing and Delivery of Recyclate to Reprocessors Only

System	Year	Fuel used	Energy used	Distance travelled	CO_2 produced	Waste collected	CO_2 footprint	Energy efficiency	Collection efficiency
		litres	GJ	km	kg	tonnes	kg/tonne	MJ/tonne	km/tonne
2	2006/7	5,611	213	18,703	14,757	5,611	2.63	38	3.33
1	2005/6	23,042	876	76,806	60,600	3,337	18.16	262	23.02

The effect of the reduction of transport to the paper reprocessor is to make the overall carbon footprint and energy efficiency in the case of paper recycling similar for both systems.

4 Overall Performance of the Collection and Processing Systems

The overall energy consumption and carbon dioxide emission per tonne of recyclate collected is shown in table 10.

For the co-mingled service the energy consumption per tonne of recyclate collected and delivered to the process boundary is 458 MJ/ Tonne compared with 301 MJ/ Tonne for the kerbside sorted collection.

The carbon footprint is 37.43 Kg/tonne for the co-mingled collection against 21.12 Kg/tonne for the kerbside sorted collection. This indicates a 77% increase in the carbon footprint of the co-mingled service over the kerbside collection

However the collection efficiency defined as kilometres per tonne that is collected processed and delivered to the arbitrary M25 boundary as in the diagram in figure 1 is 14.23 km/tonne for the co-mingled collection and transfer in comparison to 21.68 km/tonne for the kerbside sorted collection. This shows a 35% improvement.

The effect of the reduction of transport to the reprocessor paper is to make the carbon footprint and energy efficiency in the case of paper recycling similar for to that of the former system.

Table 10 Overall Carbon Dioxide and Energy Efficiency for Collection Processing and Delivery of Recyclate as far as M25

System	Year	Fuel used	Energy used	Distance travelled	CO_2 produced	Waste collected	CO_2 footprint	Energy efficiency	Collection efficiency
		litres	GJ	km	kg	tonnes	kg/tonne	MJ/tonne	km/tonne
2	2006/7	74,201	3,728	115,749	304,598	16,274	37.43	458	14.23
1	2005/6	50,760	1,841	132,391	128,980	12,221	21.11	301	21.67

The relative make up of the different components of the two collection systems is shown graphically in figures below

Figure 4

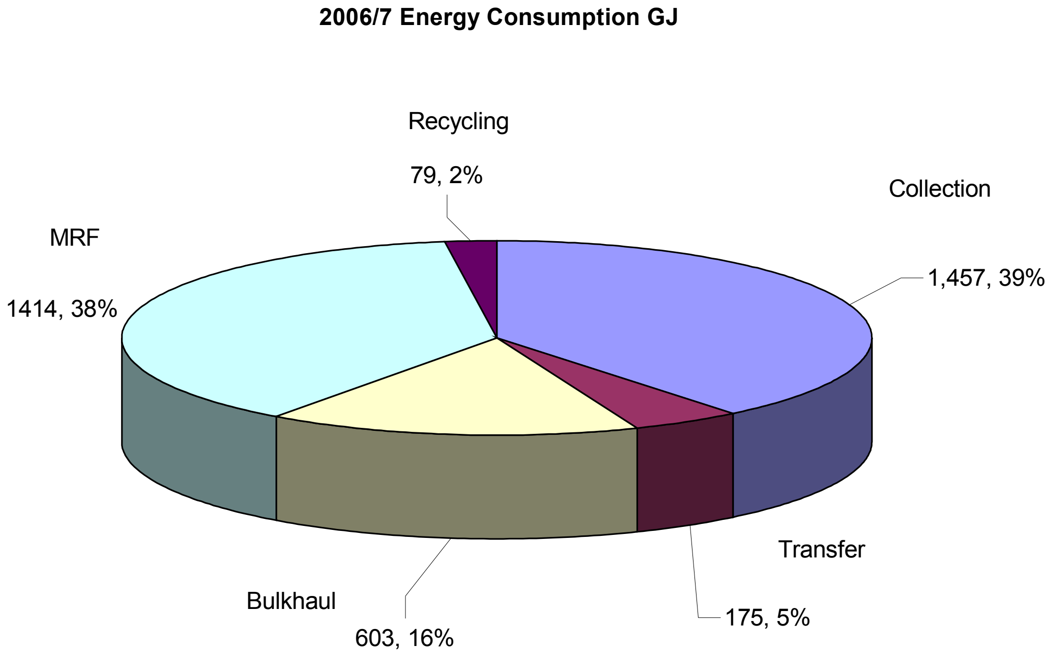


Figure 5

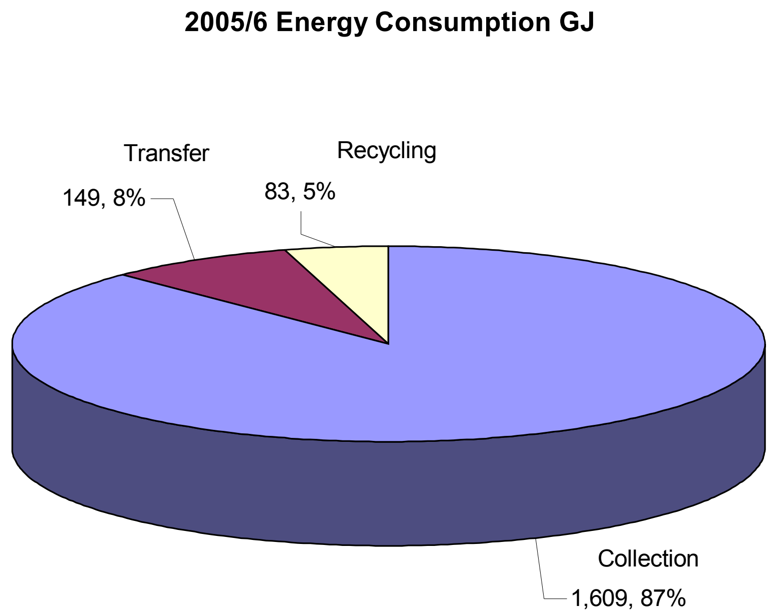


Figure 6

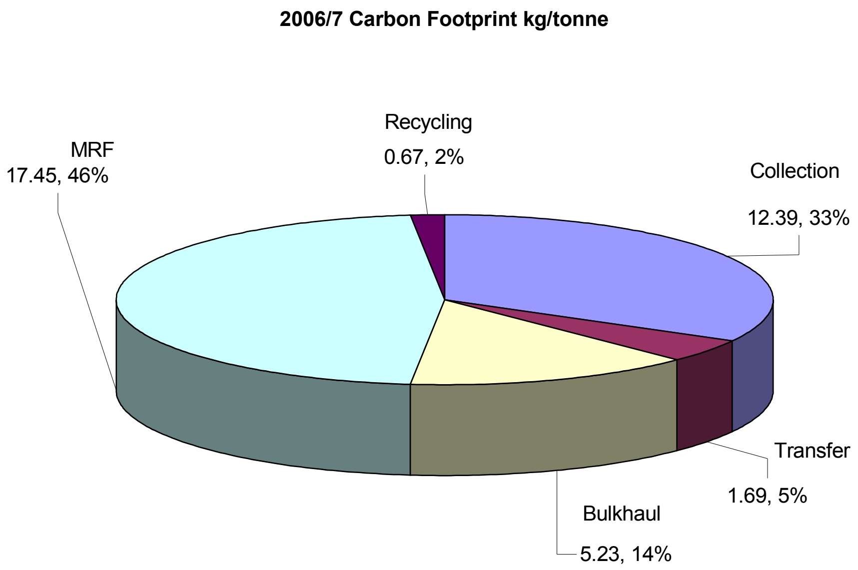


Figure 7

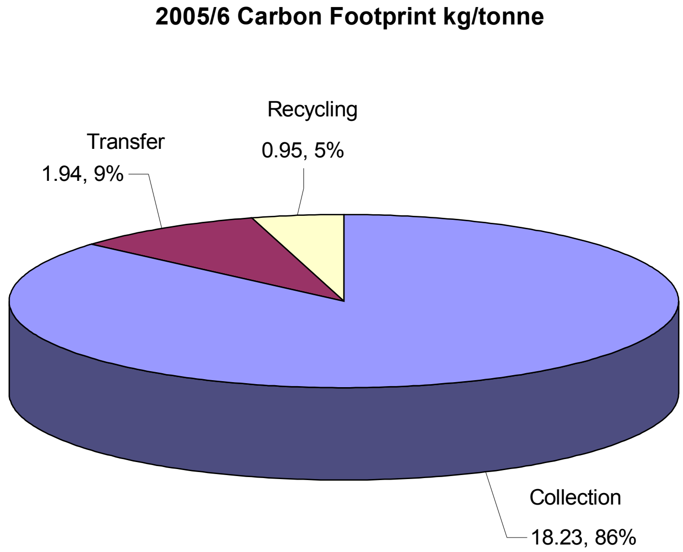
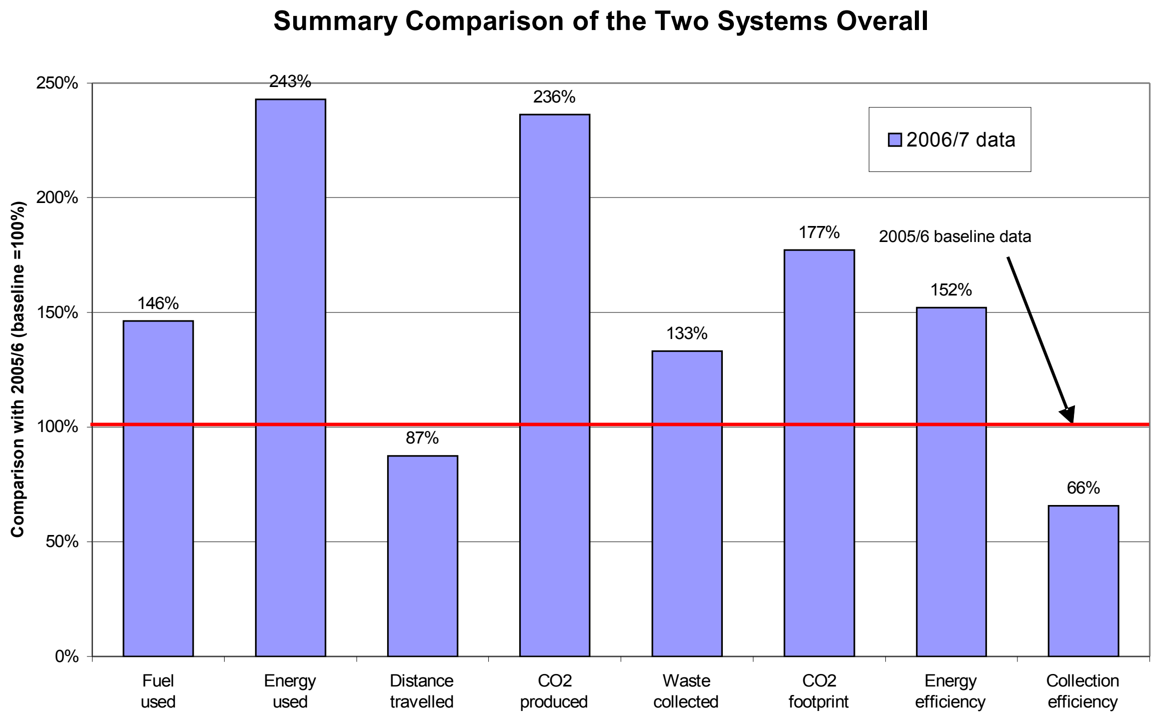


Figure 8 shows the relative performance of the 2006/7 co-mingled collection and recycling to the baseline of the 2005/6 collection.

Figure 8



5 Waste Quantities and Composition

The composition of the recyclate that is handled by the waste transfer stations and the MRF was analysed from vehicle delivery recorded weights and waste compositional survey information. The change in composition, quantities and the amounts received by each of the transfer stations is shown in table 11.

The mass of co-mingled recyclate from the 2005/6 trial round 4 collection was not included in the analysis. Fuel data for round 4 was also excluded in the overall calculations.

From this comparison the overall quantity of recyclate has increased. The additional recyclate classes of plastics and metal show significant contributions to the total

Table 11 Summary of Total waste in each Class

Year		**2006/7**			**2005/6**	
2005/6 classes	**2006/7 classes**	**Tonnage Total**	**Greenwich MRF % split (as reported by Veolia)**	**by 2005/6 class**	**Tonnage Total**	**%ex. co-mingled**
			% **total average**	**% average**		
	Soft mixed paper	181	2.27			
	News & Pams	3,524	43.30			
Paper	Mixed paper	1,533	18.83	64.40	3,337	67.5
	Cardboard	372	4.58	4.58		
	HDPE	0	0.00			
	PET	1	0.02			
	Mixed plastics	285	3.49			
	Plastic Sacks	0	0.00			
Plastic Bottles	Plastic Film	60	0.73	4.23		
	Cans Steel	206	2.52			
	Cans Aluminium	39	0.47			
Metal	Cans Mixed	188	2.31	5.29	28	0.6
Glass	Glass NC	1,402	17.31	17.31	1,562	31.6
Residual	Waste	350	4.27	4.27		
Total		**8,143**	**100.00**	**100.00**	**4,943**	**100.0**

The introduction of card to the collection has increased the percentage of paper and card over the paper fraction of the kerbside sorted collection.

The overall mass of glass has remained similar for both collection schemes. This shows that the introduction of the scheme has successfully stimulated recycling in the targeted materials.

6 Health and Safety

Health and safety risk is also a consideration for kerbside recycling collection. A comparison of the hazards and risk was made for the two collection systems. The source data for this is the risk assessments and reports carried out by managers over the period December 2004 to February 2006.

Documents consulted include:

Workplace Assessment: Kerbside Co-Mingle Service Risk Assessment Record Form Camden Environment February 2006

Activity: Recycling Collection of Handheld Recycling Boxes, Baskets & Bags Manual Handling Assessment Veolia Environment February 2006

Workplace Assessment: MMKC Vehicle Sheeting Risk Assessment Record Form Camden Environment December 2005

Albert Terrace Mews Report on procedures for limited access collection Camden Environment February 2003

Workplace Assessment: MMKC unloading – Forklift truck Risk Assessment Record Form Camden Environment December 2004

6.1 Hazards in Kerbside Collections

The essential tasks for kerbside collection are compared from risk assessments dated December 2004 (kerbside sorting)

- Risk assessment information sheets were obtained from the contractors for the two rounds
- Mechanisms for risk change were identified
- Reduction/change of the task
- Different mitigation options
- Change in staff number involved

From the risk assessments obtained, the number of tasks that have a significant risk were identified and compared. These are tabulated in Appendix 4. This showed 15 hazards for the kerbside sorting collection. For the co-mingled collection the number of hazards with significant risk is 10.

The number of staff on the collection round is changed from 24 with the kerbside sorting collection system, to 18 with the co-mingled collection. By combination the overall collection risk factor for the collection methods can be compared.

Table 12 Risk Factors for Kerbside Collection

Collection System	**2004/5**	**2006/7**
Significant risks	15	10
No of staff	24	18
Risk factor	360	190
Percentage of kerbside sorting	100%	53%

6.2 Hazards at the Waste Transfer Station

Hazards at the waste transfer station are related to vehicle unloading. For the co-mingled system the load is tipped. For the kerbside sorted materials on the cage vehicles unloading is by forklift truck. Both these involve vehicle movement and significant risk. For tipping this is a single operation. For the unloading of multi container vehicles this will involve multiple operations per vehicle.

6.3 Hazards at the MRF

Hazard information at the MRF was not available. The manning levels involved are appropriate to the total quantity of recyclate that is treated within the facility. Allocation of staff number and activities to the quantity of LBC recyclate is limited in accuracy. Therefore it was decided to limit the boundary of the assessment to the collection round and the unloading of the collection vehicles at the transfer stations.

7 Resident Satisfaction and External Cost

7.1 Resident satisfaction surveys

The changes in the kerbside collection were instigated in response to the survey of residents. The overriding desire to participate in plastic and card recycling were responded to in the inclusion of plastic bottles and cardboard in the new co-mingled kerbside collection service. This is highlighted in table 13.

Table 13 2005 Resident Waste Survey

Issue	Count	% Surveys Issues
Plastic / card collection	**703**	36.4
Bin lids not replaced / spillage not cleared	**258**	13.4
Box/Bag Request	**185**	9.5
Boxes for estate residents	**109**	5.6
Unreliable recycling service	**74**	3.7
Green waste issues	**68**	3.5
Unreliable refuse service	**64**	3.3
More recycling collections	**58**	3
More recycling banks	**56**	2.9
Bulky waste issue	**54**	2.8
Other	**303**	16

The indicators of resident satisfaction in connection with kerbside collection and recycling are surveyed regularly:

- BV90a waste collection
- BV90b local recycling

Information obtained from surveys undertaken and submitted to the audit commission can be compared for the periods 2003/4[6], 2005/6[7] and 2006/7[8]

Table 14 shows that satisfaction with waste collection (BV90a) has raised by five percentage points since 2003/4. The level of the performance found in the survey in 2005, the last year of the kerbside sorting collection system has been maintained with the introduction of the co-mingled collection system. The benefits of the change of collection are apparent in satisfaction with doorstep recycling collection which has seen a dramatic increase since 2003/4. Just under two-thirds of Camden residents (64%) are satisfied with present co-mingled collection of items for recycling overall. A similar proportion of residents are also positive about the containers provided for their items for recycling (65%) and how clean and tidy streets are following the current co-mingled recycling collection (70%). Although comparative percentages for the latter two indicators are not available, these are both higher than the general overall recycling collection and they are indicative of a similar level of improvement in satisfaction with the co-mingled collection.

The overall satisfaction with local recycling services (BV90b) in Camden has seen an increase of nine percentage points since 2003/4.

[6] Audit Commission
[7] London Borough of Camden Refuse Survey August 2005
[8] IpsosMORI Best Value General Survey for Camden Council http://www.camden.gov.uk/ccm/content/council-and-democracy/plans-and-policies/best-value/file-storage/best-value-general-user-survey-2006-7.en

Table 14 Comparison of BV90 satisfaction and other kerbside recycling related issues

Indicator	2003/4 kerbside segregated %	2005/6 kerbside segregated %	2006/7 co-mingled collection %
BV90a waste collection service	62	76	75
Doorstep recycling	56		64
Container provided for items of recycling			65
How clean and tidy street following recycling collection			70
BV90b local recycling	52		62

7.2 External Cost Kerbside Collection

The changes to the collection system affect the cost and inconvenience experienced by residents and the community in general. The external costs come from use of vehicles in the Borough through inconvenience of the collection fleet on the road. These were calculated from the distances and emissions from fuel that was consumed using emission, infrastructure, congestion, noise, and accident cost factors [4]. These can be seen in table 15. The absolute external costs for the recycling operation are increased marginally (10%). However the larger volume of recyclate that is collected under the new system results a 19 % reduction in the in the cost per tonne from £15.28 to £12.46.

Table 15 External Costs for Recycling Kerbside Collection

	System1	System2
External Cost	**£**	**£**
infrastructure	3743.22	7499.67
noise	1664.39	1490.29
congestion	59837.55	60234.67
accidents	8905.45	7426.66
pollution	19210.24	24745.04
Totals	**93360.86**	**101396.34**
External Cost per Tonne Collected	**15.28**	**12.46**

8 Conclusions

From this desk exercise it has been possible to undertake analysis of the energy used in the co-mingled collection and compare this against the baseline of kerbside sorted collection that it replaced.

8.1 Distances and transport efficiency

The overall distance that refuse vehicles travel in the Borough is reduced in absolute terms with the introduction of the co-mingled service.

The efficiency of collection in kilometres travelled by the vehicles is improved by 50%

The time that the collection vehicles are in use on the road is reduced by 30%

When the bulk haulage of the recyclate to the MRF is included the efficiency of collection is 35% better.

Sending the recyclate to a MRF closer to the Borough would improve the transport efficiency of the system

8.2 Energy and Carbon footprint

The energy used in servicing the borough with household recyclate collection has reduced by 9% in absolute terms with the introduction of comingled collection.

The carbon footprint of the collection service within the Borough is 32% smaller per tonne of waste for the co-mingled service.

This advantage is reduced to 4% when the transport to the MRF is added.

The carbon footprint of the MRF treatment is as much as that of the collection and bulk transport combined.

The carbon footprint of the whole process for the co-mingled collection, transfer and MRF is 77% greater than for the kerbside sorted recyclate collection system .

Long transport distances to reprocessors that were used for the kerbside sorted materials give comparable effect on the footprint as the use of the MRF.

The introduction of the co-mingled scheme has been successful in stimulating recycling of additional material classes of plastics and card and mixed paper.

8.3 Health and Safety

The number of hazardous operations with significant risk has reduced with the introduction of the co-mingled collection.

Fewer members of staff are exposed to these remaining risks.

8.4 Resident Satisfaction

The level of resident satisfaction with the recycling collection has increased significantly since the introduction of the co-mingled service.

The introduction of the co-mingled scheme has been successful in stimulating recycling of additional material classes of plastics and card and mixed paper.

The external cost to infrastructure, congestion, noise accident and pollution are lower per tonne of recyclate collected.

9 Recommendations

More information should be supplied on the energy use in the waste transfer stations for the differences in bulking up and loading recyclate.

The collection options for diverting the still dominant quantity of newspaper and magazines directly to reprocesses instead of incurring energy costs in transport and MRF represents an obvious option to reduce the carbon footprint of the recycling operation.

Further investigation of the processing required to avoid high energy MRF sorting of the paper waste stream is required.

Contracts that encourage the use of green tariff electricity use at the MRF will substantially reduce the carbon dioxide emission from this element of the collection and recycling process.