Annex I: Solid waste – supplementary material

I.1 EXTRA FIGURES AND DATA ANALYSIS

Table 1: Waste arisings by sector for each growth scenario: detailed version. The colour indicates likelihood of problems – green for no problems likely, orange may cause problems; red likely to be problematic

			Annual arisings (Mt)							
			2015		2020		2050		2100	
Low growth	MSW – 2009: 30.3Mt, 2006: 33.5 Mt	Lo (static)	31.6	Below 2006 level Investment to increase recyc and replace old plant	32.2	Below 2006 level. Investment to increase recyc and replace old plant	33.2	Minor increase. Investment to replace old plant	30.3	Decrease. Investment to replace old plant
		Hi (GDP)	30.9	Below 2006 level Investment to increase recyc and replace old plant	32.8	Below 2006 level Investment to increase recyc and replace old plant	46.4	50% (0.5 Mtpa) increase. At least one big plant/yr. Up to £250M/ yr Planning/ bank problems?	84.1	80% (0.8 Mtpa) increase. 1–2 big plants/yr. Up to £400M/yr Planning/bank problems?
	C&D 2005/6 112.4 Mt	Lo	85.7	Below 2005/6 level Investment to increase recyc and replace old plant	87.4	Below 2005/6 level Investment to increase recyc and replace old plant	90.3	Below 2005/6 level Investment to increase recyc and replace old plant	82.9	Below 2005/6 level Investment to increase recyc and replace old plant

Low growth	C&D 2005/6: 112.4 Mt	Hi	117.7	5 Mt above 2005/6 levels. 1.2 Mtpa. 3 big plants/yr. £600M/yr. Planning/bank problems	121.7	0.8 Mtpa increase. 1–2 big plants/yr. Up to £400M/yr Planning/bank problems?	125.0	Minor increase. Investment to replace old plant	113.6	Decrease. Investment to increase recyc and replace old plant
	C&I* 2009: 54.6 Mt	Following IoP	63.3	Below 2002/3 level for Eng. No problem unless need 8.7Mt capacity increase from 2009	67.2	At 2002/3 level for Eng – as for 2015	86.3	0.6 Mtpa increase. 1–2 big plants/yr. Up to £300M/yr Planning/bank problems?	105.4	0.4 Mtpa increase. 1 big plant/yr. Up to £200M/yr Planning/bank problems?
		Static	81.9	From end 2010 inc in MSW targets. 30Mt increase over 09 level. Problem? Unrealistic?	83.5	Minor increase from 2015 but still likely to be difficult	86.6	Minor increase Investment to replace old plant	80.0	Decrease. Investment to replace old plant
Medium growth	MSW – 2009: 30.3Mt, 2006: 33.5 Mt	Lo (static)	32.1	Below 2006 level. Investment to increase recyc and replace old plant	33.2	Below 2006 level. Investment to increase recyc and replace old plant	38.3	Minor increase given timescale. Some new plant but likely covered by capacity increase at replacement	45.2	Minor increase given timescale. Some new plant but likely covered by capacity increase at replacement
		Hi (GDP)	32.6	Below 2006 level. Investment to increase recyc and replace old plant	36.2	0.6 Mtpa increase. 1–2 big plants/yr. Up to £300M/yr Planning/bank problems?	67.9	1 Mtpa increase. 1–3 big plants/yr. Up to £500M/yr Planning/bank problems?	201.7	2.6 Mtpa increase. 5–7 big plants/yr. Up to £1300M/yr Planning/bank problems?
	C&D 2005/6: 112.4 Mt	Lo	87.1	Below 2005/6 level Investment to increase recyc and replace old plant	90.0	Below 2005/6 level Investment to increase recyc and replace old plant	104.1	Below 2005/6 level Investment to increase recyc and replace old plant	123.2	0.4 Mtpa increase
		Hi	121.4	9 Mt above 2005/6 levels. 2.3 Mtpa	125.4	0.8 Mtpa increase	144.4	0.6 Mtpa increase	169.8	0.5 Mtpa increase

Medium growth	C&I* 2009: 54.6 Mt	Following IoP	64.3	Below 2002/3 level for Eng. No problem unless need 8.7Mt capacity increase from 2009	69.2	1 Mtpa increase. 1–3 big plants/yr. Up to £500M/yr Planning/bank problems?	99.4	1 Mtpa increase. 1–3 big plants/yr. Up to £500M/yr Planning/bank problems?	156.2	1 Mtpa increase. 1–3 big plants/yr. Up to £500M/yr Planning/bank problems?
		Static	**83.2**	**From end 2010 inc in MSW targets. 30Mt increase over 09 level. Problem? Unrealistic?**	86.0	0.6 Mtpa increase. 1–2 big plants/yr. Up to £300M/yr Planning/bank problems?	99.7	0.4 Mtpa increase. 1 big plant/yr. Up to £200M/yr Planning/bank problems?	118.5	0.4 Mtpa increase. 1 big plant/yr. Up to £200M/yr Planning/bank problems?
High growth	MSW - 2009 : 30.3Mt, 2006: 33.5 Mt	Lo (static)	32.6	Below 2006 level. Investment to increase recyc and replace old plant	34.2	Minor increase. Investment to increase recyc and replace old plant	43.6	Minor increase given timescale. Some new plant but likely covered by capacity increase at replacement	63.0	0.4 Mtpa increase. 1 big plant/yr. Up to £200M/yr Planning/bank problems?
		Hi (GDP)	33.9	Minor increase. Investment to increase recyc and replace old plant	38.8	1 Mtpa increase. 1–3 big plants/yr. Up to £500M/yr Planning/bank problems?	88.9	1.6 Mtpa increase. 4 big plants/yr. Up to £800M/yr Planning/bank problems?	372.4	Nearly 6 Mtpa
	C&D 2005/6: 112.4 Mt	Lo	88.4	Below 2005/6 level Investment to increase recyc and replace old plant	92.7	Below 2005/6 level Investment to increase recyc and replace old plant	118.6	0.9 Mtpa increase.	171.8	1 Mtpa increase
		Hi	**123.3**	**11 Mt above 2005/6 levels. Annual production exceeds current inert landfill capacity**	129.2	1.2 Mtpa increase	164.8	1.2 Mtpa increase	237.6	1.4 Mtpa increase

High grpwth	C&I* 2009: 54.6 Mt	Following IoP	65.3	Below 2002/3 level for Eng. No problem unless need 8.7Mt capacity increase from 2009	71.3	1.2 Mtpa increase. 3 big plants/yr. Up to £600M/yr.	113.2	0.8 Mtpa increase. 2 big plants/yr. Up to £400M/yr. Planning/bank problems?	164.8	1 Mtpa increase. 1–3 big plants/yr. Up to £500M/yr Planning/bank problems?
		Static	84.4	From end 2010 inc in MSW targets. 30Mt increase over 09 level. Problem? Unrealistic?	88.6	Minor increase from 2015 but still likely to be difficult	113.5	0.8 Mtpa increase. 2 big plants/yr. Up to £400M/yr. Planning/bank problems?	217.3	2 Mtpa increase. 5 big plants/yr. Up to £1000M/yr Planning/bank problems?

Table 2: Growth rates by mass and proportion of arisings for MSW in England

	Annual increase from 1997/8 to 2009/10		Annual increase from 2007/8 to 2009/10	
	By mass (kt)	By proportion of arisings (%)	By mass (kt)	By proportion of arisings (%)
Green recycling	337.6	1.259	215.8	1.388
Dry recycling	432.2	1.624	69.8 (107.83)	1.197
EfW & RDF	124.7	0.429	223.4	1.253

Table 3: Amounts of recycling and recovery compared to target levels based on the 2007/8 to 2009/10 mass growth column shown in Table 2

	Low growth		Business as usual		High growth	
	Following GDP (%)	Static per capita (%)	Following GDP (%)	Static per capita (%)	Following GDP (%)	Static per capita (%)
Recycling 2015 (target 45%)	45.2	44.6	42.8	44.0	41.2	43.3
Recovery 2015 (target 67%)	63.2	62.4	59.8	61.5	57.6	60.5
Recycling 2020 (target 50%)	48.4	49.6	43.8	48.2	40.8	46.9
Recovery 2020 (target 75%)	69.3	71.1	62.7	69.1	58.5	67.1

Table 4: Amounts and proportions of English MSW processable by different means. For each category, the min mass, and min and max percentages are shown

	Arisings and potential for processing 2006/7			Actual percentage processed (%)	
	Min tonnes	Lower limit %	Upper limit %	2006/07	2009/10
Biodegradable/green recyclable (1–3 or 1–5)	9,536,393	34	56	11	15.7
Dry recyclable (6 & 7 or 4–8)	3,099,134	11	44	19.5	24.0
Combustibles (10 & 16 or 4, 5, 8, 10 & 16)	1,728,414	6	39	11	13.6
Paper & Card (4 & 5)	6,429,612	23			
Plastic (8)	2,831,585	10			
Landfill (9, 11 to 15, 17–20)	4,714,974	17		58	46.7

Note: 1: food waste; 2: garden waste; 3: other organic; 4: paper; 5: card; 6: glass; 7: metals; 8: plastics; 9: textiles; 10: wood; 11: WEEE; 12: Hazardous; 13: sanitary; 14: furniture; 15: mattresses; 16: misc. combustible; 17: misc non-combustible; 18: soil; 19: other; 20: fines

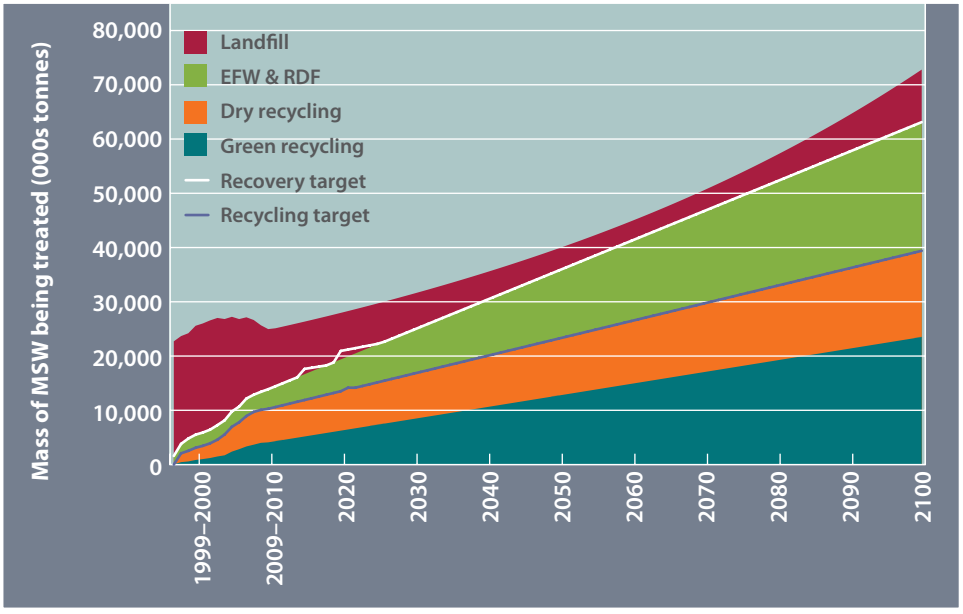


Figure 1: Graph showing the treatment of English MSW in the low growth with waste arisings following GDP scenario. Treatment methods follow the trajectories previously described (based on growth between 2007/8 and 2009/10). Landfill is not permitted to rise above 12.2 Mtpa but this is never reached. The lines show the recycling and recovery targets.

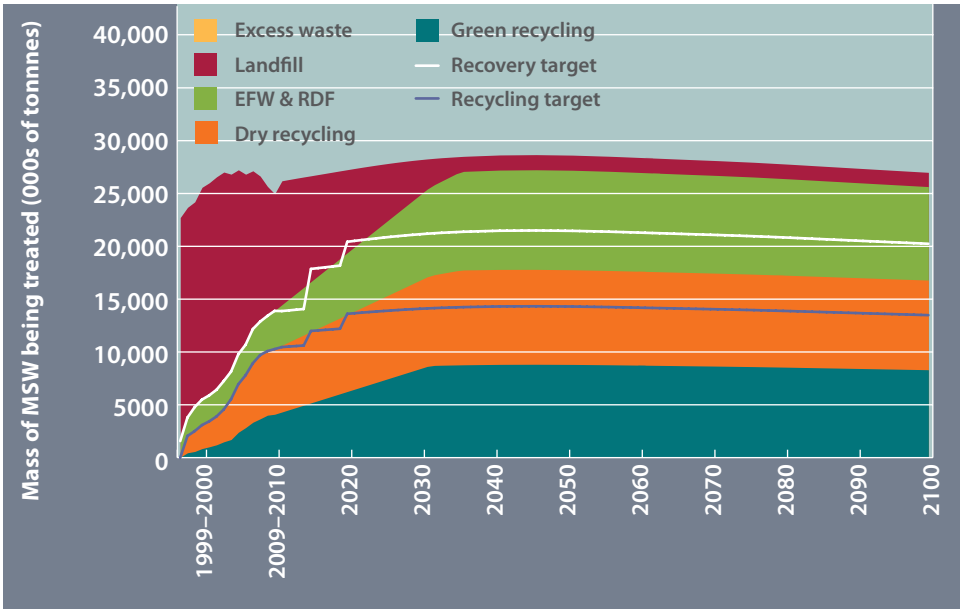


Figure 2: Graph showing the treatment of English MSW in the low growth with static per capita waste arisings. Treatment methods follow the trajectories previously described (based on growth between 2007/8 and 2009/10). Landfill is not permitted to drop below 5% of the total (reached in 2036). Green recycling is capped at 90% of the organic waste fraction (30.7% of total) and this occurs in 2032. In order to prevent recovery exceeding generation, EfW and dry recycling are reduced (arbitrarily by 2/3 and 1/3 of the excess recovery above 95%) from 2036 such that total recovery doesn't go above 95%. The lines show the recycling and recovery targets.

Table 5: Showing the extra MSW requiring treatment over and above that accounted for in treatment growth trajectories based on Figures 1 and 2

Year	Extra recycling required to meet target (kt)		Extra recovery needed to meet target (kt)[1]		Extra waste requiring treatment (kt)[2]	
	Following GDP	Static per capita	Following GDP	Static per capita	Following GDP	Static per capita
2015		94.7	1009.2	1133.1		
2020		97.6	1591.9	959.7		
2030						
2040						
2050						

1 Extra recovery does not include the required extra recycling.

2 Extra waste requiring treatment is the shortfall in treatment less the shortfalls in recovery and recycling.

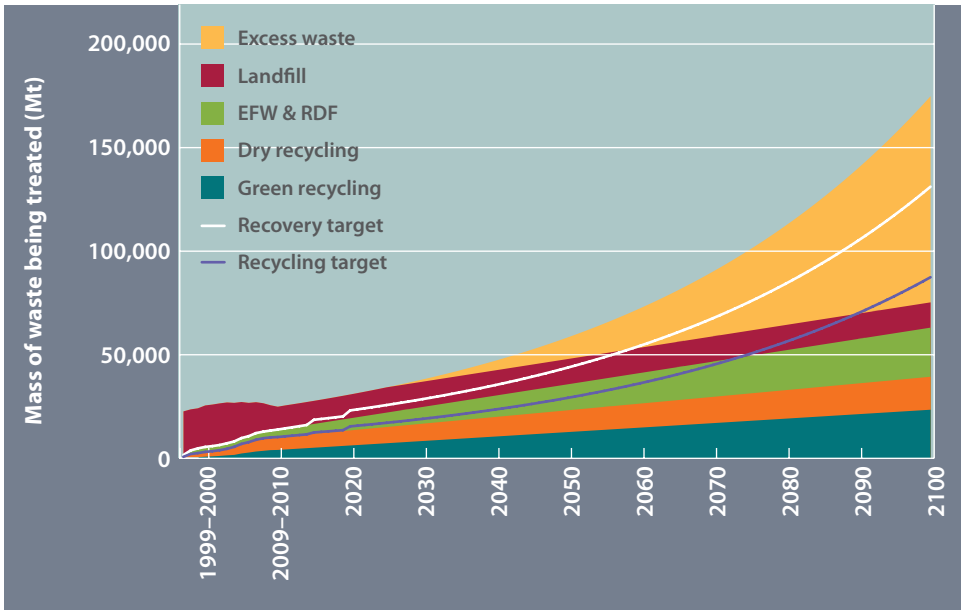


Figure 3: Graph showing the treatment of English MSW in the medium growth scenario with waste arisings following GDP. Treatment methods follow the trajectories previously described (based on growth between 2007/8 and 2009/10). Landfill is not permitted to rise above 12.2 Mtpa (reached in 2026). The lines show the recycling and recovery targets. The purple sector is waste not accounted for, which must be recovered or recycled if the landfill target is to be met.

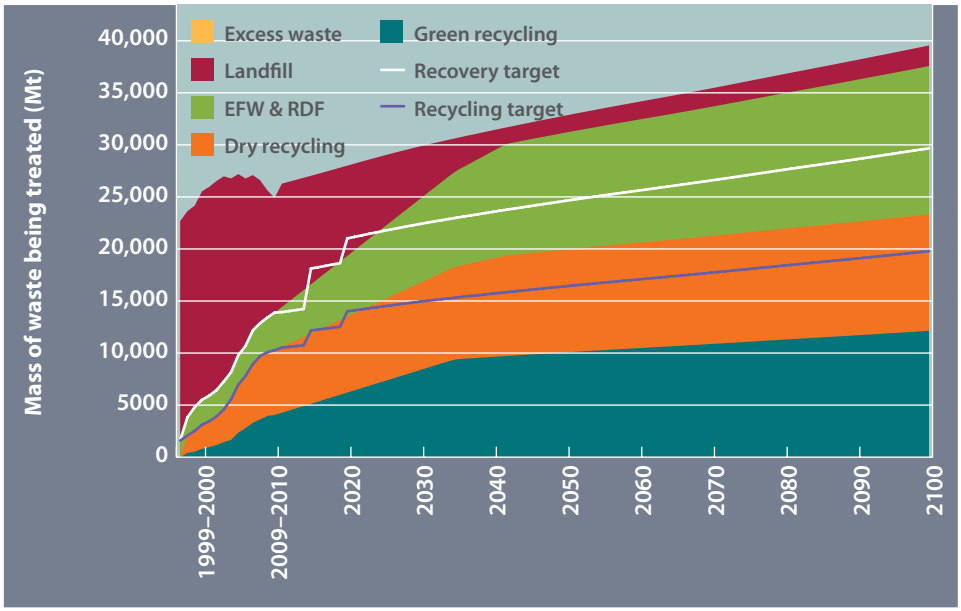


Figure 4: Graph showing the treatment of English MSW in the medium growth scenario with static per capita waste arisings. Treatment methods follow the trajectories previously described (based on growth between 2007/8 and 2009/10). Landfill is not permitted to drop below 5% of the total (reached in 2042). Green recycling is capped at 90% of the organic waste fraction (30.7% of total) and this occurs in 2035. In order to prevent recovery exceeding generation, EfW and dry recycling are reduced (arbitrarily by 2/3 and 1/3 of the excess recovery above 95%) from 2042 such that total recovery does not go above 95%. The lines show the recycling and recovery targets.

Table 6: Showing the extra MSW requiring treatment over and above that accounted for in treatment growth trajectories based on Figures 3 and 4

Year	Extra recycling required to meet target (kt)[1]		Extra recovery needed to meet target (kt)[2]		Extra waste requiring treatment (kt)	
	Following GDP	Static per capita	Following GDP	Static per capita	Following GDP	Static per capita
2015	603.8	277.3	1382.0	1222.4		
2020	1914.6	499.6	1868.2	1160.7		
2030	2310.9		1450.3			
2040	3589.8		1473.6		3175.7	
2050	5991.3		2058.3		8395.8	

1 Extra recycling is difference between red line and red block in Figure 3.

2 Extra recovery does not include the required extra recycling, i.e. is the difference between the black line and the black block less 1 in Figure 3.

3 Extra waste requiring treatment is the shortfall in treatment, i.e. the part of the purple sector above the black line in Figure 3.

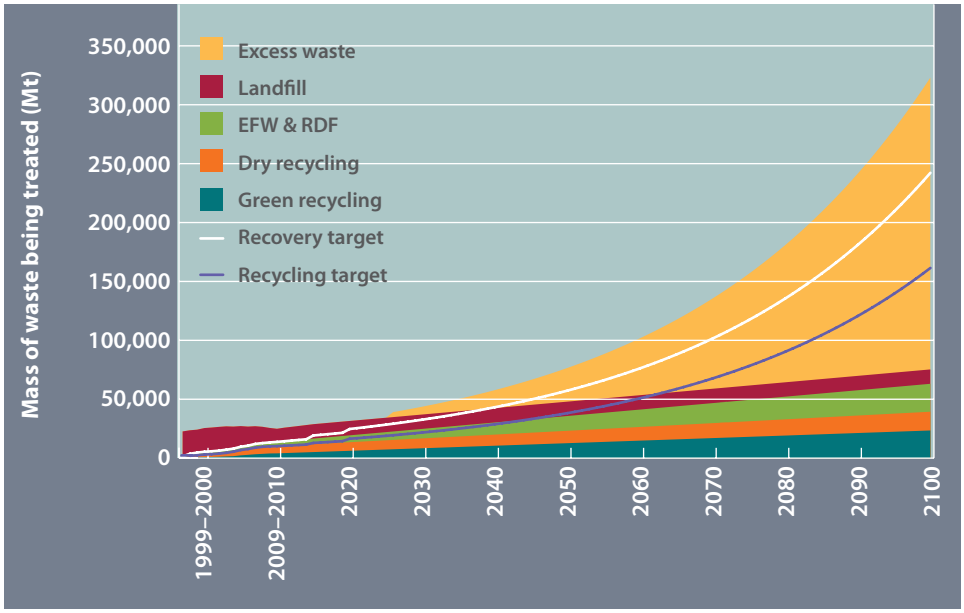


Figure 5: Graph showing the treatment of English MSW in the high growth scenario with waste arisings following GDP. Treatment methods follow the trajectories previously described (based on growth between 2007/8 and 2009/10). Landfill is not permitted to rise above 12.2 Mtpa (reached in 2015). The lines show the recycling and recovery targets. The purple sector is waste not accounted for, which must be recovered or recycled if the landfill target is to be met.

Figure 6: Graph showing the treatment of English MSW in the high growth scenario with static per capita waste arisings. Treatment methods follow the trajectories previously described (based on growth between 2007/8 and 2009/10). Landfill is not permitted to drop below 5% of the total. Green recycling is capped at 90% of the organic waste fraction (30.7% of total) and this occurs in 2041. The lines show the recycling and recovery targets.

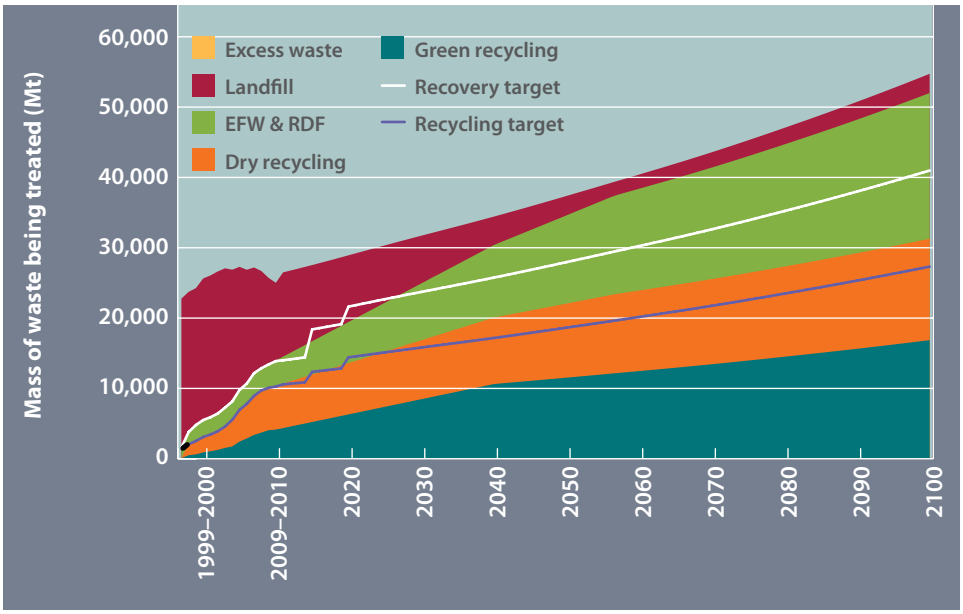


Table 7: Showing the extra MSW requiring treatment over and above that accounted for in treatment growth trajectories based on Figures 5 and 6

Year	Extra recycling required to meet target (kt)[1]		Extra recovery needed to meet target (kt)[2]		Extra waste requiring treatment (kt)[3]	
	Following GDP	Static per capita	Following GDP	Static per capita	Following GDP	Static per capita
2015	1088.2	461.2	1618.9	1312.3		
2020	3037.3	908.0	2429.6	1364.9		
2030	5080.7		2835.2		3794.1	
2040	8880.7		4119.1		11,112.1	
2050	15,058.9		6592.1		21,997.3	

1 Extra recycling is difference between red line and red block in Figure 5.

2 Extra recovery does not include the required extra recycling, i.e. is the difference between the black line and the black block less 1 in Figure 5.

3 Extra waste requiring treatment is the shortfall in treatment, i.e. the part of the purple sector above the black line in Figure 5.

I.1.1 Capital and operational costs of waste treatment plant

Table 8: Capex and opex costs of waste treatment from Wheeler and de Rome (2002) in £ per tonnes per year (£/tpa)				
Treatment	Capital Costs (£/tpa)		Operational Costs (£/tpa)	
	min	max	min	max
Anaerobic Digestion	70	200	22	30
Materials Recycling / Recovery Facility (Inc. Transfer Station) (Clean)	67	177	35	55
Materials Recycling / Recovery Facility (Inc. Transfer Station) (Dirty)	40	74	25	41
Mechanical Biological Treatment	85	150	14	25
Mechanical Heat Treatment	85	150	14	25
In-Vessel Composting	100	300	19	45
Open Windrow	25	90	15	25
Gasification/Pyrolysis (Whole Waste)	350	450	46	61
Gasification/Pyrolysis (RDF)	350	450	46	61
Incineration 100 kt Electricity only	353	353	24	24
Incineration 200 kt Electricity only	265	265	22	22
Incineration 400 kt Electricity only	227	227	17	17
Incineration 100 kt total CHP	411	411	26	26
Incineration 200 kt total CHP	314	314	24	24
Incineration 400 kt total CHP	265	265	18	18

Table 8 shows capital and operating costs for different waste facility types. The figures are from Wheeler and de Rome (2002). More recent figures from the EA Waste Technologies Data Centre and announcements from Letsrecycle.com show lower capital costs for gasification (£160–500 tpa); pyrolysis (£160–833 tpa) and incineration (£192–500 tpa).

I.2 Generation and GDP

Household generation and GDP

Figures 7 to 9 show the per capita household waste arisings for each country against per capita GDP. For each country, GDP has been plotted against the complete data set and also against a reduced data set which appears to have the best fit to the waste generation data.

Figure 7: England household waste generation.

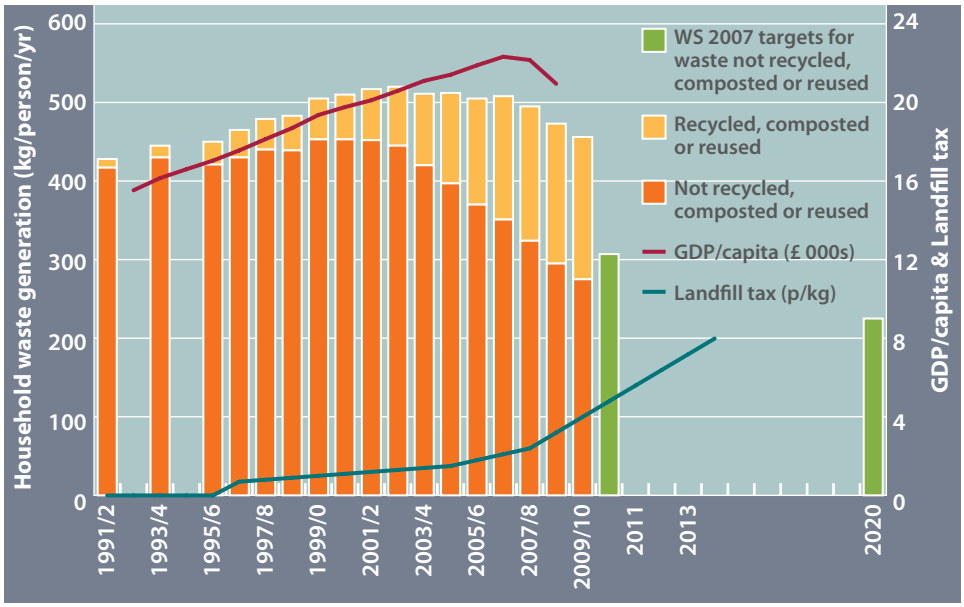


Figure 8: Scotland household waste generation.

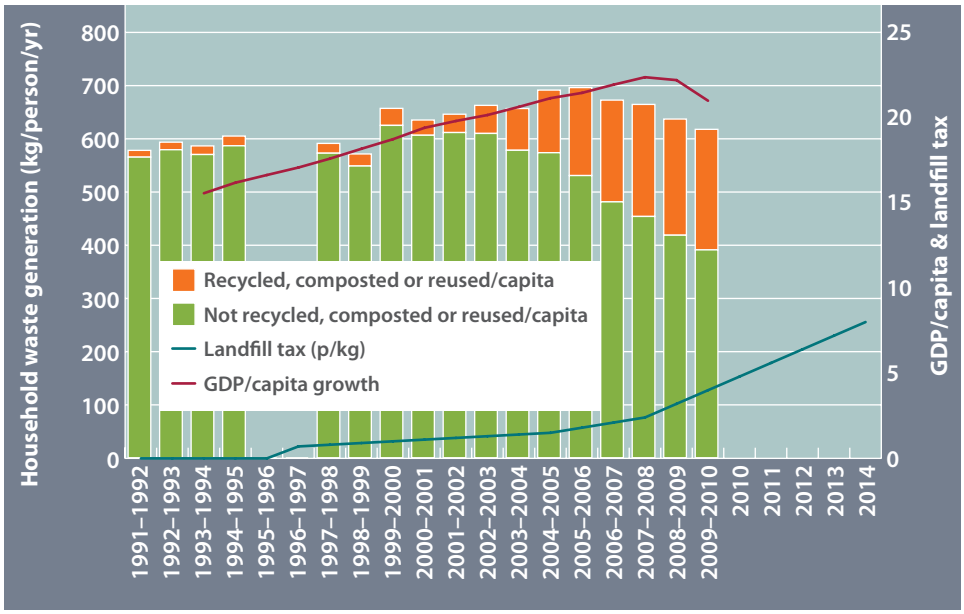
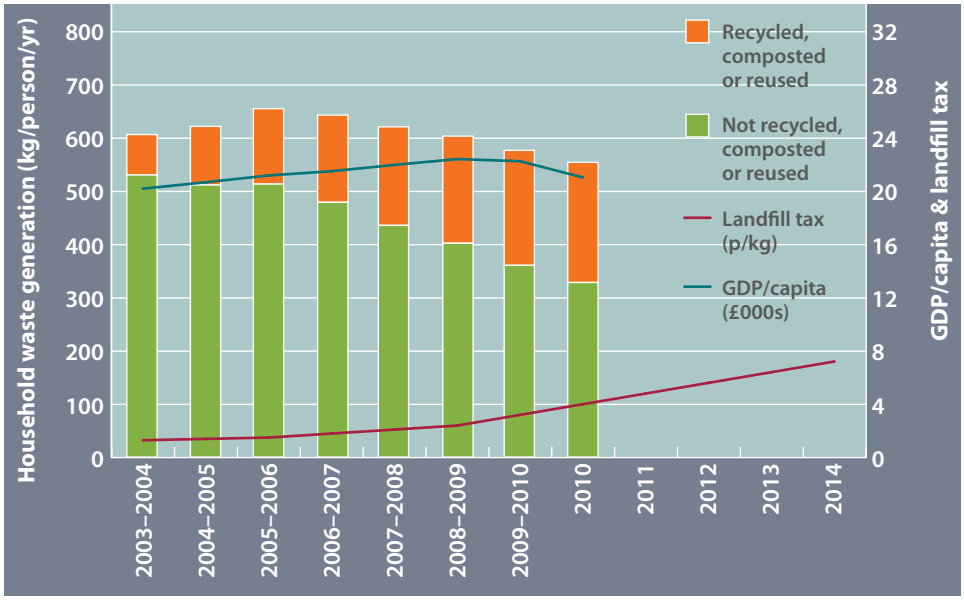
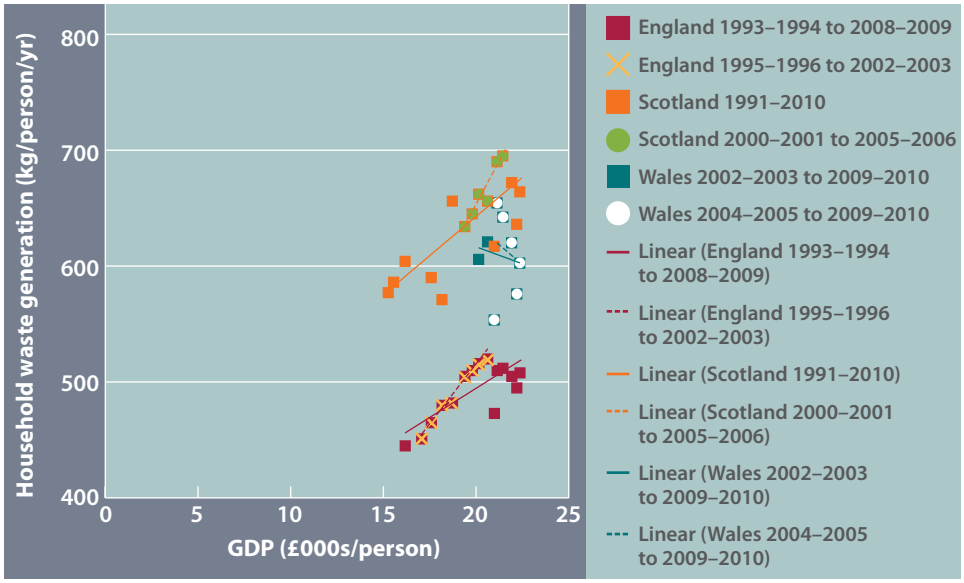


Figure 9: Wales household waste generation.



As can be seen in Figures 7 and 10, English per capita MSW generation was very strongly coupled to economic conditions between 1995/96 and 2002/3 and the equation for the England 1995/96 to 2002/3 best fit line, shown in Figure 10 is that which has been used to create the high waste generation scenario. After 2002/03, there was a partial decoupling, although MSW generation has followed the dip in GDP since 2008. The same pattern can be seen in the Scottish data for 2000/1–2005/6 (Figures 8 and 10) but with a lower R2 value and the equation for the Scotland 2000/1– 2005/6 best fit line, shown in Figure 4 has been used to create the high end waste generation scenario. Once again, it appears as if waste generation and GDP may have decoupled (this time after 2005/6) but Scottish MSW arisings have also followed the post-2008 drop in GDP. There appears to be no correlation between GDP and waste generation for Wales (Figures 9 and 10).

Figure 10: National per capita household generation against GDP.



C&I generation scenarios, IoP, and GDP

Two possible economic drivers for C&I arisings have been considered – GDP and index of production (IoP), which measures the volume of production of the manufacturing, mining and quarrying, and energy supply industries, which covered 17.2% of the UK economy in 2006. The index is measured at base year prices (currently 2006). It was thought that population and energy prices are likely to be weak drivers given the large temporal variations in C&I arisings.

Figure 11 would suggest that IoP is a more likely driver than GDP for England and similarly, Figure 12 shows that IoP is also a better fit to the Scottish data.

Figure 13 shows that neither manufacturing output nor IoP correlate well with GDP, although IoP wa closely correlated to GDP between 1991 and 2000. Figure 14 does suggest that it might be possible to use a linear extrapolation for IoP and use this to predict a second scenario for C&I waste, despite the apparent non-linearity since 2002, which could make the validity of this somewhat suspect.

Figure 11: C&I waste arisings for England plotted with UK GDP and IoP for the same period.

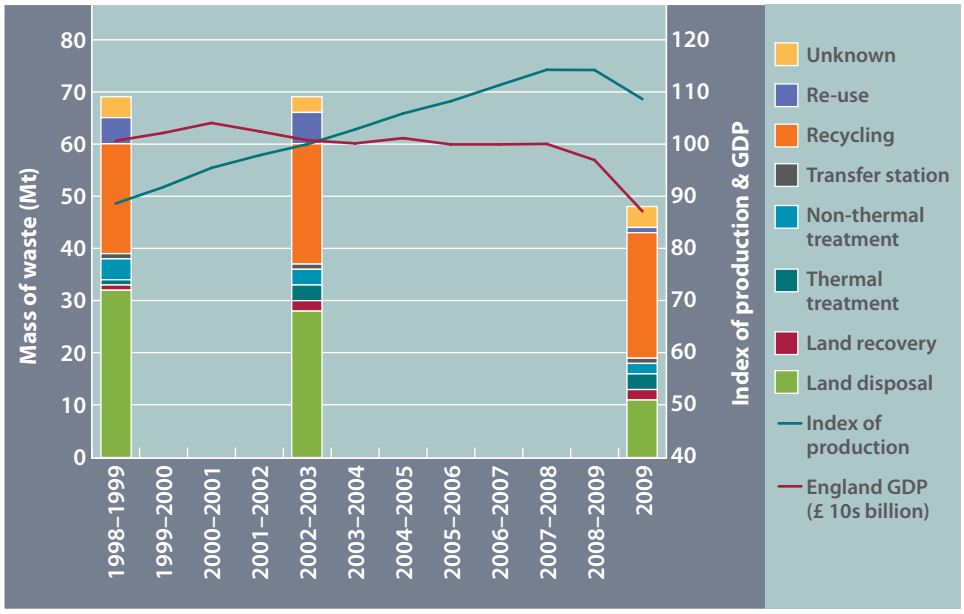


Figure 12: C&I waste arisings for Scotland plotted with UK GDP and IoP for the same period.

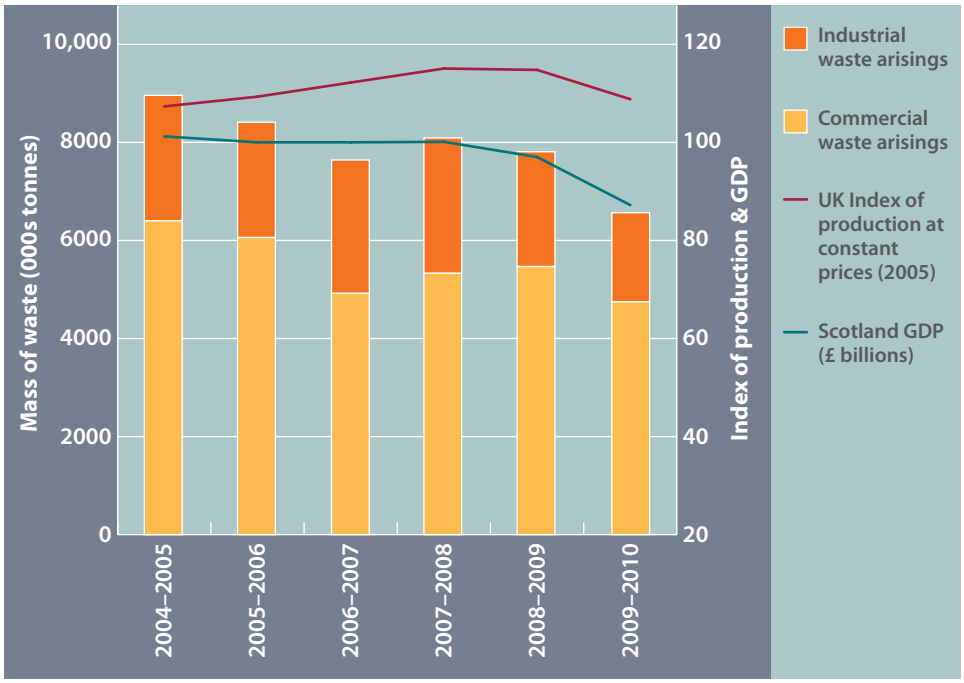


Figure 13: UK IoP and manufacturing output plotted against GDP from 1991 to 2010.

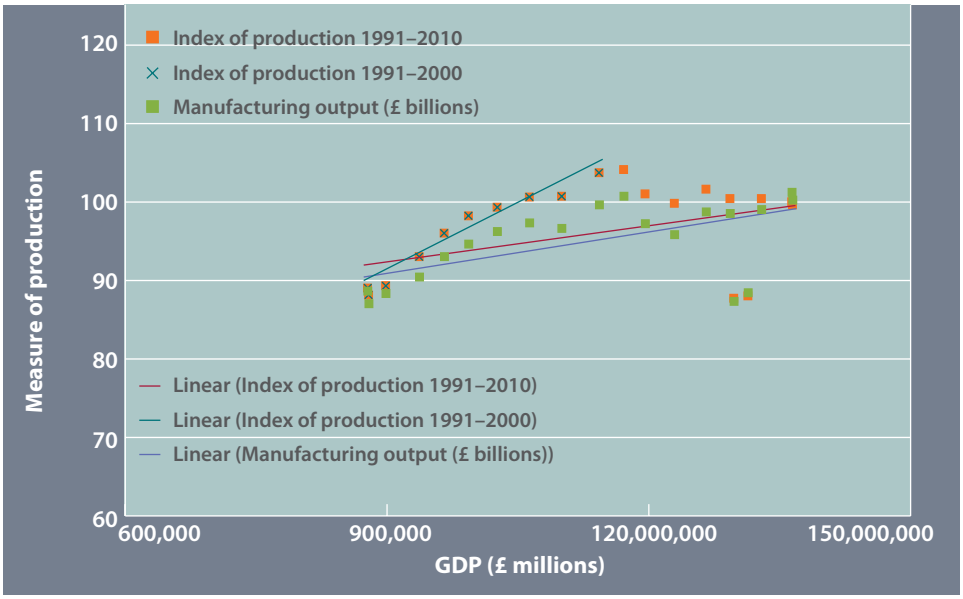


Figure 14: Quarterly UK GDP and IoP data plotted from 1995 to 2009.

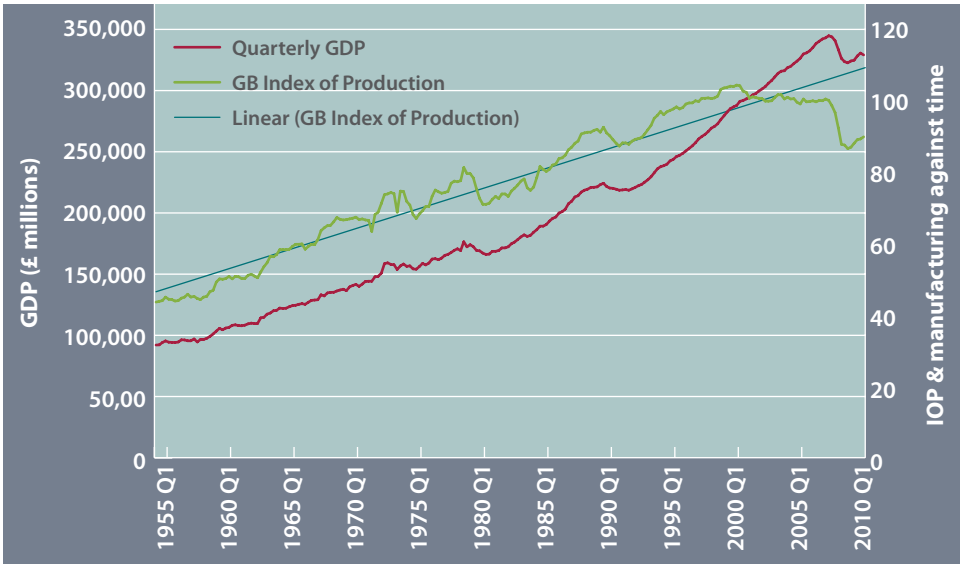
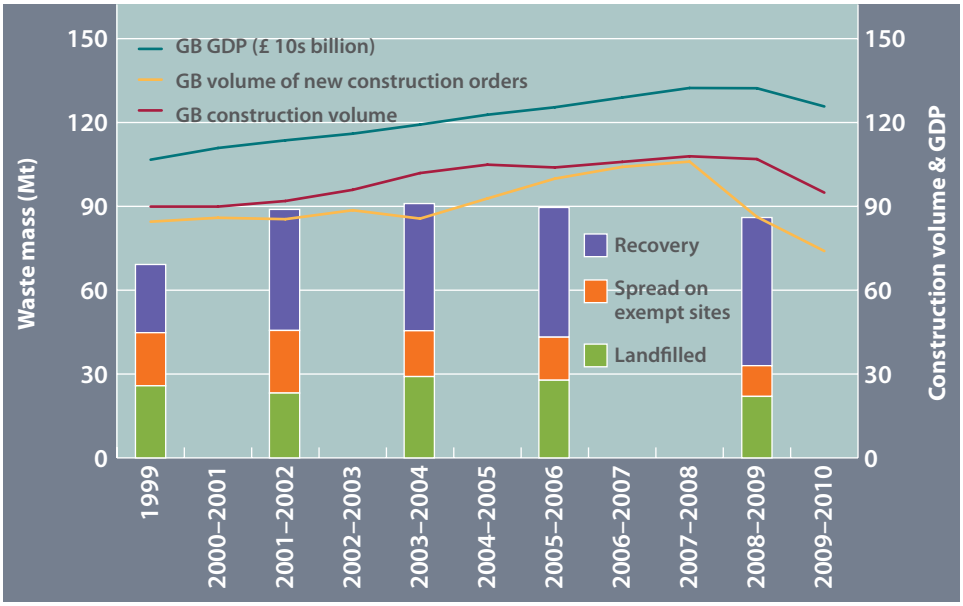


Figure 15: English C&D arisings plotted with construction volume; volume of new construction and GDP.



Construction and demolition (C&D) and GDP

Figures 15–17 show national C&D waste arisings, plotted with GDP and two construction industry metrics – construction volume (output) and an index of new orders. It would perhaps be expected that the construction industry with its long contracts would display a lagged response to recession. This does not appear to be the case.

English C&D waste arisings (Figure 15) seem to be essentially constant albeit over a relatively short period and with much of the data extrapolated from a single regional survey. Scottish C&D arisings (Figure 16)seem to track the new order index (i.e. work which has yet to start) rather than construction output (i.e. ongoing projects).

It is not clear what has driven the significant increase in Welsh C&D arisings (Figure 17) but they don't appear strongly linked to either GDP or the construction metrics. It may well be that one or two large projects have significantly skewed the data as the comparative data is all for GB.

Figure 16: Scottish C&D arisings plotted with construction volume; volume of new construction and GDP.

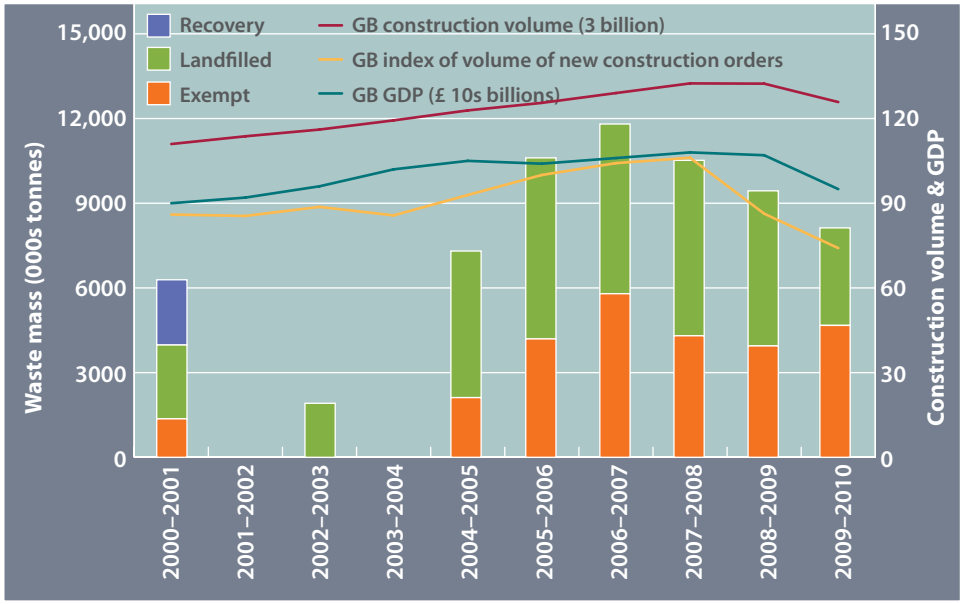
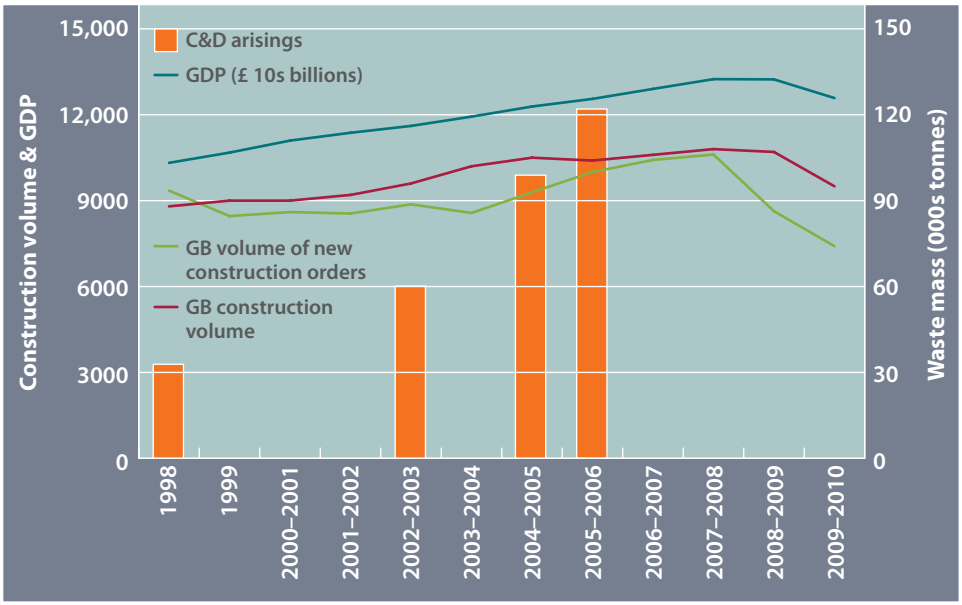


Figure 17: Welsh C&D arisings plotted with construction volume; volume of new construction and GDP.



I.3 Previous quantified assessments

There is a large amount of data available regarding waste generation, recovery of recyclables, disposal to landfill etc. A number of reports have assessed the link between waste generation and factors such as population, economics, social change, policy and regulation. Previous assessments of waste management demand and capacity in the UK have been reviewed, along with a limited review of the sector in European countries, since waste management is operated under the similar regulatory system but recovery of waste is more advanced than in the UK. Scenarios from Europe may indicate the potential for future waste reduction/recycling in the UK.

REFERENCE

Wheeler, P. A. and De Rome, L. (2002). Waste pre-treatment: a review (P1-344/TR). Environment Agency. Bristol, UK.