Annex 1: Analysis of construction, refurbishment and demolition waste data

This Annex accompanies the SID5 report for the Defra funded project 'Understanding and Predicting Construction Waste' (WR0111). This Annex gives details of the data analysis undertaken and the subsequent results. The Annex is based on data collected up to the 31st August 2008. As part of the Defra funded project, a benchmarking website was developed whereby the construction industry were encouraged to submit waste data; additionally data was also analysed from BRE's SMARTWaste system, which is a web based tool for monitoring and managing waste. SMARTWaste has been operating for over 10 years and Defra funding has enabled the data collected to be scrutinized in detail.

Data analysis

Data obtained via BRE's SMARTWaste system and the benchmarking website for all completed projects goes through a number of logical and statistical tests, to ensure that the data used to produce the key performance indicators (KPI) and other data are valid. These are as follows*:*

For the KPI $m^3/100m^2$:

- The floor area must be greater than 10 m^2.
- The waste volume must be more than 10 m^3 or the data is excluded.
- The volume of waste in m^3 per 100 m^2 floor area must be between 5 and 75.

For the KPI m^3/£100K:

- The project value must be greater than £100.
- The waste volume must be more than 10 m^3 or the data is excluded.
- The volume of waste in m^3 per £100K of project value must be between 5 and 75

Once these logical tests have been applied then the following statistical tests are performed:

- A count of the number of plausible results, the average, standard deviation and median of the results is obtained.
- Limits at a given confidence were calculated using a standard T-table and the basic formula where outlying results are suspected:

  LIMIT (at confidence) value = AVERAGE value + (Standard Deviation x T-table value (fn number of results, confidence level required)).

For example: upper 95% limit = Average value + (std. dev. of data) x (T-table result based on 29 results and 95% confidence) which is 14.2 + (10.5 x1.699) = 32.04 value which is the 95% upper confidence level.

Data evaluation

The key performance indicators of m^3 (volume) of waste per 100 m^2 of floor area and m^3 (volume) of waste per £100K of project value have been produced for completed new build projects for different project types. The project types are shown in Table 1 with examples of each project type. Summaries of performance indicators for the different project types are given in Tables 2 and 3.

Project Type	Examples
Civil Engineering	Bridges, tunnels, roads, railways, utilities, car parks
Commercial Retail	Food store, retail warehouse, shopping centre, supermarket, department store
Commercial Offices	Institutional, suites, call centres, others
Commercial Other	Film TV studios, newspaper HQ, banks/building societies
Education	Primary Schools / Nurseries, universities, student accommodation, high schools
Healthcare	Hospitals / nursing homes, health centres
Industrial Buildings	Industry (heavy, light, food), scientific labs, distribution/warehousing, farm buildings
Leisure	Cinema / Theatre, hotel/holiday camp, sports facilities, parks/gardens/playgrounds, pubs/clubs/restaurants
Public Buildings	Fire / police stations, government admin, prison service, museums/galleries, religious centres
Residential	Flats / Apartments, houses, old peoples homes, student accommodation/hostels, military accommodation

Table 1: Project types and examples

Project Type	Number of completed projects passing logical tests	Number of companies	Average m^3/100 m^2
Residential	116	21	15.3
Public Buildings	6	5	26.1
Leisure	3	3	12.3
Industrial Buildings	5	5	20
Healthcare	14	8	15
Education	20	11	13.4
Commercial Offices	24	10	20.1
Commercial Retail	27	6	15
Civil Engineering	9	5	24.3
Total	224	74	

Table 2: Average m^3/100 m^2 by project type for new build projects completed by 31/08/08

Project Type	Number of completed projects passing logical tests	Number of companies	Average m^3/£100K
Residential	112	21	18.3
Public Buildings	8	6	22.2
Leisure	5	5	20.6
Industrial Buildings	5	5	11.3
Healthcare	12	7	13.4
Education	21	14	17.3
Commercial Retail	22	10	14.9
Commercial Offices	24	6	10.4
Civil Engineering	6	6	20.3
Total	215	80	

Table 3: Average m^3/£100K by project type for new build projects completed by 31/08/08

Results can also be obtained for the waste categories currently on BRE's SMARTStart (see www.smartwaste.co.uk) by project type and these results are given in Tables 4 and 5 and Figures 1 and 2. Providing KPI information by waste type to both the construction industry and the Government provides the data for tools for forecasting types and amounts of waste that are likely to be generated based on the floor size or the value of a particular development.

	$m^3/100m^2$								
Description	**Civil Engineering**	**Commercial Offices**	**Commercial Retail**	**Education**	**Healthcare**	**Industrial Buildings**	**Leisure**	**Public Buildings**	**Residential**
Canteen/office/ad-hoc	3.63	1.49	1.96	3.23	1.62	1.17	0.05	1.81	1.73
Ceramics/bricks	0.14	0.54	0.37	0.59	0.64	0.28	0.10	1.40	1.44
Concrete	2.15	1.73	0.56	0.75	0.99	1.02	0.52	6.95	1.90
Electrical equipment	0.27	0.17	0.30	0.28	0.21	0.04	0.31	0.14	0.15
Furniture	0.01	0.09	0.12	0.06	0.04	0.00	0.17	0.20	0.08
Hazardous	0.20	0.23	0.03	0.01	0.46	0.02	0.01	0.09	0.06
Inert	10.40	2.28	5.32	0.71	0.85	7.67	0.01	6.87	0.67
Insulation	0.79	0.55	1.05	0.63	0.67	0.85	1.42	0.49	1.09
Liquids and Oils	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.05
Metals	1.96	1.67	1.40	0.87	1.26	1.42	1.27	1.38	0.59
Packaging	1.36	2.02	3.27	1.73	2.49	2.13	1.61	2.17	2.71
Plaster/cement	1.03	1.26	1.61	1.30	3.22	2.99	5.55	1.66	1.87
Plastics	0.39	0.66	0.58	0.57	0.57	0.50	0.34	0.59	1.05
Timber	1.96	2.32	3.57	2.75	2.02	1.98	0.95	1.97	1.89

Table 4: $m^3/100m^2$ data by waste group for projects completed by 31/08/08

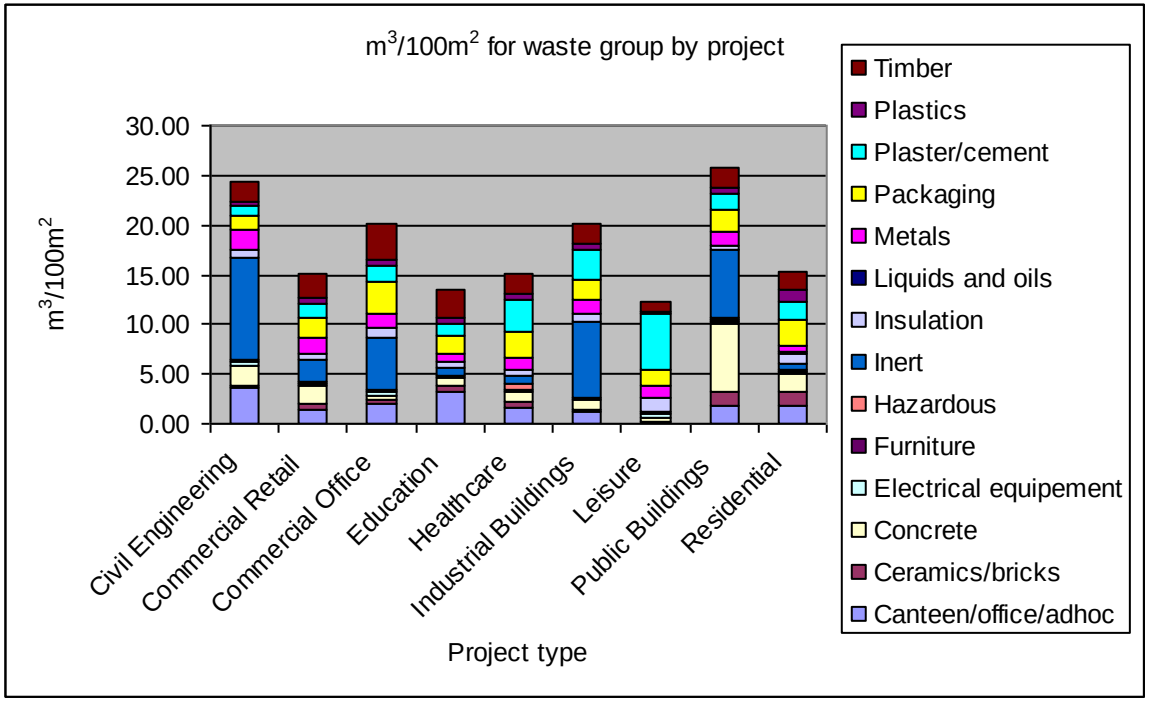

Figure 1: $m^3/100m^2$ for all waste groups for different project types (based on data in Table 4)

	m^3/£100K								
Description	**Civil Engineering**	**Commercial Offices**	**Commercial Retail**	**Education**	**Healthcare**	**Industrial Buildings**	**Leisure**	**Public Buildings**	**Residential**
Canteen/office/ad-hoc	0.76	0.83	0.73	2.38	1.08	0.63	0.10	2.37	1.79
Ceramics/bricks	0.01	0.36	0.20	1.84	0.79	0.37	0.09	0.61	2.06
Concrete	5.54	0.84	1.26	0.42	0.79	0.31	0.37	4.35	3.26
Electrical equipment	0.04	0.10	0.19	0.17	0.20	0.15	0.48	0.07	0.08
Furniture	0.01	0.05	0.04	0.08	0.03	0.01	0.29	0.04	0.03
Hazardous	0.74	0.22	0.03	0.02	0.31	0.03	0.03	0.96	0.02
Inert	9.89	2.00	4.75	5.61	2.25	4.29	8.84	8.58	1.34
Insulation	0.38	0.37	0.67	0.45	0.62	0.31	0.97	0.25	1.39
Liquids and Oils	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Metals	0.64	1.19	1.27	0.88	0.96	0.74	0.99	0.83	0.48
Packaging	0.59	1.43	2.09	1.51	2.04	1.87	1.18	1.43	3.23
Plaster/cement	0.52	0.71	1.01	1.01	1.92	1.00	5.72	1.16	1.84
Plastics	0.16	0.63	0.34	0.55	0.60	0.41	0.39	0.24	1.25
Timber	0.99	1.67	2.35	2.48	1.79	1.14	1.15	1.21	1.54

Table 5: m^3/£100K data by waste group for projects completed by 31/08/08

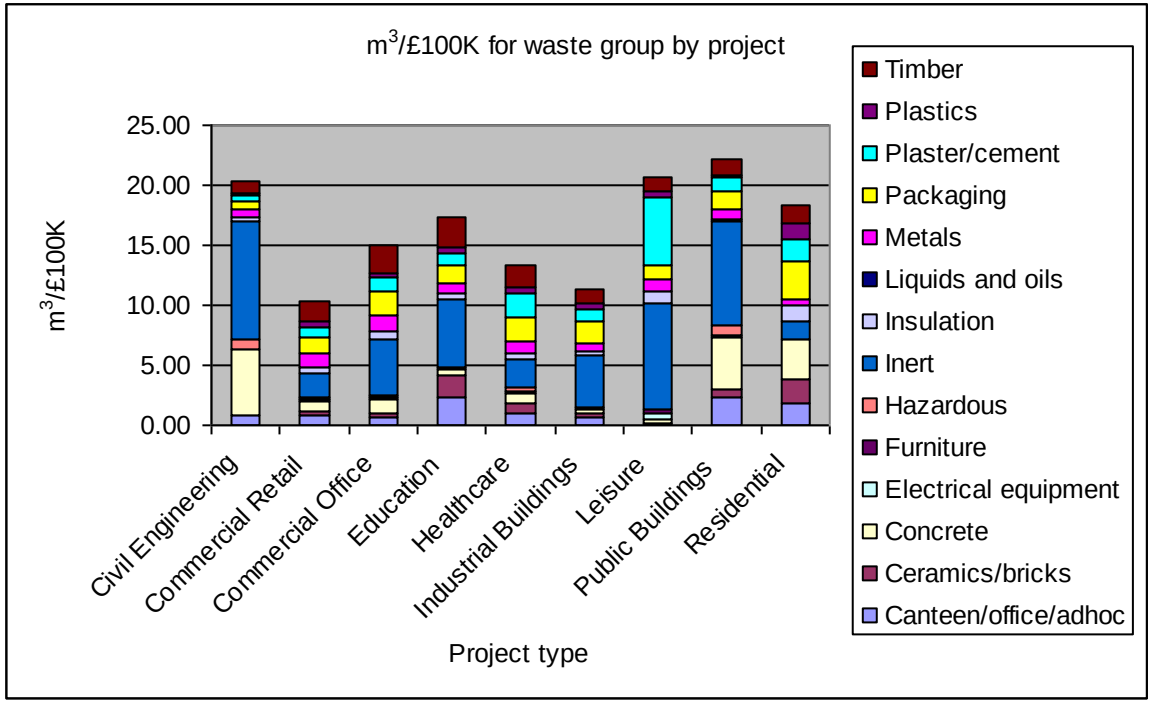

Figure 2: m^3/£100K for all waste groups for different project types (based on data in Table 5)

Data range

The range of the KPIs has been reviewed for completed projects. The lower quartile has been assigned as 'best practice', the next quartile assigned as 'good practice' and the top two quartiles assigned as 'standard practice'. These can provide benchmarks for the industry to start improving their performance and moving from standard to best practice. The volume data has also been converted to tonnes using conversion factors derived by the Environment Agency[1]. These are shown in the graphs and tables below for residential, education, healthcare, commercial retail and commercial office projects where the dataset is larger than 10.

Residential

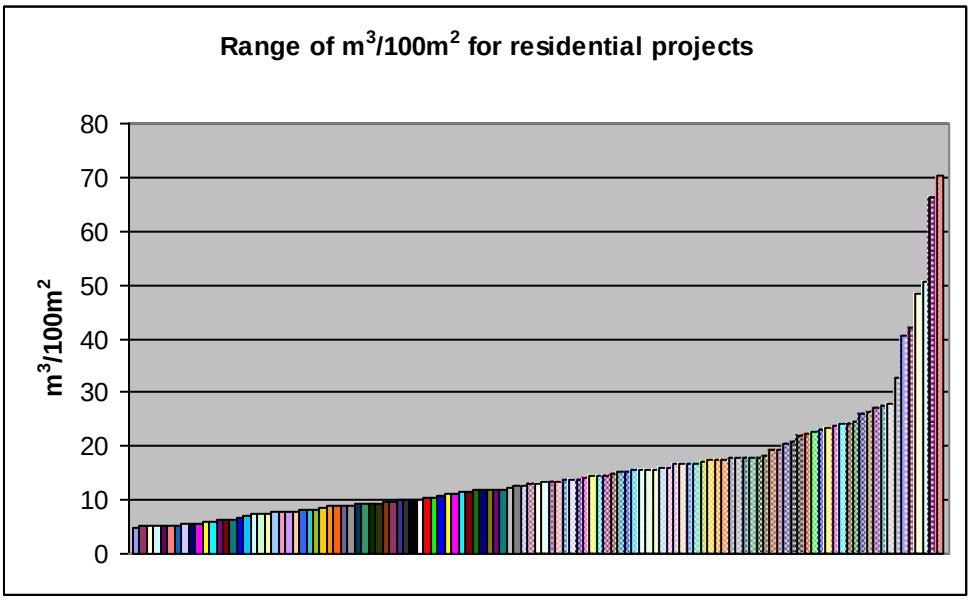

Figure 3: Range of $m^3/100m^2$ for residential projects

Benchmarks for Residential Projects	$m^3/100m^2$	Tonnes/$100m^2$
Best Practice (Lower Quartile)	<9.0	<4.7
Good Practice	9.0 - 12.9	4.7 – 6.7
Standard Practice	>12.9	>6.7

Table 6: Standard, good and best practice values for residential projects

[1] Environment Agency : survey on the arisings of Construction and Demolition waste in Wales 2005-06, published 2008

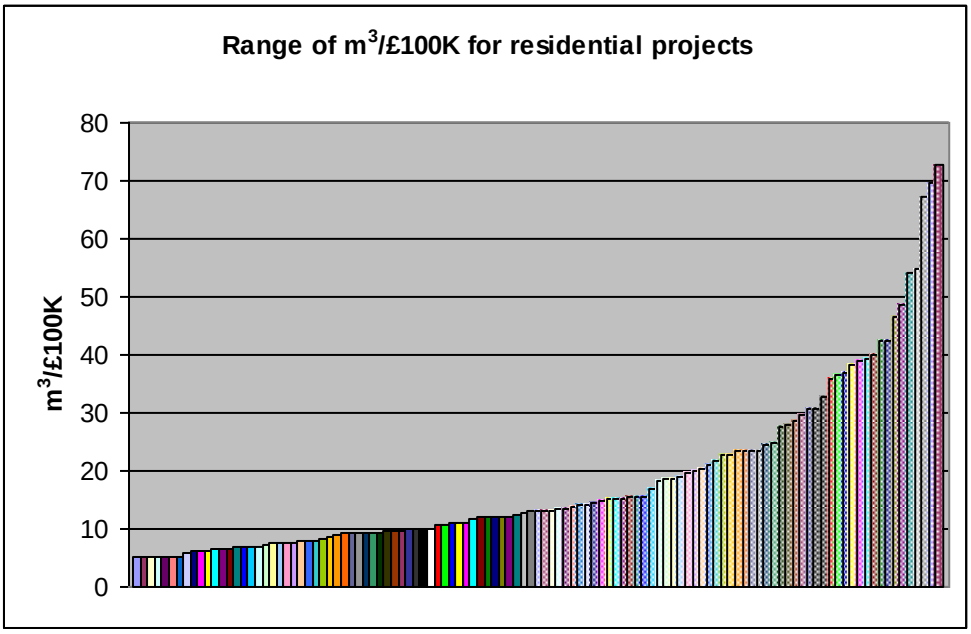

Figure 4: Range of m^3/£100K for residential projects

Benchmarks for Residential Projects	m^3/£100K	Tonnes/£100K
Best Practice (Lower Quartile)	<7.7	<4.7
Good Practice	7.7 – 13.1	4.7 – 8.0
Standard Practice	>13.1	>8.0

Table 7: Standard, good and best practice values for residential projects

Healthcare

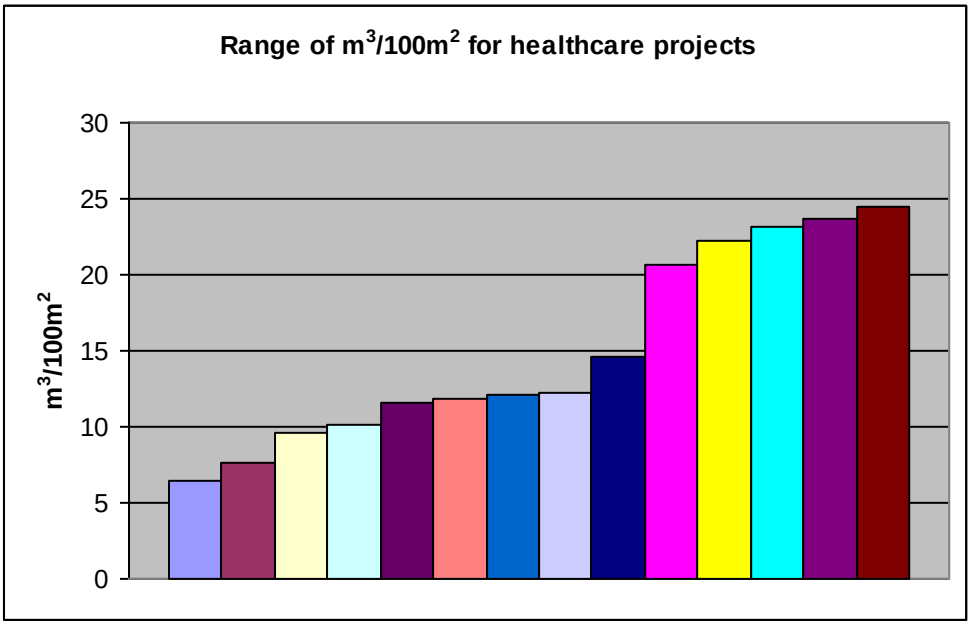

Figure 5: Range of $m^3/100m^2$ for healthcare projects

Benchmarks for Healthcare Projects	$m^3/100m^2$	Tonnes/$100m^2$
Best Practice (Lower Quartile)	<10.2	<4.7
Good Practice	10.2 – 12.0	4.7 - 5.5
Standard Practice	>12.0	>5.5

Table 8: Standard, good and best practice values for healthcare projects

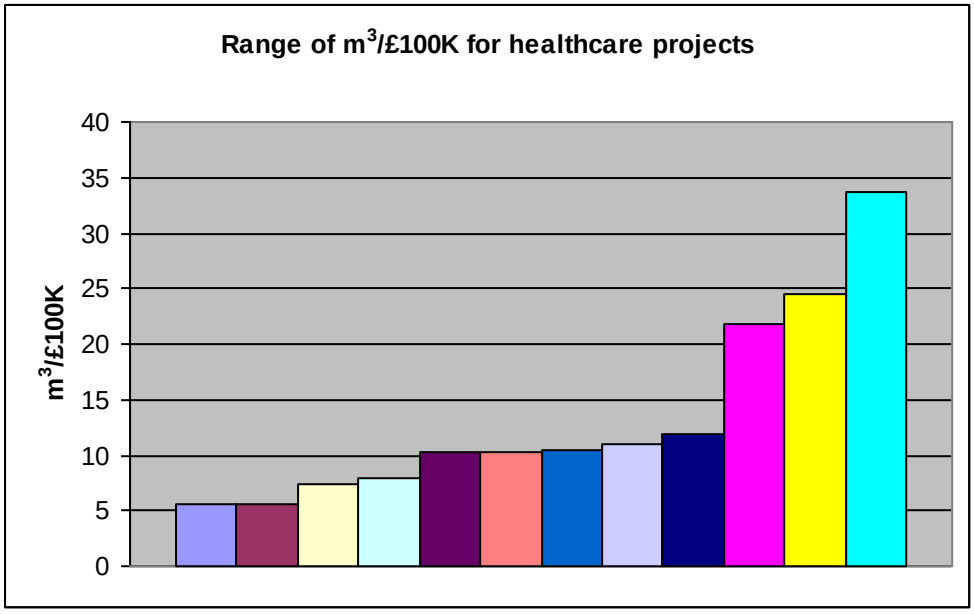

Figure 6: Range of m^3/£100K for healthcare projects

Benchmarks for Healthcare Projects	m^3/£100K	Tonnes/£100K
Best Practice (Lower Quartile)	<7.4	<4.2
Good Practice	7.4 – 10.3	4.2 – 5.9
Standard Practice	>10.3	>5.9

Table 9: Standard, good and best practice values for healthcare projects

Education

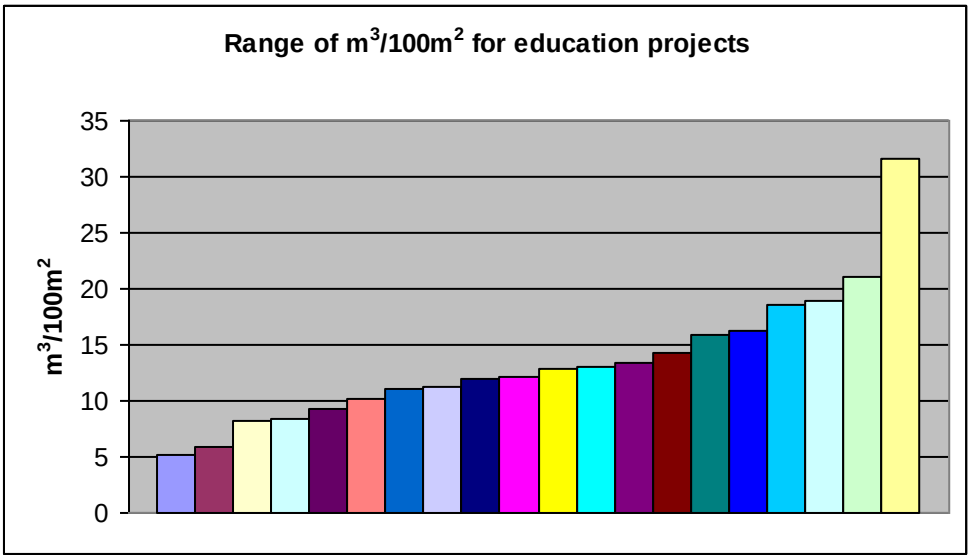

Figure 5: Range of $m^3/100m^2$ for education projects

Benchmarks for Education Projects	$m^3/100m^2$	Tonnes/$100m^2$
Best Practice (Lower Quartile)	<9.3	<3.9
Good Practice	9.3 – 12.1	3.9 - 5.1
Standard Practice	>12.1	>5.1

Table 10: Standard, good and best practice values for education projects

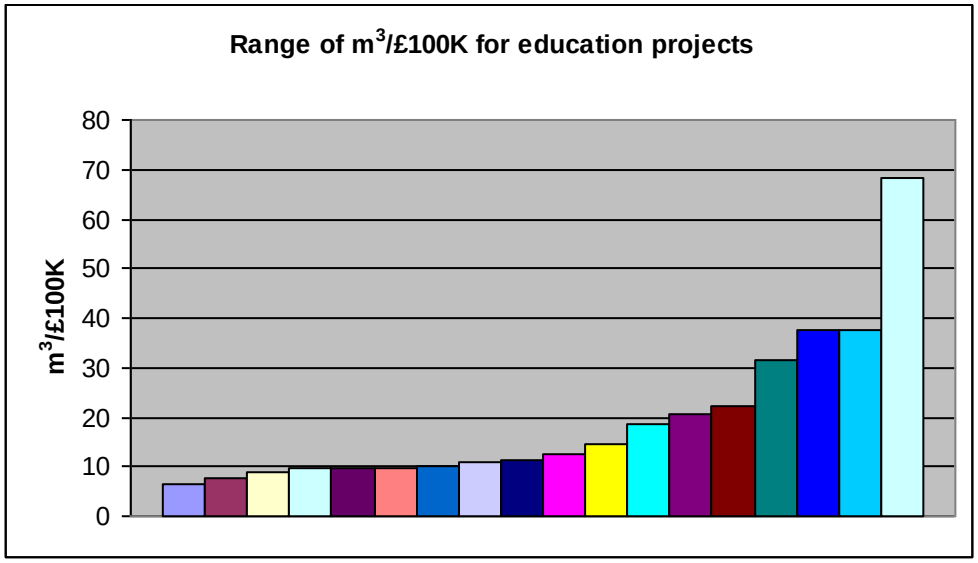

Figure 6: Range of m^3/£100K for education projects

Benchmarks for Education Projects	m^3/£100K	Tonnes/£100K
Best Practice (Lower Quartile)	<7.8	<5.5
Good Practice	7.8 – 10.0	5.5 - 7.0
Standard Practice	>10.0	>7.0

Table 11: Standard, good and best practice values for educational projects

Commercial Retail

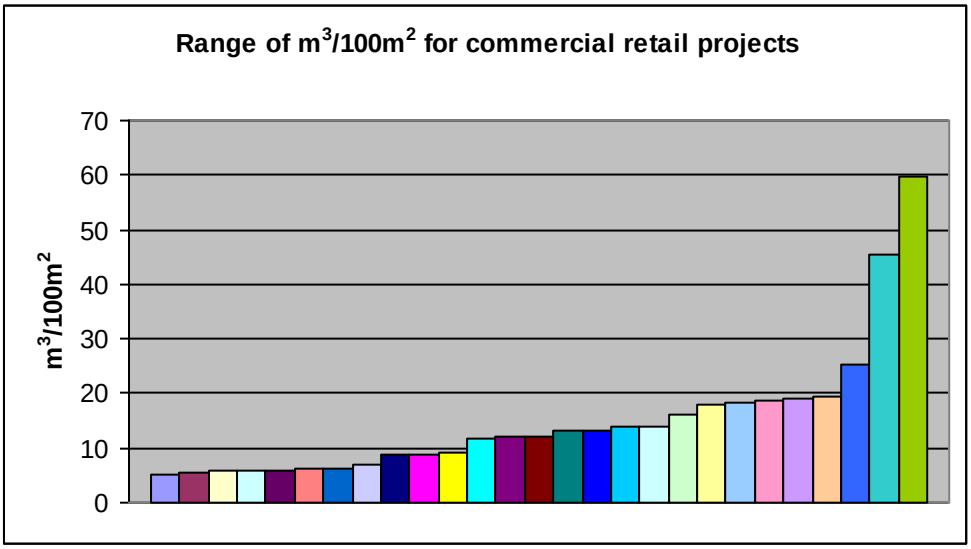

Figure 7: Range of $m^3/100m^2$ for commercial retail projects

Benchmarks for Commercial Retail Projects	$m^3/100m^2$	Tonnes/$100m^2$
Best Practice (Lower Quartile)	<6.2	<3.7
Good Practice	6.2-12.1	3.7 - 7.1
Standard Practice	>12.1	>7.1

Table 12: Standard, good and best practice values for commercial retail projects

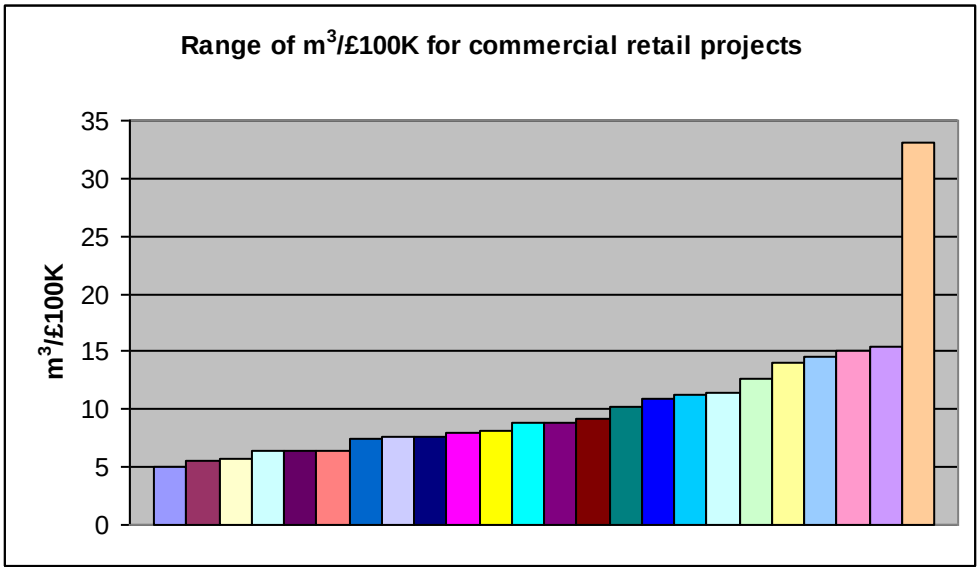

Figure 8: Range of m^3/£100K for commercial retail projects

Benchmarks for Commercial Retail Projects	m^3/£100K	Tonnes/£100K
Best Practice (Lower Quartile)	<6.5	<3.8
Good Practice	6.5 - 8.8	3.8-5.2
Standard Practice	>8.8	>5.2

Table 13: Standard, good and best practice values for commercial retail projects

Commercial Offices

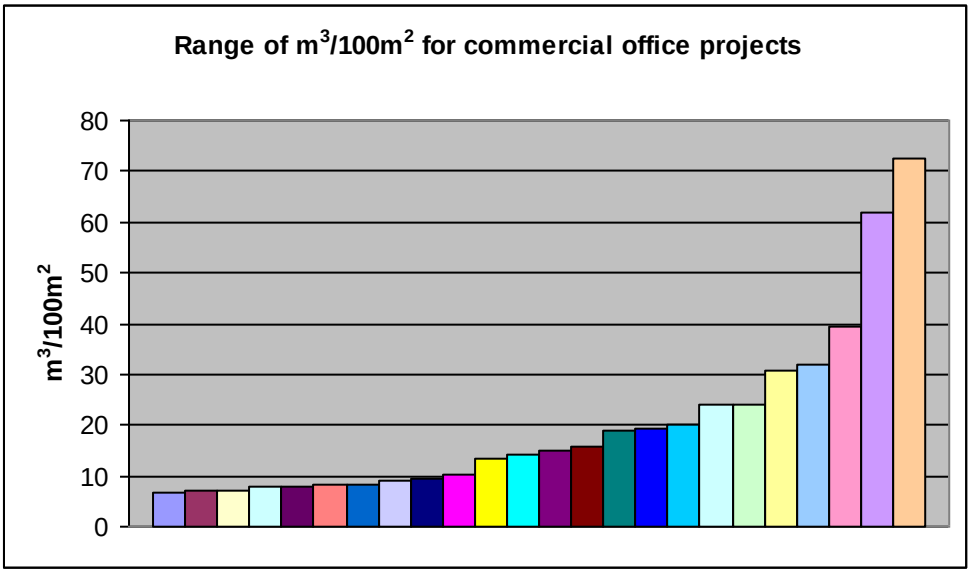

Figure 9: Range of $m^3/100m^2$ for commercial office projects

Benchmarks for Commercial Office Projects	$m^3/100m^2$	Tonnes/$100m^2$
Best Practice (Lower Quartile)	<8.3	<4.8
Good Practice	8.3-14.0	4.8 – 8.1
Standard Practice	>14.0	>8.1

Table 14: Standard, good and best practice values for commercial office projects

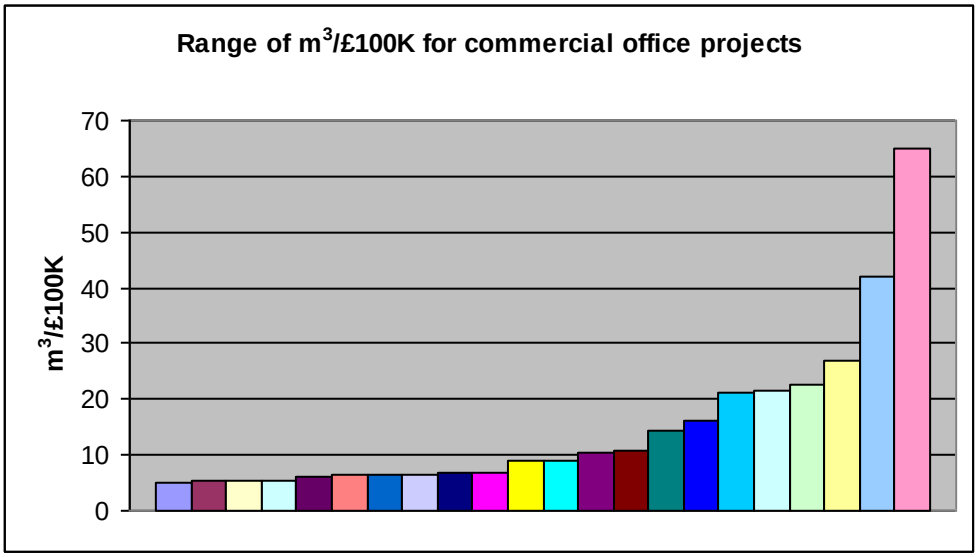

Figure 10: Range of m^3/£100K for commercial office projects

Benchmarks for Commercial Office Projects	m^3/£100K	Tonnes/£100K
Best Practice (Lower Quartile)	<6.3	<4.3
Good Practice	6.3 – 9.0	4.3 – 6.2
Standard Practice	>9.0	>6.2

Table 15: Standard, good and best practice values for commercial office projects

Analysis of data by region

This data set for new build completed projects was further analysed to look at the regional variation. The regions align with Government Office Regions in England. The average KPIs were calculated for each region for the whole data set and also for the residential and commercial retail project types which had enough regional data for analysis. The data is summarised for $m^3/100m^2$ in Table 16 and Figure 11 and for m^3/£100K in Table 17 and Figure 12.

Region	All data		Residential projects		Commercial Retail projects	
	Average $m^3/100m^2$	Number of projects	Average $m^3/100m^2$	Number of projects	Average $m^3/100m^2$	Number of projects
East Anglia	20.14	11	13.41	7	6.08	1
East Midlands	15.32	9	16.05	5	8.68	1
London	18.73	76	17.74	31	15.90	7
North West	10.82	20	11.21	11	6.86	3
North East	14.58	17	17.19	6	9.74	3
South East	16.23	33	11.15	9	27.86	5
South West	13.86	12	14.07	8	8.98	1
Scotland – Central	16.65	1	16.65	1	0.00	0
Scotland – Other	7.95	5	6.93	4	12.05	1
Wales - North	0.00	0	0.00	0	0.00	0
Wales - South	9.21	5	9.21	5	0.00	0
West Midlands	15.33	13	14.08	10	0.00	0
Yorkshire & Humberside	12.82	16	10.95	9	14.52	3
Northern Ireland	0.00	0	0.00	0	0.00	0
National*	17.66	18	28.49	9	12.66	2

* This is all projects where a region is not defined.

Table 16: Regional variation in $m^3/100m^2$ for new build projects completed by 31/08/08

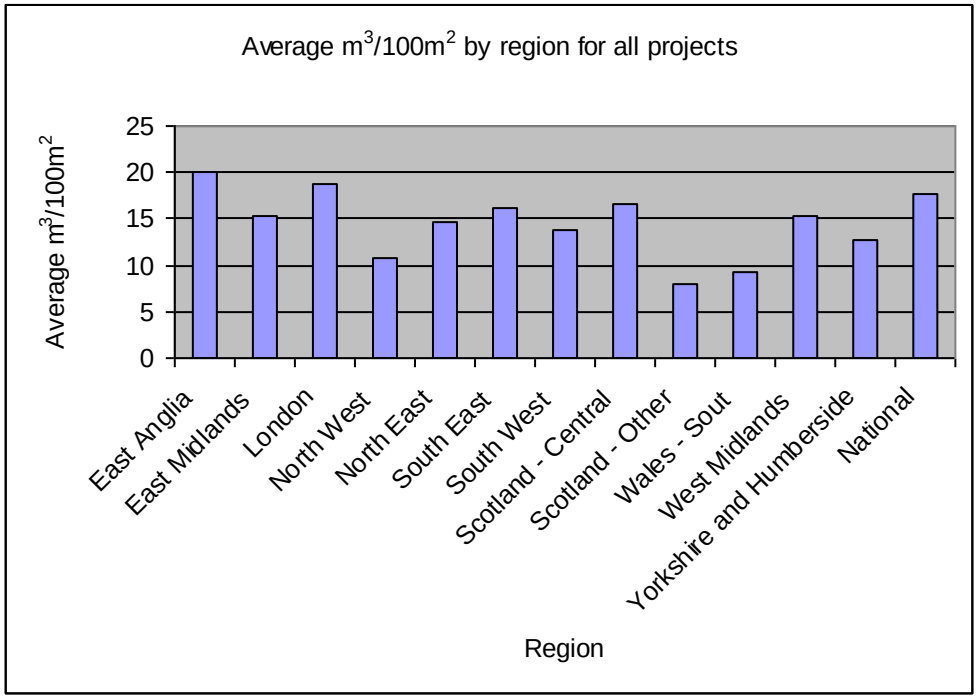

Figure 11: Variation in $m^3/100m^2$ by region

Region	All data		Residential projects		Commercial Retail projects	
	Average m^3/£100K	Number of projects	Average m^3/£100K	Number of projects	Average m^3/£100K	Number of projects
East Anglia	19.71	12	13.06	7	0.00	0
East Midlands	16.84	13	26.78	6	8.23	3
London	16.65	69	20.77	28	10.11	5
North West	13.71	19	14.41	11	6.74	3
North East	23.21	19	15.66	6	23.84	2
South East	9.62	24	8.68	9	10.23	4
South West	20.11	11	25.36	8	0.00	0
Scotland – Central	12.23	1	12.23	1	0.00	0
Scotland - Other	28.43	6	21.67	4	10.88	1
Wales - North	0.00	0	0.00	0	0.00	0
Wales - South	9.43	4	9.43	4	0.00	0
West Midlands	16.08	16	18.01	12	11.44	1
Yorkshire & Humberside	22.64	14	26.26	7	7.69	3
Northern Ireland	0.00	0	0.00	9	0.00	0
National*	13.96	17	16.49	9	10.11	2

* This is all projects where a region is not defined.

Table 17: Regional variation in m^3/£100K for new build projects completed by 31/08/08

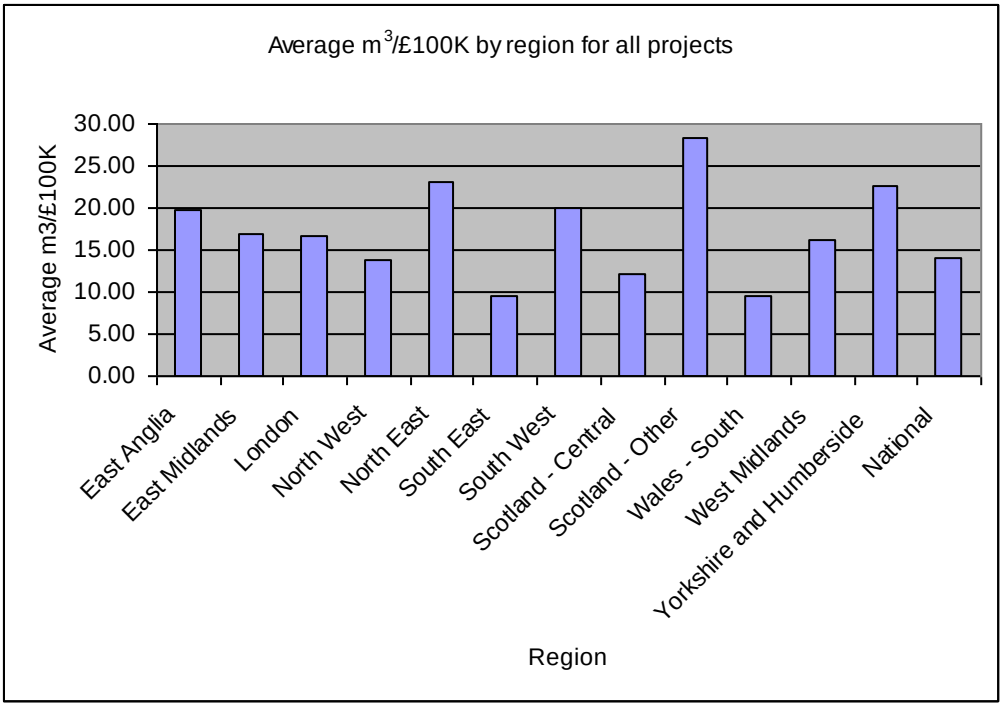

Figure 12: Variation in m^3/£100K by region

Comparison of performance indicators from SMARTWaste system and the benchmarking website

In order to compare the performance indicators in $m^3/100m^2$ from the SMARTWaste system with tonnes/$100m^2$ from the benchmarking website, conversion factors[2] were applied to the $m^3/100m^2$ figures to produce tonnes/$100m^2$ performance indicators as shown in Table 18. Also shown in Table 18 are tonnes/£100K performance indicators which have been calculated by applying the same conversion factors to the m^3/£100K performance indicators.

Data have also been analysed from the benchmarking website for tonnage data and this gives a performance indicator of 10.4 tonnes/$100m^2$ based on 38 completed, new-build residential projects which is consistent with the figure from the SMARTWaste system of 7.9 for new build residential projects.

[2] Environment Agency : survey on the arisings of Construction and Demolition waste in Wales 2005-06, published 2008

Tonnes/100m^2									
Description	**Civil Engineering**	**Commercial Offices**	**Commercial Retail**	**Education**	**Healthcare**	**Industrial Buildings**	**Leisure**	**Public Buildings**	**Residential**
Canteen/office/ad-hoc	0.763	0.314	0.413	0.678	0.341	0.245	0.011	0.381	0.364
Ceramics/bricks	0.149	0.579	0.399	0.642	0.689	0.299	0.113	1.509	1.560
Concrete	2.728	2.195	0.706	0.958	1.262	1.293	0.656	8.829	2.416
Electrical equipment	0.073	0.046	0.082	0.075	0.057	0.011	0.083	0.037	0.039
Furniture	0.003	0.016	0.021	0.011	0.006	0.001	0.030	0.037	0.014
Hazardous	0.174	0.199	0.027	0.006	0.396	0.019	0.012	0.082	0.048
Inert	12.892	2.826	6.593	0.875	1.058	9.506	0.015	8.519	0.837
Insulation	0.197	0.136	0.263	0.157	0.167	0.213	0.356	0.124	0.273
Liquids and Oils	0.000	0.000	0.000	0.001	0.001	0.001	0.000	0.002	0.009
Metals	0.824	0.701	0.588	0.366	0.528	0.595	0.531	0.579	0.249
Packaging	0.286	0.424	0.687	0.363	0.522	0.446	0.338	0.456	0.570
Plaster/cement	0.339	0.416	0.532	0.429	1.063	0.986	1.833	0.547	0.617
Plastics	0.089	0.152	0.132	0.131	0.131	0.115	0.078	0.136	0.243
Timber	0.665	0.789	1.213	0.936	0.687	0.672	0.324	0.668	0.643
Grand Total	19.2	8.8	11.7	5.6	6.9	14.4	4.4	21.9	7.9

Table 18: Tonnes/100m^2 performance indicators based on SMARTWaste projects completed by 31/08/08

Tonnes/£100K									
Description	**Civil Engineering**	**Commercial Offices**	**Commercial Retail**	**Education**	**Healthcare**	**Industrial Buildings**	**Leisure**	**Public Buildings**	**Residential**
Canteen/office/ad-hoc	0.160	0.174	0.154	0.500	0.226	0.133	0.021	0.497	0.377
Ceramics/bricks	0.008	0.393	0.213	1.985	0.855	0.405	0.097	0.657	2.227
Concrete	7.037	1.068	1.599	0.528	1.005	0.391	0.471	5.520	4.142
Electrical equipment	0.012	0.027	0.051	0.046	0.054	0.041	0.130	0.020	0.022
Furniture	0.001	0.009	0.007	0.014	0.005	0.002	0.051	0.008	0.006
Hazardous	0.641	0.192	0.025	0.014	0.273	0.023	0.028	0.838	0.014
Inert	12.261	2.480	5.896	6.952	2.787	5.324	10.967	10.638	1.659
Insulation	0.095	0.094	0.168	0.113	0.155	0.078	0.244	0.062	0.348
Liquids and Oils	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001
Metals	0.267	0.499	0.534	0.368	0.401	0.311	0.416	0.351	0.203
Packaging	0.125	0.299	0.440	0.318	0.429	0.394	0.247	0.300	0.678
Plaster/cement	0.172	0.234	0.335	0.333	0.634	0.330	1.888	0.383	0.607
Plastics	0.037	0.144	0.078	0.127	0.137	0.095	0.089	0.055	0.287
Timber	0.337	0.569	0.800	0.843	0.610	0.388	0.392	0.413	0.525
Grand Total	21.2	6.2	10.3	12.1	7.6	7.9	15.0	19.7	11.1

Table 19: Tonnes/£100K performance indicators based on SMARTWaste projects completed by 31/08/08

New Waste Categories

The waste categories used in SMARTWaste have been modified slightly for the new SMARTWaste Plan tool in order to align them with the European Waste Catalogue categories; this should make it easier for industry to collect data based on these waste types and provides consistency. It is hoped that the revised waste categories will enable more accurate recording of actual waste arisings based on both the product and waste type. The changes to the categories are summarised in Table 20 below. The assumptions used to split the categories are based on the likely amount of products to be used during the construction process; this has been based on previous datasets and expert knowledge at BRE. Most of the conversion factors (i.e. converting volume to weight) remain unchanged. There is a slight change to the conversion factors used for ceramics/bricks from 1.1 for the combined category to 0.59 for ceramics and 1.20 for bricks.

All future benchmarks will be reported in the SMARTWaste Plan categories.

SMARTWaste Waste categories	SMARTWaste Plan waste categories	EWC code	Assumptions	Conversion factor (tonnes per m^3)*
Canteen/office/ ad-hoc	Canteen/office/ ad-hoc	20 03 01		0.21
Ceramics/bricks	Ceramics	17 01 02 17 01 03	10% of ceramics/bricks	0.59
	Bricks		90% of ceramics/bricks	1.20
Concrete	Concrete	17 01 01		1.27
Electrical equipment	Electrical equipment	16 02 14		0.27
Furniture	Furniture	20 03 07		0.18
Inert	Inert	17 01 07	90% of inert	1.24
	Asphalt		10% of inert	1.24
Insulation	Insulation	17 06 04		0.25
Metals	Metals	17 04 07		0.42
Packaging	Packaging	15 01 06		0.21
Plaster/cement	Plaster (includes plasterboard)	17 08 02	90% of plaster/cement	0.33
	Cement		10% of plaster/cement	0.33
Plastics	Plastics	20 01 39		0.23
Timber	Timber	17 02 01		0.34

* Derived the Environment Agency: survey on the arisings of Construction and Demolition waste in Wales 2005-06, published 2008

Table 20: Changes to waste categories

The performance indicators calculated from the data can be used to estimate performance indicators for the revised waste categories using the assumptions shown in Table 20 and these are shown in Tables 21 and 22 for $m^3/100m^2$ and tonnes/$100m^2$ and in Tables 23 and 24 for m^3/£100K and tonnes/£100K. A method for converting the existing data is being developed so that data from SMARTWaste and the newer SMARTWaste Plan tool can be amalgamated.

There are minimal differences between the volume performance indicators produced using the two sets of waste categories. The differences can be explained by the fact that hazardous and liquid and oil wastes are not included for the analysis in the SMARTWaste Plan categories and that some rounding has taken place. There are similar small differences between the tonnage performance indicators produced using the two sets of waste categories.

$m^3/100m^2$									
Description	**Civil Engineering**	**Commercial Offices**	**Commercial Retail**	**Education**	**Healthcare**	**Industrial Buildings**	**Leisure**	**Public Buildings**	**Residential**
Canteen/office/ad-hoc	3.634	1.494	1.964	3.228	1.624	1.167	0.054	1.813	1.735
Ceramics	0.014	0.054	0.037	0.059	0.064	0.028	0.010	0.140	0.144
Bricks	0.124	0.482	0.332	0.535	0.574	0.249	0.094	1.257	1.300
Concrete	2.148	1.728	0.556	0.754	0.993	1.018	0.517	6.952	1.902
Electrical equipment	0.272	0.169	0.303	0.278	0.209	0.040	0.308	0.137	0.146
Furniture	0.015	0.087	0.117	0.059	0.036	0.004	0.167	0.204	0.079
Inert	9.357	2.051	4.785	0.635	0.768	6.899	0.011	6.183	0.607
Asphalt	1.040	0.228	0.532	0.071	0.085	0.767	0.001	0.687	0.067
Insulation	0.787	0.546	1.052	0.629	0.668	0.851	1.423	0.495	1.093
Metals	1.961	1.668	1.400	0.872	1.257	1.417	1.265	1.379	0.592
Packaging	1.362	2.019	3.269	1.726	2.487	2.126	1.612	2.173	2.714
Plasterboard	0.923	1.136	1.452	1.169	2.899	2.690	4.999	1.492	1.684
Cement	0.103	0.126	0.161	0.130	0.322	0.299	0.555	0.166	0.187
Plastics	0.388	0.662	0.575	0.569	0.571	0.502	0.341	0.593	1.055
Timber	1.956	2.322	3.568	2.753	2.020	1.977	0.953	1.966	1.892

Table 21: $m^3/100m^2$ for new waste categories for new build projects completed by 31/08/08

Tonnes/100m^2									
Description	**Civil Engineering**	**Commercial Offices**	**Commercial Retail**	**Education**	**Healthcare**	**Industrial Buildings**	**Leisure**	**Public Buildings**	**Residential**
Canteen/office/ad-hoc	0.763	0.314	0.413	0.678	0.341	0.245	0.011	0.381	0.364
Ceramics	0.008	0.032	0.022	0.035	0.038	0.016	0.006	0.082	0.085
Bricks	0.149	0.579	0.399	0.642	0.689	0.299	0.113	1.509	1.560
Concrete	2.728	2.195	0.706	0.958	1.262	1.293	0.656	8.829	2.416
Electrical equipment	0.073	0.046	0.082	0.075	0.057	0.011	0.083	0.037	0.039
Furniture	0.003	0.016	0.021	0.011	0.006	0.001	0.030	0.037	0.014
Inert	11.603	2.543	5.933	0.788	0.952	8.555	0.014	7.667	0.753
Asphalt	1.289	0.283	0.659	0.088	0.106	0.951	0.002	0.852	0.084
Insulation	0.197	0.136	0.263	0.157	0.167	0.213	0.356	0.124	0.273
Metals	0.824	0.701	0.588	0.366	0.528	0.595	0.531	0.579	0.249
Packaging	0.286	0.424	0.687	0.363	0.522	0.446	0.338	0.456	0.570
Plasterboard	0.305	0.375	0.479	0.386	0.957	0.888	1.650	0.492	0.556
Cement	0.034	0.042	0.053	0.043	0.106	0.099	0.183	0.055	0.062
Plastics	0.089	0.152	0.132	0.131	0.131	0.115	0.078	0.136	0.243
Timber	0.665	0.789	1.213	0.936	0.687	0.672	0.324	0.668	0.643

Table 22: Tonnes/100m^2 for new waste categories for new build projects completed by 31/08/08

m^3/£100K									
Description	**Civil Engineering**	**Commercial Offices**	**Commercial Retail**	**Education**	**Healthcare**	**Industrial Buildings**	**Leisure**	**Public Buildings**	**Residential**
Canteen/office/ad-hoc	0.762	0.829	0.735	2.382	1.076	0.631	0.102	2.366	1.795
Ceramics	0.001	0.036	0.020	0.184	0.079	0.037	0.009	0.061	0.206
Bricks	0.007	0.328	0.177	1.654	0.713	0.337	0.081	0.548	1.856
Concrete	5.541	0.841	1.259	0.416	0.791	0.308	0.371	4.347	3.261
Electrical equipment	0.043	0.099	0.190	0.170	0.202	0.152	0.483	0.072	0.082
Furniture	0.007	0.049	0.038	0.078	0.026	0.009	0.286	0.043	0.032
Inert	8.899	1.800	4.279	5.046	2.023	3.864	7.960	7.721	1.204
Asphalt	0.989	0.200	0.475	0.561	0.225	0.429	0.884	0.858	0.134
Insulation	0.381	0.375	0.673	0.453	0.619	0.314	0.975	0.246	1.391
Metals	0.637	1.189	1.273	0.876	0.955	0.740	0.991	0.835	0.484
Packaging	0.594	1.426	2.093	1.513	2.041	1.875	1.178	1.429	3.227
Plasterboard	0.469	0.638	0.913	0.909	1.728	0.899	5.149	1.044	1.656
Cement	0.052	0.071	0.101	0.101	0.192	0.100	0.572	0.116	0.184
Plastics	0.161	0.627	0.340	0.553	0.595	0.414	0.389	0.238	1.246
Timber	0.991	1.675	2.354	2.481	1.793	1.140	1.154	1.213	1.544

Table 23: m^3/£100K for new waste categories for new build projects completed by 31/08/08

Tonnes/£100K									
Description	**Civil Engineering**	**Commercial Offices**	**Commercial Retail**	**Education**	**Healthcare**	**Industrial Buildings**	**Leisure**	**Public Buildings**	**Residential**
Canteen/office/ad-hoc	0.160	0.174	0.154	0.500	0.226	0.133	0.021	0.497	0.377
Ceramics	0.000	0.021	0.012	0.108	0.047	0.022	0.005	0.036	0.122
Bricks	0.008	0.393	0.213	1.985	0.855	0.405	0.097	0.657	2.227
Concrete	7.037	1.068	1.599	0.528	1.005	0.391	0.471	5.520	4.142
Electrical equipment	0.012	0.027	0.051	0.046	0.054	0.041	0.130	0.020	0.022
Furniture	0.001	0.009	0.007	0.014	0.005	0.002	0.051	0.008	0.006
Inert	11.035	2.232	5.306	6.257	2.508	4.791	9.871	9.574	1.493
Asphalt	1.226	0.248	0.590	0.695	0.279	0.532	1.097	1.064	0.166
Insulation	0.095	0.094	0.168	0.113	0.155	0.078	0.244	0.062	0.348
Metals	0.267	0.499	0.534	0.368	0.401	0.311	0.416	0.351	0.203
Packaging	0.125	0.299	0.440	0.318	0.429	0.394	0.247	0.300	0.678
Plasterboard	0.155	0.210	0.301	0.300	0.570	0.297	1.699	0.345	0.546
Cement	0.017	0.023	0.033	0.033	0.063	0.033	0.189	0.038	0.061
Plastics	0.037	0.144	0.078	0.127	0.137	0.095	0.089	0.055	0.287
Timber	0.337	0.569	0.800	0.843	0.610	0.388	0.392	0.413	0.525

Table 24: Tonnes/£100K for new waste categories for new build projects completed by 31/08/08

Monthly figures

The performance indicators for $m^3/100m^2$ and $m^3/£100K$ have been evaluated in terms of the monthly variation in the figures from May 2007 to August 2008. These are shown for $m^3/100m^2$ in Figure 9 and Table 25 and for $m^3/£100K$ in Figure 10 and Table 26. The data show reasonable consistency over this data reporting period, particularly for project types such as residential and commercial retail where there are a large number of projects. There is more variation in project types such as civil engineering, industrial buildings and public buildings. This is because there are only a small number of these project types and so the inclusion of an extra project would have a larger effect. We would anticipate that the figures would change as a result of implementation of Site Waste Management Plans and other key policies. It is likely that as more data become available from more companies the overall figures will increase slightly. This is because a larger range of companies with different site practices will be included in the data. However, as time goes on and more companies implement waste minimisation practices it is expected that the figures will eventually decrease. The benchmarks for standard, good and best practice should shift downwards as waste minimisation practices are used more widely.

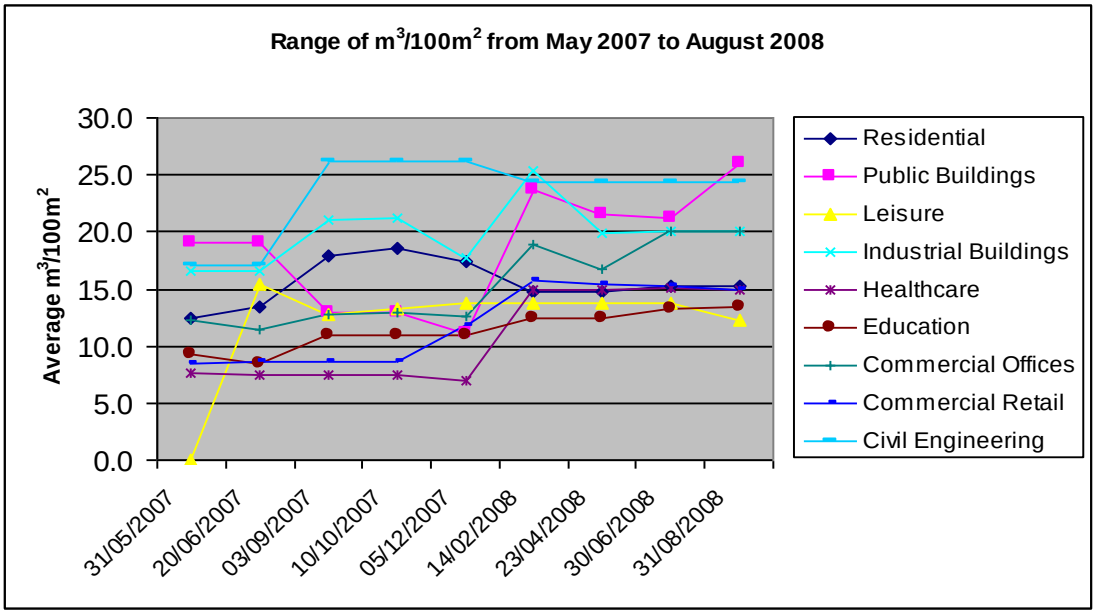

Figure 13: Variation in $m^3/100m^2$ data from May 2007 to February 2008

Date	31/5/07	20/6/07	03/9/07	10/10/07	5/12/07	14/2/08	23/4/08	30/6/08	31/8/08
Residential	12.4	13.4	17.9	18.5	17.4	14.8	14.75	15.3	15.2
Public Buildings	19.1	19.1	13.0	13.0	11.1	24.0	21.5	21.2	26.1
Leisure	-	15.4	12.8	13.2	13.8	13.8	13.8	13.8	12.3
Industrial Buildings	16.5	16.5	21.1	21.2	17.7	25.3	19.9	20	20
Healthcare	7.6	7.5	7.5	7.5	7.0	15	15	15.1	15
Education	9.2	8.4	10.9	10.9	10.9	12.5	12.5	13.3	13.4
Commercial Retail	8.5	8.7	8.6	8.6	11.7	15.8	16.7	20	20.1
Commercial Offices	12.2	11.4	12.8	12.9	12.6	18.9	15.4	15.3	15
Civil Engineering	17.0	17.0	26.2	26.2	26.2	24.3	24.3	24.3	24.3

Table 25: Variations in $m^3/100m^2$ from May 2007 to August 2008

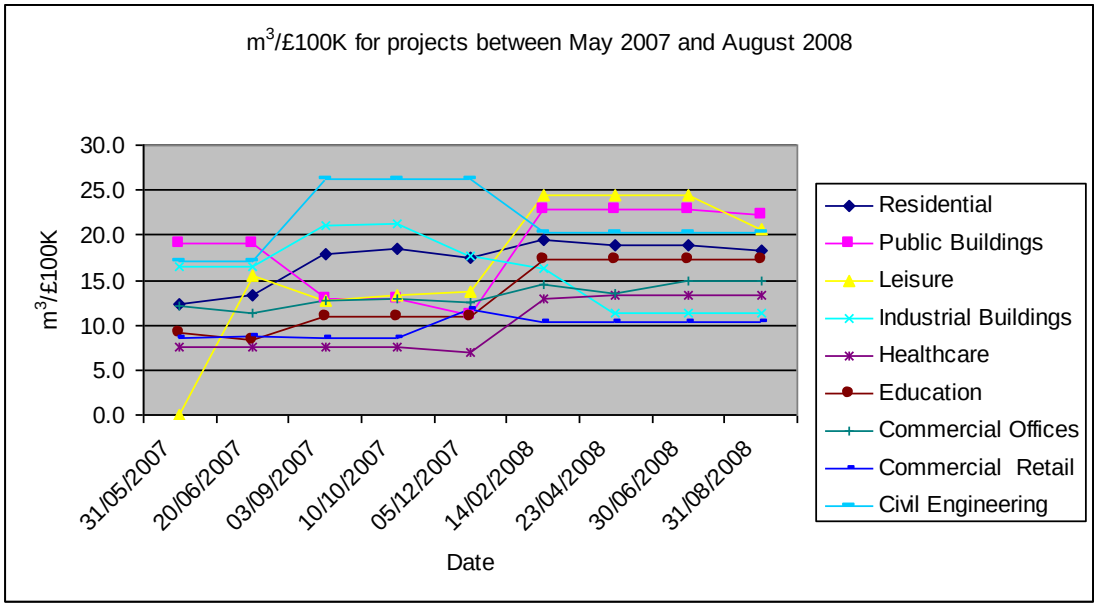

Figure 14: Variation in m^3/£100K data from May 2007 to August 2008

Date	31/5/07	20/6/07	03/9/07	10/10/07	05/12/07	14/2/08	23/4/08	30/6/08	31/8/08
Residential	12.4	13.4	17.9	18.5	17.4	19.4	18.9	18.8	18.3
Public Buildings	19.1	19.1	13.0	13.0	11.1	22.8	22.8	22.8	22.2
Leisure	-	15.4	12.8	13.2	13.8	24.4	24.4	24.4	20.6
Industrial Buildings	16.5	16.5	21.1	21.2	17.7	16.3	11.3	11.3	11.3
Healthcare	7.6	7.5	7.5	7.5	7.0	13	13.3	13.3	13.4
Education	9.2	8.4	10.9	10.9	10.9	17.3	17.3	17.3	17.3
Commercial Retail	8.5	8.7	8.6	8.6	11.7	10.4	13.6	14.9	14.9
Commercial Offices	12.2	11.4	12.8	12.9	12.6	14.6	10.4	10.4	10.4
Civil Engineering	17.0	17.0	26.2	26.2	26.2	20.3	20.3	20.3	20.3

Table 26: Variations in m^3/£100K from May 2007 to August 2008

Bulk Volume Performance Indicators

Bulk volume (total container volume) KPIs have been calculated using the total bulk volume data for completed new build projects as of 31-08-08. Total bulk volume $m^3/100m^2$ floor area has been calculated and is shown in Table 27 and total bulk volume m^3/£100K project value is shown in Table 28. The value can be compared with the $m^3/100m^2$ from Constructing Excellence of 39.1[3] which is the median figure for construction process waste from 2007. The median figure for all projects in Table 27 below is lower than that from Constructing Excellence. However, the Constructing Excellence figure applies to all construction process waste whereas the benchmarking data is for new build projects only. Additionally the

[3]http://www.constructingexcellence.org.uk/pdf/kpizone/KPI_Launch_Presentations_03-07-2007.pdf

Constructing Excellence figure is obtained from survey data rather than a measurement system such as SMARTWaste.

Project Type	Number of projects	Average $m^3/100m^2$	Median $m^3/100m^2$
Residential	114	28.1	25.3
Public Buildings	8	48.3	27.6
Leisure	3	24.0	17.0
Industrial Buildings	6	49.6	39.3
Healthcare	14	26.7	24.2
Education	20	26.0	24.1
Commercial Offices	24	34.6	22.5
Commercial Retail	27	27.0	23.2
Civil Engineering	9	47.9	44.8
Total	225	30.7	25.3

Table 27: Bulk volume $m^3/100m^2$

Project Type	Number of projects	Average $m^3/100m^2$	Median $m^3/100m^2$
Residential	112	34.6	23.4
Public Buildings	8	40.9	33.7
Leisure	5	37.3	27.4
Industrial Buildings	6	32.4	18.3
Healthcare	12	23.9	20.7
Education	21	48.0	19.7
Commercial Retail	22	26.5	13.9
Commercial Offices	24	18.8	16.2
Civil Engineering	6	39.8	29.5
Total	216	33.2	20.7

Table 28: Bulk volume m^3/£100K

Segregation of waste

Data collected by SMARTWaste and the benchmarking website also include the amount of waste that has been segregated onsite. Statistical analysis was carried out on the dataset, to see if there was any correlation between floor area and the percentage segregated; and the project value and the percentage segregated. These results are shown in Figures 15 and 16 and currently show no strong correlation.

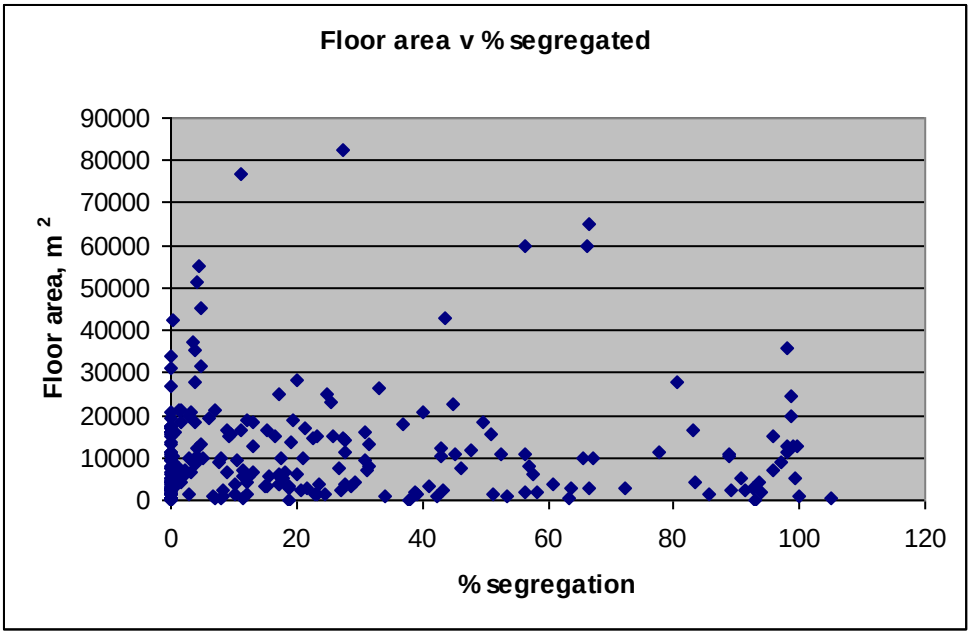

Figure 15: Floor area against percentage segregated

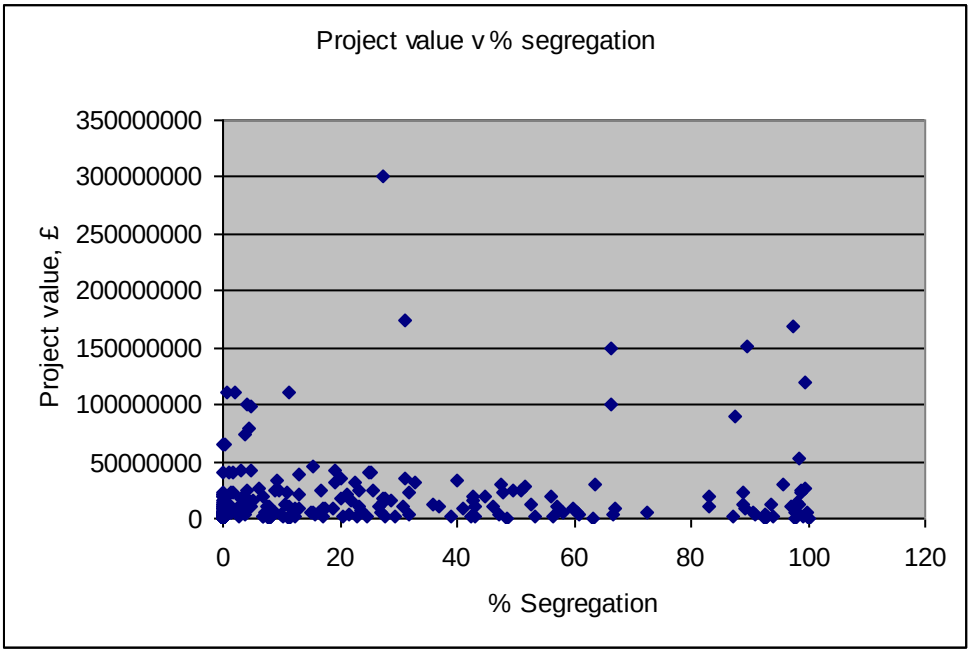

Figure 16: Project value against percentage segregated

The percentage waste segregated for different project types has also been calculated for comparison. These results are shown in Table 29 below and show that for all project types there is a large variation in the segregation rates. However, the median values do indicate that there is generally more segregation in civil engineering, public buildings and industrial building projects.

	% waste segregated		
	Average	**SD**	**Median**
Residential	17.3	25.1	4.7
Public Buildings	42.7	35.9	40.8
Leisure	0.5	0.9	0
Industrial Buildings	40.7	29.8	23.1
Healthcare	28.4	25.0	7.0
Education	20.5	24.3	10.9
Commercial Offices	36.4	29.8	25.4
Commercial Retail	39.3	37.7	23.2
Civil Engineering	52.9	46.4	31.1

Table 29: Percentage segregation for different project types

Demolition and Refurbishment data

In addition to the new build projects analysed above there are 17 refurbishment projects from 6 companies and 2 demolition projects from 2 companies. Some of the existing projects did not specify whether the project was a new build/demolition/ refurbishment and so could not be included in the data analysis but in future all new projects added to the SMARTWaste Plan tool will be required to specify the type of project to ensure all data are included. The data for refurbishment are summarised in Table 30 below.

Project type	Number of projects	Average $m^3/100m^2$	Number of projects	Average m^3/£100K
Commercial retail	9	14.9	8	9.7
Commercial offices	4	14.1	4	12.9
Education	3	49.5	4	34.4
Healthcare	1	14.6	2	10.4
Industrial buildings	1	10.6	1	5.3
Leisure	2	9.5	3	13.9
Public Buildings	-	-	1	14.5
Residential	5	17.8	9	26.4
Total	25	18.9	32	18.3

Table 30: Performance indicators for refurbishment projects completed by 31-08-08

Both of the demolition projects passing the logical tests (see page 1) were commercial office projects and the average $m^3/100m^2$ is 24.2.

Excluded projects

A summary of the number of completed projects and the number of projects not passing the logical and statistical tests is given in Table 31 below. Excluded projects continue to be contacted to confirm that the floor area, project values and waste values all apply to the whole project. Some of the data may only apply to certain stages of the project (e.g. fit-out).

Date	5/4/07	20/6/07	10/10/07	14/2/08	31/8/08
Total number of projects			644	758	854
No. Completed projects	224	303	382	520	616
No. Projects included	87	102	149	213	270
No. Projects excluded £/m^2 (or <10 m^2 floor area)	65	99	110	14	8
No. Projects excluded <10 m^3 waste	18	48	59	172	195
No. Projects excluded, m^3 waste/100m^2 floor area <5 or >75	54	54	64	116	143
% Projects excluded	54%	66%	61%	61%	56%

Table 31: Summary of excluded projects

Table 31 shows that up to August 2008 there were 616 projects completed with 270 (44%) of these passing the logical tests and 346 (56%) not passing all the logical tests. There are a number of reasons for projects not passing the logical tests including users only entering data in as test project (i.e. when the waste is less than 10m^3), and where the floor area or project value is not known. Although companies have been contacted to provide more details about these projects, limited extra data were obtained due to the majority of the projects being more than a year old (and in some cases more than 5 years old). Table 32 breaks down the number of projects that are excluded by region with London and the South East having the highest number.

Region	**Projects excluded £/m^3 or < 10 m^2**	**Projects excluded < 10 m^3 waste**	**Projects excluded EPI<5 or >75**
East Anglia	8	7	6
East Midlands		7	11
London		42	35
North West		6	10
North East		5	7
South East		93	25
South West		5	6
Scotland – Central		0	0
Scotland – Other		8	2
Wales – North		0	0
Wales – South		3	1
West Midlands		6	21
Yorkshire & Humberside		7	5
Northern Ireland		0	0
National		6	14
Total	**8**	**195**	**143**

Table 32: Summary of excluded projects by region August 2008

Project Completion Dates

The project end dates for ongoing projects are summarised in Table 33 below.

All ongoing projects		
Date	No Projects due to complete	Cumulative
September 2008	16	16
October 2008	19	35
November 2008	7	42
December 2008	17	59
January 2009	11	70
February 2009	9	79
		+ 88 to Jan 11
		+ 63 with no completion dates

Table 33: Project completion dates

In terms of the types of projects that will be completed over the next year, the majority are residential, followed by commercial offices (shown in Table 34) where there is already a larger dataset than compared to other projects. The data from these projects will help to develop the benchmarks further. In terms of a regional split for future completion dates for projects the majority appear to be in the London and South East areas as shown by Table 35.

Date	Civil Engineering	Commercial Retail	Commercial Offices	Commercial Other	Education	Healthcare	Industrial Buildings	Leisure	Public Buildings	Residential
Sep 08		2	4		2	1	3			4
Oct 08			4	1	5					9
Nov 08			3	1	1		4			2
Dec 08	1	1		4	1	1				8
Jan 09	1	3		1	3					4
Feb 09		1	2		1	1				4
Mar 09			1	2	1					5
Total	**2**	**7**	**14**	**9**	**14**	**3**	**7**			**36**

Table 34: Type of SMARTWaste projects completing by March 2009

Date	East Anglia	East Midlands	London	North West	North East	South East	South West	Scotland - Central	Scotland - Other	Wales - North	Wales - South	West Midlands	Yorkshire and Humberside	Northern Ireland	National
Sep 08	2		4			6		1	2						1
Oct 08	2	1	6		1	3	2			1	2	1			
Nov 08	1		4				5					1			
Dec 08	5	2	5			3							1		
Jan 09	4		6		1	1									
Feb 09			4	2	1	1						1			
Mar 09	2		4			1	1					1			
Total	**16**	**3**	**33**	**2**	**3**	**15**	**8**	**1**	**2**	**1**	**2**	**4**	**1**	**0**	**1**

Table 35: Location of SMARTWaste projects completing by March 2009

Further work

BRE will continue to analyse data collected to produce benchmarks. New projects added to SMARTStart are being checked monthly to ensure that floor area, project value and waste data are being entered correctly (N.B the number of new projects being added to SMARTStart is relatively small as this is only now available to existing users and new users must use the SMARTWaste Plan tool, which is described below).

In addition to the SMARTWaste system and the benchmarking website; there are a number of other BRE systems that are collecting data which will be subsequently analysed and included in the KPIs. Other data sources include BRE's SMARTWaste Plan tool, the collection of data on the SmartLIFE (which now has 5 completed projects entered onto SMARTWaste Plan), the SMARTStart Olympics and the Design for Manufacture and Carbon Challenge construction projects. Further data sources are summarised in Table 36.

Data source	Number of projects registered	Number of completed projects (as of 31-08-08)	Number of completed projects meeting criteria
SMARTWaste Plan	1819	227	37
SMARTStart Olympics	83	22	0
Design for Manufacture /Carbon Challenge	5	0	0
Total	1907	249	37

Table 36: Additional datasets for benchmarking

SMARTWaste Plan Tool

BRE have now developed SMARTWaste Plan which has been designed to allow users to write their own Site Waste Management Plans. Users of the tool also enter actual waste arisings in either tonnes or volumes and so this data can also be used in the development of performance indicators.

The SMARTWaste Plan tool collects all the data that are currently being collected by SMARTStart and the Benchmarking website and the data are held in a similar database. Therefore, the data can be analysed in the same way as the SMARTStart data to provide the same benchmarks by project type or by region and broken down by material type. A method for amalgamating the data from the various datasets is currently being developed. In addition, the SMARTWaste Plan tool also collects cost information. The data analysis carried out in this project and the results will be updated on a bi-monthly basis to ensure data continually being collected by BRE's SMARTWaste Plan are utilised. More information on the data and the updates can be found at www.smartwaste.co.uk.

Existing SMARTWaste Plan data

There are 2457 companies registered on the SMARTWaste Plan tool as of October 2008 with 307 of these being test companies and 80 duplicates. This leaves 2071 companies with 1819 projects entered. Of these 1819 projects, 154 are test projects and 139 have no dates entered so these will not be used for analysis. There are 227 completed projects (based on the end date) and of the remaining 1299 projects, 950 do not yet have any waste data entered.

A breakdown of the projects to be completed is shown in Table 37 and details of the location and project types are given in Tables 38 and 39 respectively.

Project	No. projects
New build	780
Refurbishment	256
Demolition	36
New build and refurbishment	142
Fit out	55
Demolition and New Build	15
Remediation	1
Not specified	14
Total	1299

Table 37: Breakdown of project class for SMARTWaste Plan projects to be completed

Region	No. of projects
East Anglia	115
East Midlands	65
London	269
North West	107
North East	146
South East	229
South West	130
Scotland – Central	18
Scotland – Other	6
Wales – North	11
Wales – South	29
West Midlands	59
Yorkshire & Humberside	68
Northern Ireland	21
National	14
Non-UK	12
Total	**1299**

Table 38: Breakdown of SMARTWaste Plan projects to be completed by region

Project Type	Number of projects
Residential	464
Public Buildings	46
Leisure	73
Industrial Buildings	58
Healthcare	57
Education	184
Commercial Other	24
Commercial Offices	128
Commercial Retail	136
Civil Engineering	71
Unspecified	58
Total	**1299**

Table 39: Breakdown of SMARTWaste Plan projects to be completed by project type

Completed SMARTWaste Plan projects

There are 227 completed projects on SMARTWaste Plan. Details of those excluded as a result of failing the logical tests are summarised in Table 40 below.

Project class	No. complete or no date	No. with no waste data or < 10 m^3	No. in m^3 or tonnes	No. with EPI < 5 or > 75	No. projects OK
New build, m^3	185	136	36	19	17
New build, tonnes			13	6	7
Refurbishment, m^3	85	61	12	7	5
Refurbishment, tonnes			12	11	1
Demolition, m^3	11	10	1	1	0
Demolition, tonnes			0	0	0
New build and refurb, m^3	33	25	5	4	1
New build and refurb, tonnes			3	0	3
Fit-out, m^3	26	12	2	1	1
Fit-out, tonnes			12	10	2

Table 40: Summary of completed SMARTWaste Plan projects

The performance indicators for new build projects are shown in Table 41 for projects reporting waste by volume and in Table 42 for projects reporting in tonnes.

Project type	No. projects	Average $m^3/100m^2$	No. projects	Average m^3/£100K
Commercial Retail	3	16.8	2	8.2
Education	1	40.4	1	25.5
Residential	13	21.5	9	23.0
Total	17	21.8	12	20.8

Table 41: Summary of completed new build SMARTWaste Plan projects reporting by volume

Project type	No. projects	Average tonnes/100m^2	No. projects	Average tonnes/£100K
Civil Engineering	1	10.0	1	13.3
Commercial Retail	0	-	1	19.9
Industrial Buildings	1	51.3	0	-
Public Buildings	1	24.9	1	10.4
Residential	4	17.3	4	13.6
Total	7	22.2	7	14.0

Table 42: Summary of completed new build SMARTWaste Plan projects reporting in tonnes

Similar results are shown for refurbishment projects in Table 43.

Project type	No. projects	Average tonnes/100m^2	No. projects	Average tonnes/£100K
Commercial Retail	1	8.0	2	33.7
Education	1	7.6	1	14.2
Leisure	1	14.0	-	-
Residential	2	10.9	2	27.8
Total	5	10.3	5	27.5

Table 43: Summary of completed refurbishment SMARTWaste Plan projects reporting by volume

The remaining completed projects are summarised in Table 44.

Project Class	Project type	No. projects	Average
Refurbishment, tonnes	Residential	1	12.6 tonnes/100m^2
New build and refurb, m^3	Commercial Office	1	10.9 m^3/100m^2
New build and refurb, tonnes	Commercial Retail	3	10.8 tonnes/100m^2
Fit-out, m^3	Commercial Retail	1	18.4 m^3/100m^2

Table 44: Summary of completed SMARTWaste Plan projects

In addition to the data analysis to calculate performance indicators further data will be analysed including:

- Segregation rates will be analysed to establish if any of the data can be used to create meaningful benchmarks for the percentage of waste segregated onsite.
- Data on SMARTWaste Plan can be analysed to create benchmarks for the amount and types of waste reused, recycled, recovered and disposed of
- Data on costs can be analysed.

BRE are liaising with interested policymakers and industry groups to ensure that data continues to be analysed and feed into both policy decisions and industry targets/standards.