Imperial College London

Waste Infrastructure Requirements for England

Centre for Environmental Policy

Imperial College London

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Abbreviations

AC	Available Capacity
AD	Anaerobic Digestion
BMW	Biodegradable Municipal Waste
C&I	Commercial and Industrial
CIWM	Chartered Institution of Wastes Management
DEFRA	Department of Environment, Food and Rural Affairs
EA	Environment Agency
EC	European Commission
EfW	Energy-from-Waste
ERF	Energy Recovery Facility
EU	European Union
LAs	Local Authorities
LAC&I	Local Authority Collected Commercial and Industrial (waste)
LACMW	Local Authority Collected Municipal Waste
LACW	Local Authority Collected Waste
LATS	Landfill Allowance Trading Scheme
LCA	Life Cycle Analysis
MBT	Mechanical Biological Treatment
MRF	Material Recycling Facility
MSW	Municipal Solid Waste
PFI	Private Finance Initiative
WAG	Welsh Assembly Government
WEEE	Waste Electrical and Electronic Equipment

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Executive Summary

In February 2013 (revised in October of the same year) Defra published a paper setting out the analysis used to

1. Forecast waste arisings and treatment capacity in England in 2020.
2. Assess the amount of Biodegradable Municipal Waste (BMW) that goes to landfill.

The purpose of this analysis was to judge whether England will meet the diversion levels necessary to comply with the EU Landfill Directive. The Directive dictates that the amount of BMW sent to landfill in 2020 must be reduced to 35% of 1995 levels (i.e. to 10.2m tonnes). The report indicated that in the next seven years the UK would be over-equipped with waste infrastructure.

In order to take a fresh view of the UKs infrastructure needs Veolia Environmental Services (VES) commissioned researchers at Imperial College London (Imperial) (Centre for Environmental Policy, Faculty of Natural Sciences) to undertake a review of the methods and results to date, to achieve a clearer and more accurate understanding of the UK needs. An objective of the work was to evaluate how sensitive the Defra findings were to the assumptions made and whether the limitations in their approach may restrict their wider application to support decision making. **The methodological approach is critical as the potential of the findings to support decision making will depend on the validity of the assumptions and the calculations used**.

The framing of the overall Defra approach was questioned, and in particular concerns were raised with regard to the limitations in the forecast model used in terms of uncertainty and assumptions made, suggesting that their findings could be misleading, particularly when used for the types of decisions for which they provided support.

Rather than directly challenge other independent reports, this study looked into the Defra data on waste arisings, not to dispute the actual data, but to **review the methodology** used to estimate capacity needs across the UK.

For calculating future infrastructure needs, the study considered

- the **composition** of different waste streams rather than aggregating them;
- the **regional significance** of facilities (rather than taking an aggregate of all facilities across the UK);
- the **technologies** necessary to deliver the necessary infrastructure.

Findings demonstrated that considering quantities of materials arising at a regional level was more realistic, using compositional data for household and specific waste-streams for Commercial and Industrial sources. A more robust approach for forecasting total quantities of material arising and the consequent demand for facilities was proposed which addressed the main limitations of simply adding different tonnages. A more appropriate method for calculating treatment capacity requirements for each region was proposed. This way, more informed assumptions about how inputs are prioritised to different facilities can be made (e.g. sorted recyclables go to MRFs, residual material goes to ERFs), so that by subtracting the relevant existing treatment capacity from calculated regional requirements, the composition of the waste remaining untreated and subsequent future infrastructure needs can be easily and more reliably estimated.

ADVANTAGES OF IMPERIAL METHOD
Focuses on regional analysis to determine appropriate infrastructure needs
Estimates arisings of waste materials and their treatment needs
Empowers local authorities to make best use of existing infrastructure
Empowers local authorities to determine demand for additional infrastructure

WHAT WAS CONCLUDED?

- ✓ DEFRA'S FORECAST OF CAPACITY GAP APPEARS TO BE RATHER MISLEADING

The framing of the question associated with future infrastructure requirements needs to be technology specific, appropriate to different waste streams and accept that waste cannot generally be transported from one end of the UK to the other without long term consequences. On this basis, **significant capacity gaps** exist at a regional level.

- ✓ METHOD LIMITATIONS SUGGEST CAUTION WHEN INTERPRETING RESULTS

The assumptions made in the Defra forecast and the limitations of the overall approach restrict the potential of its findings to support decisions. The aggregation of waste composition and treatment capacity nationally may disguise regional variations and lead to the assumption that one region's surplus can meet another region's deficit. This study highlights that even in cases where this refers to similar materials or similar technologies, aggregations of which could be appropriate, the **cost and practical implications of long-distance haulage should be further investigated** before decisions are taken.

- ✓ WE SHOULD NOT AGGREGATE MATERIAL STREAMS

Municipal waste is a complex stream of many different materials that cannot be considered as one single stream. By using data on waste composition and grouping technologies by input, this study provides more detailed information about waste materials and their treatment needs, **empowering local authorities** to make the best use of existing infrastructure as well as determining the demand for additional facilities.

- ✓ DEFRA STRATEGY: APPLICATION OF CUTS TO FUNDING WITHOUT A STRATEGY IN PLACE

The use of the Defra findings to justify significant reductions in funding for new waste infrastructure is problematic particularly where decisions were taken without an assessment of the performance of existing capacity or the viability of planned/proposed capacity.

1. Introduction

The UK is bound by the EC Landfill Directive (99/31/EC) which sets mandatory targets for the reduction of biodegradable municipal waste (BMW) sent to landfill[1]. Additionally the Government has established national targets for the recovery of municipal waste and recycling / composting of household waste[2] . In order to establish whether sufficient infrastructure treatment capacity is expected to be in place to meet these targets, the need to forecast waste arisings and infrastructure treatment capacity in England in 2020 has emerged. However, such efforts and the on-going discussion as to whether there will be sufficient capacity in the UK in the future are rather misleading, particularly as they centre around the question of overcapacity or undercapacity of residual waste treatment.

For example, a recent report on Commercial and Industrial (C&I) waste, commissioned by the Chartered Institution of Wastes Management (CIWM) (Ricardo–AEA, 2013) concluded that, by 2020, there would not be enough waste processing capacity in the UK. This was contrary to the Defra forecasting report (2013b) as well as other studies, which earlier that year had indicated that in the next seven years the UK would be over-equipped with waste infrastructure.

Defra's forecasting report (published in February 2013 and updated in October 2013) set out the analysis used to forecast waste arisings and treatment capacity in England in 2020, which are used to assess the amount of BMW that goes to landfill and so judge whether England was expected to meet the diversion levels necessary to comply with the EU Landfill Directive. This provided estimates of the likelihood of meeting the Landfill Directive target and the impact from withdrawing Defra's provisional allocation of financial support for those private finance initiative (PFI) projects that were yet to reach financial close. A Monte-Carlo analysis was used that produced a wide range of outcomes including both surpluses and deficits. From these, the probability of meeting the target was estimated. As a result, it was decided to withdraw the provisional allocation of Waste Infrastructure Credits to a few remaining local authority led projects still in procurement.

Implementation of EU Directives such as the Landfill Directive is affected by changes in the definition of municipal waste. Until recently the UK used a different definition of municipal solid waste (MSW) from that used in most other EU countries, and included only those wastes arising from households, plus litter and street sweepings, that were collected by the local authority. This inconsistency caused problems in the implementation process. In 2011 the Government amended the definition of MSW to match the EU definition and to bring into the municipal waste category those wastes which are similar in composition to household waste but arise from commercial and other sources. To simplify data capture and comparison for the Landfill Allowance Trading Scheme (LATS), a new category of waste was created – Local Authority Collected Waste (LACW) – which is the waste formerly called MSW. Previously household waste made up around 90% of MSW in the UK, but is reduced to 50% or less using the new MSW definition.

[1] i.e. that the amount of BMW sent to landfill in 2020 is reduced to 35% of 1995 levels i.e. 10.2 m tonnes

[2] In this context 'Recover' means to obtain value from waste through recycling, composting, other forms of material recovery, and recovery of energy.

Table 1: European Waste Legislation targets & the definition of waste[3]

Waste Framework Directive targets: Under the Waste Framework Directive, Member States are currently required to recycle or reuse a minimum of 50 per cent of household waste by 2020. However, what constitutes household/municipal waste has been interpreted differently by different Member States and there is ambiguity about the materials that count towards the target. The Commission recently invited views on issues such as whether to have a single target and calculation method based only on the quantity of municipal waste collected, which would mean that there would also need to be a consistent definition of 'municipal waste'; should targets reflect environmental weightings for materials (for example, through reference to greenhouse gas savings achieved through recycling)?; should recycling targets be extended to include additional waste streams such as wood, food waste and textiles?; should businesses be required to sort a range of waste materials for recycling and composting/anaerobic digestion?	**Landfill Directive targets:** The current target is that by 16 July 2016 the weight of biodegradable municipal waste going to landfill must be reduced to 35 per cent of 1995 levels for each Member State, although ones that were landfilling more than 85 per cent of their waste in 1995 have an extra four years to meet this target. Issues identified by the Commission include the inconsistency of targets between Member States due to differences in their respective definitions of 'municipal waste'; and questions around whether landfill diversion targets encourage disposal (e.g. through incineration) rather than recycling or re-use in line with the waste hierarchy. Possible solutions suggested recently for consultation included: e a single definition of 'municipal waste' (as for the Waste Framework Directive) and establishing a legal obligation for reporting on municipal waste; further tightening existing targets, e.g. moving progressively towards zero biodegradable municipal waste being sent to landfill; introducing targets for the progressive reduction in the amount of residual waste arising (rather than focusing on what to do with it when it has arisen).

The approach that Defra and the Welsh Assembly Government (WAG) has taken is to apply the 50% target to an aggregate of all waste from households. Moreover, "Recycling" is defined in Article 3(17) of the Waste Framework Directive as: "any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations."

It is important to investigate whether the information available to decision makers is sufficiently strong and reliable and how underlying assumptions for the findings and for choosing a specific strategy have been tested, so that decision makers can be assured that they are making the best possible choice. This is important in the context both of meeting the legally binding targets as well as maximising the overall delivery of benefits from resource management. The aim of this study is therefore to provide a better insight into infrastructure needs for resource management, testing a number of assumptions and limitations of the forecast method used in the Defra report and examining their implications in terms of the report's main findings.

[3] Source: http://www.walkermorris.co.uk/business-insights/review-european-waste-management-targets

2. The assumptions used in Defra's 2020 Forecasting Report

The infrastructure capacity model was developed to forecast waste arisings and treatment capacity in England to establish whether sufficient capacity is expected to be in place to meet the requirements of the EU Landfill Directive targets for BMW. The target requires that the amount of BMW sent to landfill in 2020 is reduced to 35% of 1995 levels (i.e. to 10.2 million tonnes in England). Figure 1 below illustrates this process: the forecast level of residual BMW in 2020 is compared to the forecast level of residual BMW capacity in 2020; the difference between these two quantities is then compared to the Landfill Directive target.

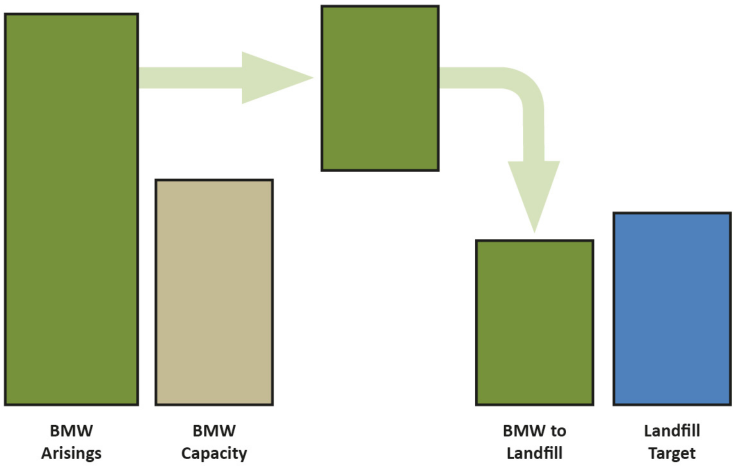

Figure 1: Illustration of the model process (source: Defra, 2013b)

Household waste arisings data are taken from WasteDataFlow, Defra's quarterly statistics from English Local Authorities (LAs) on the waste they collect. Household waste levels have fallen since an assessment of the provisional financial support for PFI projects was published in the 2010 Spending Review 2010 (SR10) (HM Treasury, 2010). In 2009-10 household waste arisings were 23.7 million tonnes. The forecast produced for SR10 predicted total household waste arisings of approximately 23.5 million tonnes in 2011-12, compared with the observed outturn of 22.9 million tonnes in that year, a 3% reduction since 2009-10 (Defra, 2013b) (figure 2).

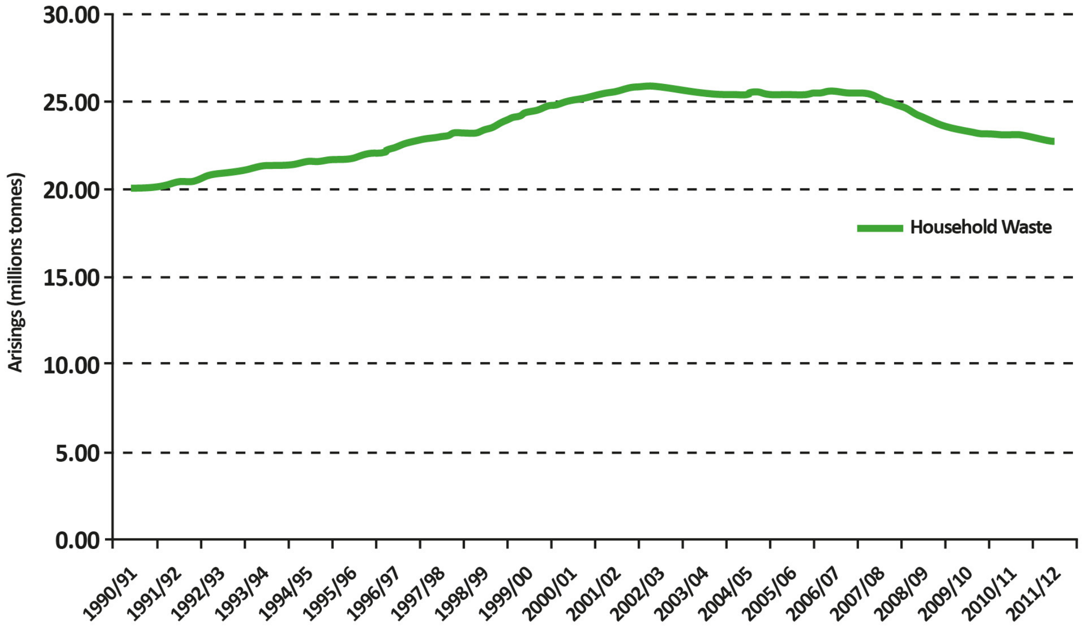

Figure 2: Household waste arising data 1990-2012 (Source: Defra, 2013b)

Data for LAC&I waste arisings in England are not regularly collected. The most recent data are from the 2009 'Commercial and Industrial Waste Generation and Management Survey' (Jacobs, 2011). In the 2009 Jacobs survey, arisings were estimated to be 47.9 million tonnes. The municipal component of this C&I waste is estimated to be 24.7 million tonnes (2013b). At the time of the analysis at SR10, the latest available data was from the previous survey, in 2002-03, which showed LAC&I waste arisings of 67.9 million tonnes. Since SR10 was completed results from the 2009 C&I waste survey have become available. These indicate that LAC&I waste arisings have fallen by a substantial 29% compared to the 2002-03 survey. The 2009 survey data also showed arisings are lower than forecast at SR10. In the previous analysis the estimate for 2008-09 was approximately 56.3 million tonnes of C&I arisings in total, which constitutes approximately 27.6 million tonnes of municipal LAC&I waste (Defra, 2013b).

Note: The municipal component of C&I waste (LAC&I) is defined as that which is similar in nature and composition to household waste.

Therefore, for both household and C&I waste there have been larger actual decreases in arisings than forecast at SR10.

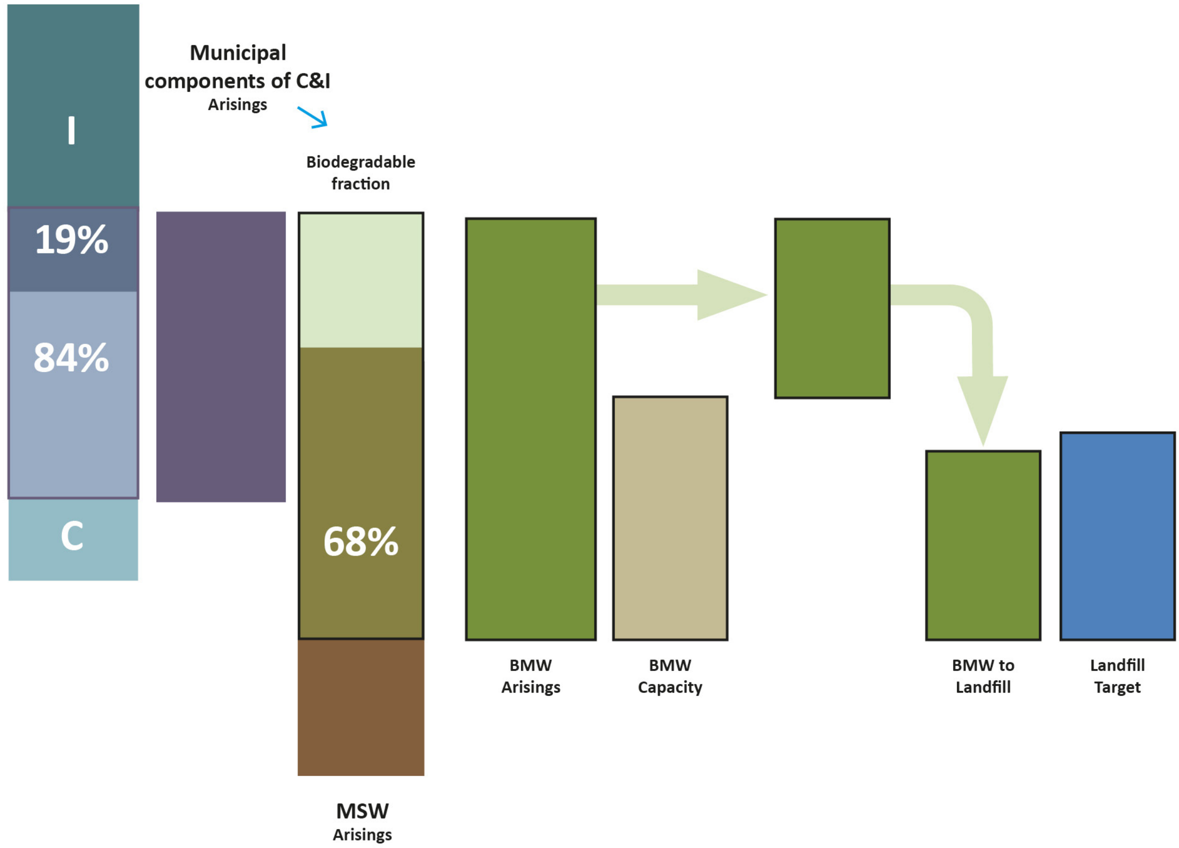

Figure 3: The approach used by Defra (2013b) to calculate total MSW arising and the treatment capacity gap

The central assumption was that the biodegradable content of municipal waste is 68%. For the year 2020 a range of 55% to 75% was used. This broad range reflects the fact that the biodegradable content may vary over time and that a shortage of data makes predicting these changes to 2020 especially uncertain. The range was not symmetric, and this was attributed to compositional studies indicating that biodegradable content is more likely to be lower than 68%.

This capacity modelling had the following limitations:

- the biodegradable fraction of MSW (68%) was considered with no further composition analysis that might have enabled distribution of components to appropriate treatment options;
- all treatment capacity required for this fraction was split between EfW and MBT, whereas other treatment options could also have been considered (as per previous point);
- the C&I component of MSW was calculated and then treated as MSW, whereas although it is of similar nature, the composition may be different, with different biodegradable fractions;
- projected capacities were aggregated to calculate total diversion for England, concealing regional differences that could have been useful;
- estimated landfill diversion demand was not corrected by taking into account the amount of biodegradable waste going to landfill through other routes.

All household waste was assumed to be municipal. The municipal component of C&I waste was estimated using data from the 2009 survey as 84% for commercial waste and 19% for industrial waste. For the 2020 municipal content of C&I waste, a range of 79% to 89% was used for commercial waste and 15% to 23% was used for industrial waste. Unlike household waste for which there is data every quarter and where trends can be discerned, the lack of regular data means the municipal content of LAC&I waste in 2020 is particularly uncertain. It was assumed that the municipal content is equally likely to be anywhere within these ranges.

Defra forecasted in 2013 that household waste would gradually fall to reach 22.6 million tonnes in 2020. This was given as a central scenario of the modelling, with the minimum and maximum being 20.3 and 24.9 mt respectively (figure 4). Similarly, the C&I component of MSW was forecast to be 23.1 million tonnes (central scenario), with the minimum and maximum scenarios being 20.7 and 26.4 mt respectively (figure 5).

The likelihood of meeting the 2020 Landfill target was forecast under two scenarios: either with provisional financial support given to all the projects or with support withdrawn for some. In the latter case, the probability of the projects being successful was reduced. The results are presented in table 2 below. In both cases, overcapacity was projected in 2020.

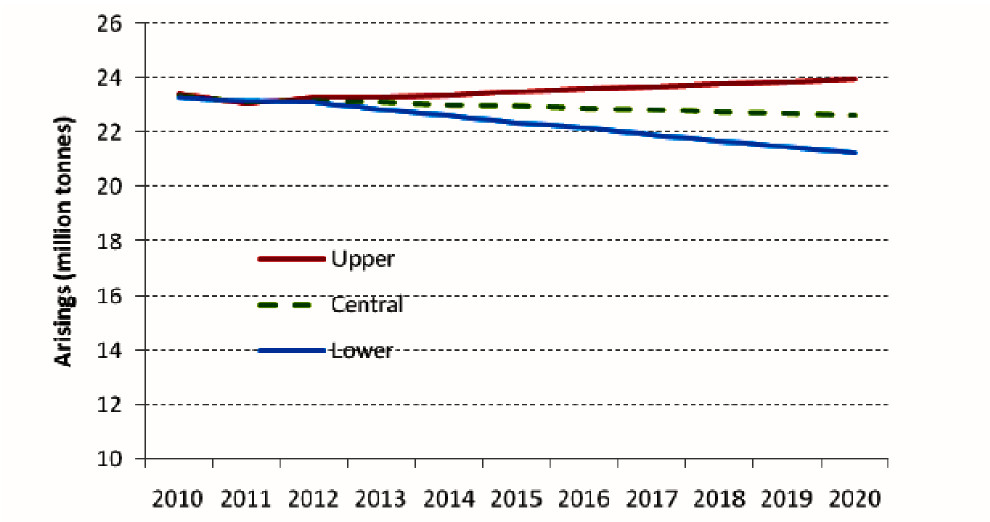

Figure 4: Household waste arising forecasts (source: Defra, 2013b)

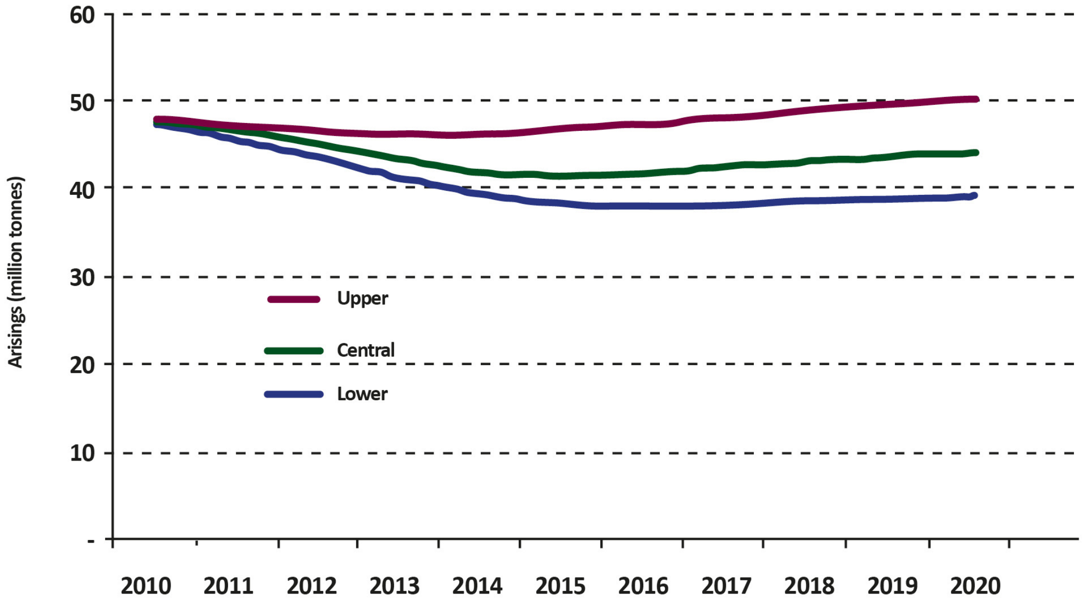

Figure 5: C&I waste arising forecasts (Source: Defra, 2013b)

Table 2: Facility forecasting results in Defra's 2020 Forecasting Report (2013b)

Option	Likelihood of meeting target	Average surplus (mt)
Provisional support withdrawn	93.2%	2.1
Support given	95.0%	2.3

Table 3 below summarises the assumptions that were used in the Defra study (2013b). By reviewing these and identifying their limitations, it was possible to find ways to address them. Overall, it is suggested that too little attention was paid to the compositional characteristics of the waste which is important in assessing real treatment requirements.

Table 3: Review of the assumptions of Defra's 2020 Forecasting Report (2013b) and possible ways to address their limitations

Assumptions of Defra model	Addressing the limitations
68% of LACMW was considered to be biodegradable.	The sum of the waste fractions that are biodegradable and could be treated by different facilities.
Targets refer to 68% of LACMW, assuming that it is one well mixed stream.	Targets refer to quantities calculated from the sum of biodegradable fractions of LACW composition.
The municipal component of C&I waste was defined as that which is similar in nature and composition to household waste.	The municipal component of C&I waste is defined as those streams that are similar in nature and composition to household waste.
84% of commercial waste and 19% of industrial waste was defined as the above.	The sum of the above fractions is considered instead.
The biodegradable component of the municipal component of C&I waste is used as 68%.	The biodegradable municipal component of C&I waste is that which can be treated by the same facilities as BMSW.
In summary, Defra treated the household and LAC&I components as one waste, of 68% biodegradability.	This study considers waste composition and matches it to appropriate facilities to identify where exactly any gaps or surpluses are.

Most of the discussion of Defra's 2020 Forecasting Report focused on uncertainties, with some concluding that Defra's approach should be refined to better reflect the uncertainty inherent in forecasting demand and capacity. For example, although reference was made to the fact that the probabilities emerging from the model were conditional on the data available at the time, and were calculated assuming that government had no flexibility to react to new or better future data, this was not taken further or explicitly acknowledged when interpreting the results. This is particularly problematic as the whole purpose of the analysis was to predict whether the EU and Government targets will be met. **In other words, even if the uncertainty was not an issue, the findings of this work alone should perhaps not have been used to justify decisions on local authority led projects still in procurement, but instead to trigger the need for Municipal Waste Management Strategy revisions in light of the evidence emerging from the work.**

Variations between local authority collections, market uncertainties with regard to resources recovery, and even regulatory changes regarding definitions all increase the uncertainty of any stochastic attempt to calculate or predict future infrastructure needs, to the degree that any benefit in doing so, is overshadowed by the potential costs attached to the resulting underestimation or overestimation of those needs. To be able to understand infrastructure needs in the future, it is necessary to start with understanding those needs now, as it is the difference between the infrastructure now in place and that required in the future that will determine those 'needs'.

Defra and others applied the principle of summing permitted and planned capacities in order to determine national infrastructure needs. In this approach:

a. it was assumed that waste could be easily and practically transported across the entire country for treatment;
b. there was a failure to account for the waste composition or the need for different technologies for different waste; and
c. the data for planned infrastructure included projects that will never be built because there is not enough waste regionally to supply them.

By way of example, there may be a planned facility in the North West (where there is a lot of capacity already), that will never be built, and yet no facility will get planning in the South East as results from the national study indicate that there is sufficient capacity.

3. Addressing the limitations of Defra's forecasting approach

The aim of this work was to evaluate how sensitive were the Defra findings to the assumptions made in their approach and if the possible limitations to their forecasting method might restrict their wider application to support decision making. Calculations have been performed for assessing infrastructure needs, addressing each of the assumptions of the Defra approach and developing figures better adapted to the data.

In this study the aim of the calculations was to consider:

- quantities of materials arising at a regional level using compositional data, rather than considering all wastes to be the same, with agglomeration across the UK;
- forecasting total quantities of material arising and the consequent demand for technologies and facilities;
- with more informed assumptions about how inputs are directed to different facilities (e.g. sorted recyclables go to MRFs, residual material goes to ERFs), subtracting from the above the relevant existing treatment capacity, the composition of the waste remaining untreated and the associated future infrastructure treatment needs can be calculated for each region.

Data from 2009/10 was used to calculate how close the predicted values were to the real and known values of a previous year. The year 2009/10 was the period studied by Defra, making the results directly comparable. Under the modified definition of MSW, the analysis refers to LACW (LACMW and LAC&I). LACMW arisings data was sourced from WasteDataFlow, while information for LAC&I was taken from the 2009 Jacobs C&I survey.

The details of the calculations undertaken in this study are presented in table 4. The assessment of infrastructure needs was performed by first distributing waste streams to suitable treatment options according to their nature in order to determine the treatment requirements, and by further comparing these requirements with available capacity to determine the amount and composition of untreated waste.

Table 4: Imperial calculations for estimating capacity needs

1	Data from 2009/10 were used to evaluate the significance and impacts of the Defra study . Under the modified definition of MSW, the analysis refers to LACW (LACMW and LAC&I). LACMW data were sourced from WasteDataFlow, while information for LAC&I waste was taken from the 2009 C&I survey.
2	Using compositional analysis for MSW (Defra, 2009) the various components of LACMW and their respective arisings per region were calculated.
3	Selected C&I waste streams were identified as having a similar nature to MSW: animal and vegetable waste, non metallic wastes and discarded equipment. The total arising for C&I similar to household waste used in this study was 25.4 mt, being very close to the relevant arising used by Defra (24,7 mt). Having the same starting point, i.e. arisings, enables the comparison of the results produced by the two different methodologies. With appropriate LAC&I waste streams being much more homogenous than LACMW, it was not difficult to calculate treatment capacity needs without detailed compositional data.
4	Per region, the treatment requirements per technology for both LACMW and the similar C&I was then calculated.
5	Environment Agency data (permitted facilities to the end of March 2010) were used to calculate capacity for the following technologies in each region: AD, Composting, MBT, Incineration, MRFs, WEEE.
6	Comparing the calculated capacity above (5) to the treatment requirements per technology (4), the remaining (untreated) materials and future infrastructure needs can be estimated.

This analysis took a regional approach. It is suggested that the spatial dimension is critical in order to be able to match offer and demand of materials. Moreover the location defines the actual local environmental and social impacts. The selection of the most suitable and at the same time environmentally beneficial treatment option depends on the type of material as well as the transport distance for treatment. There is therefore a need to consider what materials are present in each location and where suitable treatment facilities are located. The proximity principle is of importance, and it is not acknowledged in aggregated nationwide assessments.

3.1 Materials arising at a regional level using compositional data

Compositional information for LACMW (Defra, 2009) was used to calculate the arisings of the various components of LACMW per region (table 5 and table 6). A material specific approach to waste arisings is important in order to determine what treatment infrastructure is required.

The approach in the current study defined the municipal component of C&I waste as those streams that are similar in nature and composition to household waste. This is more flexible and adaptable to regional variation, and can then be estimated by calculating the regional arisings on the basis of the data for appropriate waste streams.

For the municipal component of C&I waste, the regional arisings were calculated based on information provided by the 2009 C&I waste survey. The aim was to:

- determine the MSW component of C&I waste arisings by selecting C&I waste types that were of similar nature to household waste;
- obtain a total for the MSW component of C&I waste arisings which would be as close as possible to the figure provided by Defra (25.4 million tonnes). Using similar total LAC&I waste arising as Defra would enable the direct comparison of the results produced by the two approaches, highlighting the impact of the different assumptions used.

The C&I survey reported C&I waste arisings in the following waste categories: animal and vegetable waste, chemical sludges, common sludges, discarded equipment, healthcare wastes, mineral wastes, mixed wastes, non-metallic waste and non-waste. In order to address the first objective as stated above, we selected the following waste streams for inclusion in the analysis: **animal and vegetable waste**[4]**, discarded equipment**[4] **and non-metallic waste**.

The survey also reported how the various LAC&I waste streams were treated in England. A number of treatment options were provided i.e. **landfill, thermal treatment with energy recovery, non-thermal treatment (MBT), recycling, composting**, other thermal treatment (such as clinical waste incineration), land recovery, transfer stations, reuse and unknown. Only the first five of these technologies were selected as relevant while the rest were grouped as *other* (some left as unknown). This selection of waste streams and treatment practices gave a LAC&I arising of 25.4 million tonnes for England (as 2009 C&I waste survey excluding animal and vegetable waste and discarded equipment reported as recycled[4]), relatively close to the 24.7 mt reported by Defra.

Waste to landfill only decreased minimally between 2009 and 2010. It fell by less than 2% between 2009 and 2010 and has fallen by around 46 per cent since 2000 (Defra, 2013b). One of the principal reasons is considered to be the implementation of the Landfill Directive, the other is probably the financial recession. Many older landfill sites that did not meet the stringent requirements of the Directive had to close by July 2009 at the latest and diversion targets for biodegradable municipal waste to landfill increase year on year.

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[4] Animal and vegetable waste and discarded equipment reported as recycled were excluded from the C&I arisings in this study, as they would most probably not refer to the treatment of dry recyclables but other practices and facilities not included in our study when existing infrastructure was taken into account.

Remaining capacity at landfill sites fell by just over two per cent during 2010. Overall since 2000 landfill capacity has fallen by 21 per cent. Overall inputs through permitted treatment facilities have increased by over 18 per cent. The main increase was through sites for physical and biological treatment. There was also an increase of around two per cent (81,000 tonnes) in the waste going through composting plants.

The arising of LACMW and LAC&I, as well as their estimate combined arisings for England, is shown in table 5 and illustrated per component in figure 6.

Table 5: LACMW and LAC&I waste arisings for 2009-10 (thousand tonnes)

	England	East Midlands	East	London	North East	North West	South East	South West	West Midlands	Yorkshire and Humber
LACMW	**26,228**	2265	2842	3791	1396	3649	4215	2714	2731	2624
C&I	**25,385**	2494	2580	3487	1088	4448	3610	2447	2565	2666
Total	**51,613**	**4759**	**5422**	**7278**	**2484**	**8097**	**7825**	**5161**	**5296**	**5290**

Table 6: LACMW composition and arisings (thousand tonnes) per component and per region

	% of MSW	East Midlands	East	London	North East	North West	South East	South West	West Midlands	Yorkshire and Humber	ENGLAND
Sanitary	2.51	57	71	95	35	92	106	68	69	66	**659**
Other Waste	2.32	53	66	88	32	85	98	63	63	61	**609**
Fines	1.66	38	47	63	23	61	70	45	45	44	**436**
Furniture	1.34	30	38	51	19	49	56	36	37	35	**351**
Mattresses	0.25	6	7	9	3	9	11	7	7	7	**66**
Textiles	2.83	64	80	107	40	103	119	77	77	74	**741**
Misc non-combustible	2.82	64	80	107	39	103	119	77	77	74	**740**
Food	17.84	404	507	676	249	651	752	484	487	468	**4678**
Other organic	1.73	39	49	66	24	63	73	47	47	45	**453**
Garden	14.08	319	400	534	197	514	593	382	385	369	**3693**
Wood	3.73	84	106	141	52	136	157	101	102	98	**977**
Misc Combustible	2.37	54	67	90	33	86	100	64	65	62	**621**
Soil	0.18	4	5	7	3	7	8	5	5	5	**49**
Paper	16.65	377	473	631	232	608	702	452	455	437	**4367**
Card	6.04	137	172	229	84	220	255	164	165	159	**1585**
Glass	6.64	150	189	252	93	242	280	180	181	174	**1741**
Metal	4.3	97	122	163	60	157	181	117	117	113	**1127**
Plastics	9.99	226	284	379	139	365	421	271	273	262	**2620**
Hazardous	0.53	12	15	20	7	19	22	14	14	14	**137**
WEEE	2.19	50	62	83	31	80	92	59	60	57	**574**

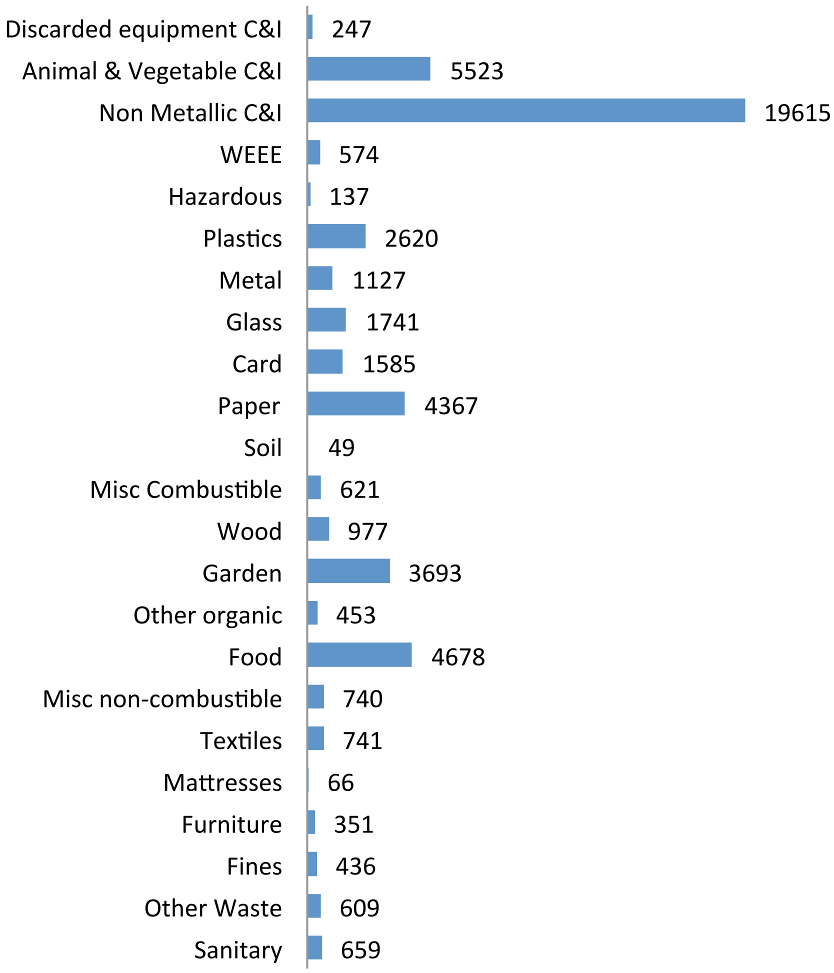

Figure 6: Calculated composition of arisings in England for 2009-10 (thousand tonnes)

Table 7: LAC&I waste streams used for the purposes for this analysis (thousand tonnes)

	Animal and vegetable waste	Discarded equipment	Non metallic wastes	Total LAC&I (LACMW alike)
East Midlands	739	21	1734	2494
East of England	581	27	1972	2580
London	640	38	2809	3487
North East	240	11	837	1088
North West	800	32	3616	4448
South East	636	43	2931	3610
South West	540	25	1882	2447
West Midlands	665	26	1874	2565
Yorkshire	682	24	1960	2666
ENGLAND	**5523**	**247**	**19615**	**25385**

3.2 Material arisings and consequent technologies and facilities' demand

The LACMW arisings of the different materials were distributed to suitable treatment options according to a maximum recycling scenario (table 8), producing the theoretical treatment requirements for LACMW (table 9).

Table 8: LACMW composition and preferred treatment option according to biodegradability

Treatment option	LA Household waste composition	Assumed biodegradability
AD/Composting	Food	100%
Composting	Garden	100%
AD/Composting	Other organic	100%
MRF	Paper	100%
MRF	Card	100%
MRF	Glass	0%
MRF	Metal	0%
MRF	Plastics	0%
50% recycling, 50% incineration	Textiles	50%
Incineration	Wood	100%
WEEE treatment	WEEE	0%
Other treatment	Hazardous	0%
100% Incineration	Sanitary	50%
50% recycling, 50% incineration	Furniture	50%
50% recycling, 50% incineration	Mattresses	50%
Incineration	Misc Combustible	50%
50% Recycling, 50% Landfill	Misc non-combustible	0%
Landfill	Soil	0%
100% incineration	Other Waste	50%
100% incineration	Fines	50%

Table 9: Treatment requirements for LACMW (thousand tonnes)

	England	East Midlands	East	London	North East	North West	South East	South West	West Midlands	Yorkshire and Humber
Recycling (MRFs)	12390	1070	1343	1791	659	1724	1991	1282	1290	1240
AD & Composting	8826	762	956	1276	470	1228	1418	913	919	883
Incineration	4021	347	436	581	214	559	646	416	419	402
WEEE	574	50	62	83	31	80	92	59	60	57
Landfill	417	36	45	60	22	58	67	43	43	42
Total	26228	2265	2842	3791	1396	3649	4215	2714	2731	2624

While the 2009 C&I survey provided the arisings of all the C&I waste streams in each region it did not provide information on how these are managed regionally. At a regional level, the survey did however report how all of the C&I waste was treated in that year. It was therefore possible to determine the regional requirements per technology for all the LAC&I considered in this study (table 10), as well as more detailed information on the regional arisings and distribution to treatment options of each LAC&I waste stream.

Table 10: Calculated treatment requirements for LAC&I (thousand tonnes)

	England	East Midlands	East	London	North East	North West	South East	South West	West Midlands	Yorkshire and Humber
Incineration	537	57	55	71	23	91	73	52	56	59
Other residual treatment (MBT)	318	39	33	39	14	47	40	31	37	37
Recycling	12478	1103	1255	1787	532	2300	1865	1197	1192	1247
Composting	447	57	47	53	19	67	54	44	52	54
Unknown	2069	204	211	284	89	357	295	200	211	218
Landfill	5013	487	509	692	215	883	718	483	504	524
Other	4522	547	470	559	196	703	566	440	513	528
Total	25385	2494	2580	3487	1088	4448	3610	2447	2565	2666

The treatment requirements for LAC&I and LACMW were calculated separately in order to assess treatment requirements. The treatment requirements for LACMW were calculated on the basis of compositional information, whereas for LAC&I for which compositional information was unavailable, the requirements were calculated on the basis of how it was managed in that year. The calculated arisings per area are illustrated in the Appendix. The results (arisings and requirements) of the separate analyses for LACMW and LAC&I are presented in the figures below.

Figures 7-10 illustrate the treatment requirements for LACMW per technology grouping and figure 8 shows the requirements for LAC&I. Overall Recycling for non-metalic waste seems to be the treatment that outweighs the others for all waste streams. This was expected since the C&I waste component that is similar to the household waste was being used.

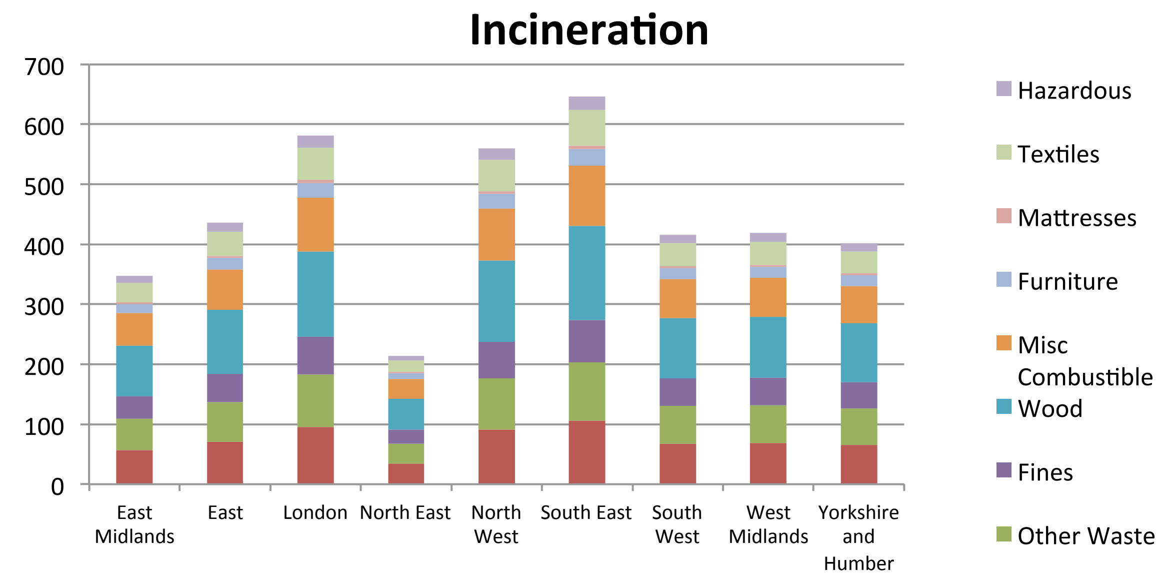

Figure 7: Breakdown of LACMW materials requiring residual treatment in 2009/10 per region (thousand tonnes)

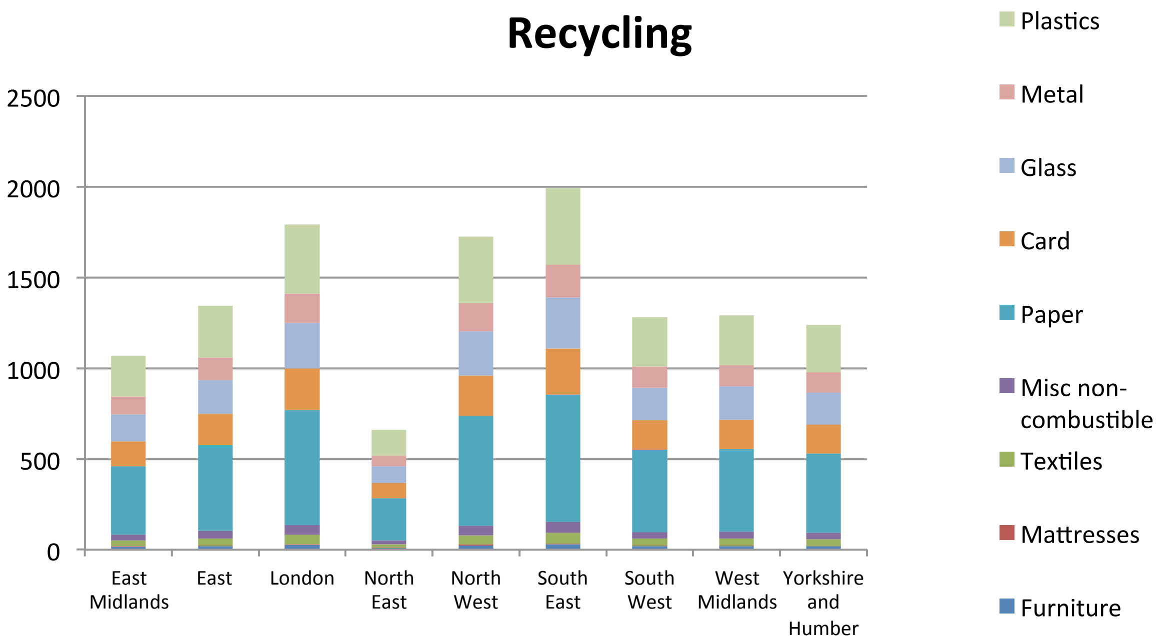

Figure 8: Breakdown of LACMW materials requiring recycling in 2009/10 per region (thousand tonnes)

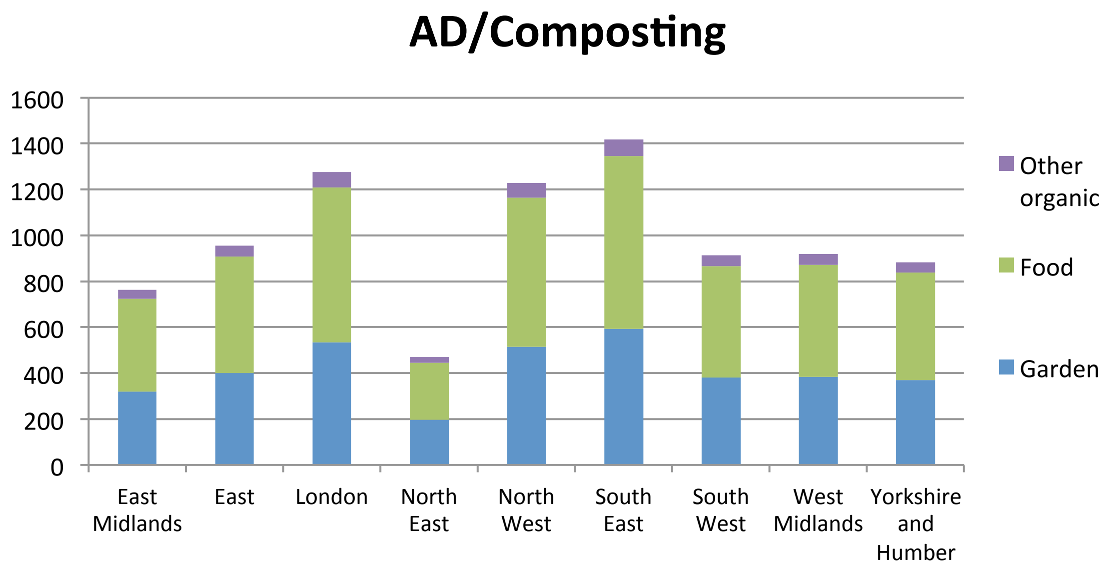

Figure 9: Breakdown of LACMW materials requiring AD/Composting in 2009/10 per region (thousand tonnes)

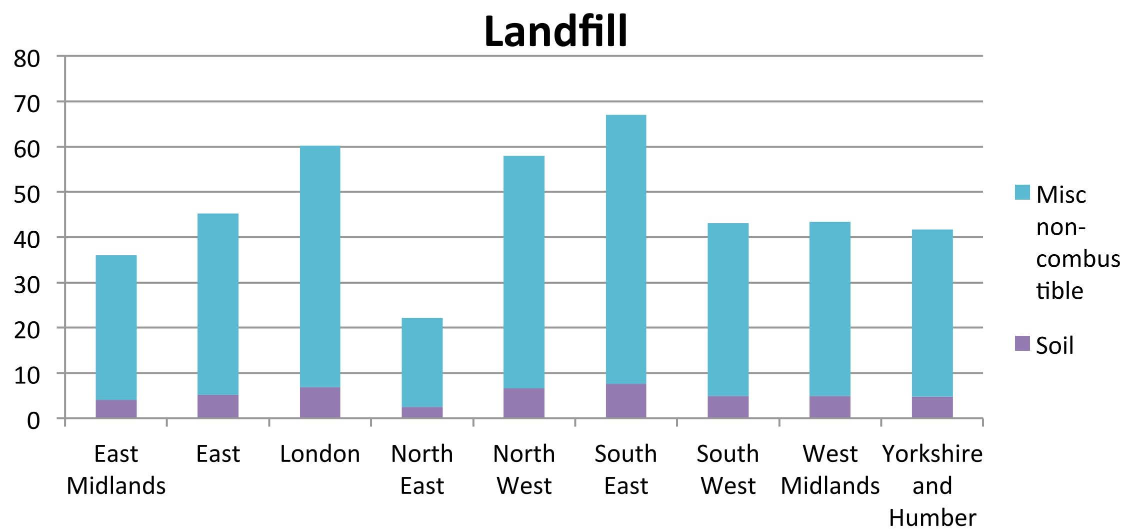

Figure 10: Breakdown of LACMW materials requiring landfilling in 2009/10 per region (thousand tonnes)

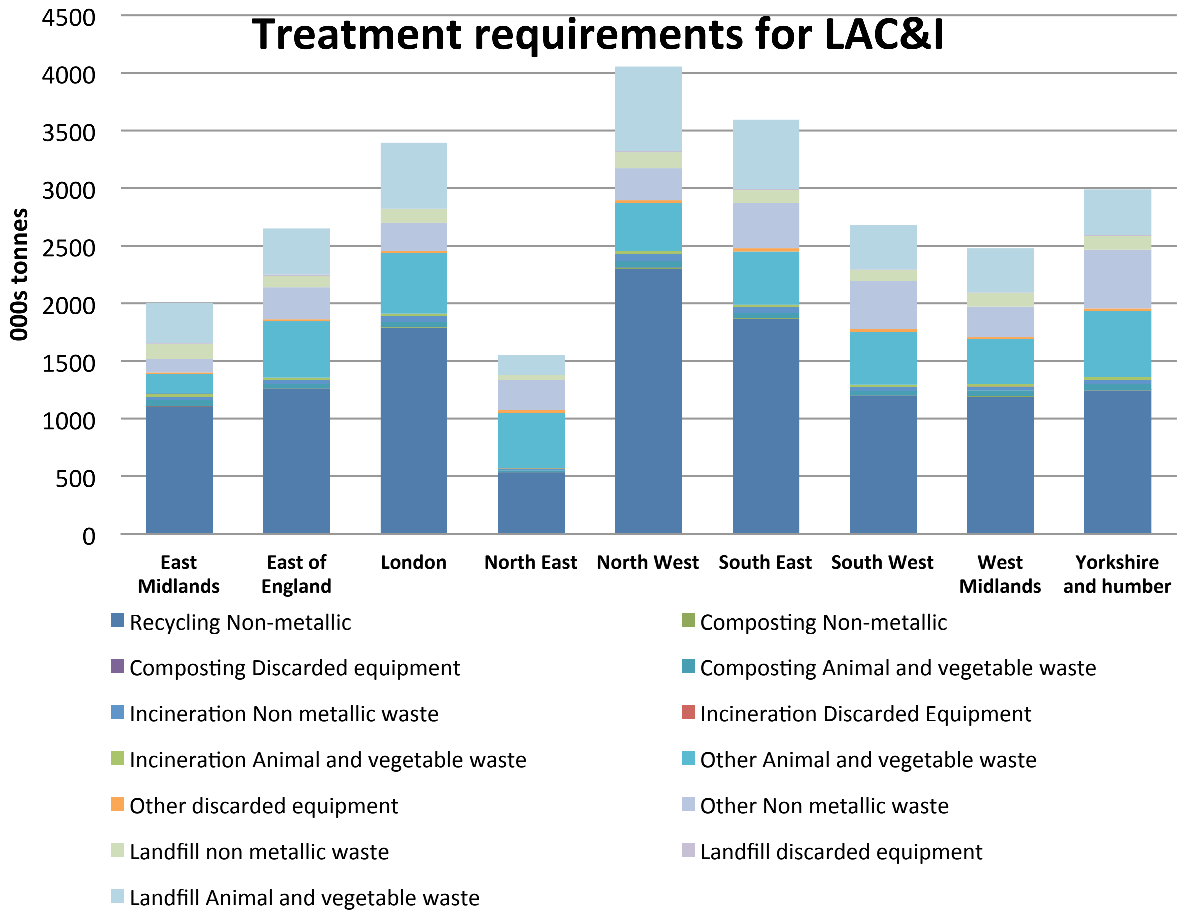

Figure 11: Treatment requirements for LAC&I streams in 2009/10 calculated on the basis of how it was managed that year (thousand tonnes)

3.3 Assessment of infrastructure availability

The entire waste management system was considered, recycling and residual waste treatment being interdependent. The amounts and types of materials that were recycled inevitably affected the amount and nature of the waste that required residual treatment.

The approach that is used by Defra is in line with a more general disconnection in the UK in the management of recycling and treatment of residual waste. Recycling infrastructure is dealt with by WRAP whereas residual treatment facilities by WIDP. They are treated as two different things rather than interconnected.

The need to link recycling and energy recovery is also acknowledged in a statement by the Environmental Agency for England and Wales: "The number of energy from waste plants needed depends on the rates of recycling and composting achieved, the use of other treatment methods, the growth in municipal waste and the size of any proposed energy from waste plants" (Environment Agency, n.d.).

In the present study, the existing infrastructure capacity was calculated using EA data on permitted infrastructure at the end of March 2010. The main classification that this database applied was that of main technology types and those that were selected as relevant to the study were: Composting, AD, MRFs, MBT, Incineration, and WEEE.

The data were inspected for suitability, for example excluding facilities that were stated to never have become operational or not yet having been built, those that appeared to be treating other types of wastes such as agricultural waste (based on EA database and other publicly available information), or fractions of their permitted capacity for multi-activity sites treating also other types of wastes. The permitted projected capacities were aggregated in order to provide the maximum available capacity for the treatment of waste (LACMW and the selected C&I which is of a similar composition) in that year. The results are presented in table 11, and represent the combined capacity for the treatment of LAC&I and LACMW.

Table 11: Infrastructure availability as per permitted capacity (thousand tonnes)

Regional capacities/technology	WEEE Treatment	MRF	AD	MBT	Incineration	Composting
East Midlands	507	725	165	125	260	927
East of England	459	1,191	82	415	0	1,195
London	459	1,822	0	562	1,088	353
North East	93	1,100	0	195	375	162
North West	410	1,240	0	541	127	1,214
South East	247	2,449	120	200	1,468	761
South West	212	440	170	150	4	553
West Midlands	308	1,029	5	0	1,140	871
Yorkshire and the Humber	345	555	552	165	431	780
Total	**3,040**	**10,552**	**1,094**	**2,353**	**4,893**	**6,817**

3.4 Infrastructure treatment capacity needs

This study compared the available infrastructure in each region (table 11) with the treatment requirements for all LACW as the sum of LACMW and LAC&I treatment requirements per technology The combined picture of LACW – including LACMW and the municipal component of similar C&I - can be seen in table 12. Furthermore table 13 compares the treatment requirements for LACW with the infrastructure availability for 2010. As can be observed under the maximum recycling scenario there was a deficit in all technologies for that year apart from Incineration. This is reasonable given that this scenario assumes near perfect segregation of materials for recycling and therefore the theoretical minimum quantitiy of material available for ERF. Currently such effective segregation would be impossible to achieve within any kind of practical affordability envelope due to technological limitations and the difficulties of encouraging effective sorting by households. Further it does not account for the benefits of an integrated energy strategy that includes waste to energy which may limit an authorities ambition to recycle. Finally, it is important to note that this approach underestimates infrastructure treatment capacity requirements as all LAC&I that went to landfill was not included, even if there is great scope to divert some of this in the future.

Table 12: Combination of all LACW (LACMW and LAC&I) treatment requirements per technology (thousand tonnes)

		East Midlands	East of England	London	North East	North West	South East	South West	West Midlands	Yorkshire and Humber	England
LACMW	MRF	1069	1342.5	1791	658.5	1724	1991.5	1282.5	1290	1240	12389
	AD/C	762	956	1276	470	1228	1418	913	919	882	8824
	Incineration	336	419.5	560.5	206	540.5	624	401	404.5	389	3881
	Other	62	77	103	38	99	114	73	74	71	711
	Landfill	36	45	60.5	22.5	58.5	67.5	43.5	43.5	42	419
	Total arising LACMW	**2265**	**2840**	**3791**	**1395**	**3650**	**4215**	**2713**	**2731**	**2624**	**26224**
LA C&I	Thermal treatment (energy recovery)	57	55	71	23	91	73	52	56	59	537
	Non thermal treatment (MBT)	39	33	39	14	47	40	31	37	37	318
	Recycling	1103	1255	1787	532	2300	1865	1197	1192	1247	12478
	Composting	57	47	53	19	67	54	44	52	54	447
	Unknown	204	211	284	89	357	295	200	211	218	2069
	Landfill	487	509	692	215	883	718	483	504	524	5013
	Other	547	470	559	196	703	566	440	513	528	4522

	Total Arising LAC&I	**2494**	**2580**	**3487**	**1088**	**4448**	**3610**	**2447**	**2565**	**2666**	**25385**

Table 13: Comparison of treatment requirements using data from table 11 and 12 (LACW = LACMW+LAC&I) and infrastructure availability or Available Capacity (AC) for 2010 (thousand tonnes)

		East Midlands	East of England	London	North East	North West	South East	South West	West Midlands	Yorkshire and Humber	England
Recycling	**LACW**	2172	2597	3578	1191	4024	3856	2480	2482	2487	24867
	AC	725	1,191	1,822	1,100	1,240	2,449	440	1,029	555	10,552
	Capacity need	**1447**	**1406**	**1756**	**91**	**2784**	**1407**	**2040**	**1453**	**1932**	**14315**
Incineration	**LACW**	393	474	632	229	631	697	453	461	448	4418
	AC	260	0	1,088	375	127	1,468	4	1,140	431	4,893
	Capacity need	**133**	**474**	**-456**	**-146**	**504**	**-771**	**449**	**-679**	**17**	**-475**
Composting - AD	**LACW**	819	1003	1329	489	1295	1472	957	971	936	9271
	AC	1092	1277	353	162	1214	881	723	876	1332	7911
	Capacity need	**-273**	**-274**	**976**	**327**	**81**	**591**	**234**	**95**	**-396**	**1360**
Other	**LACW**	852	792	986	336	1206	1015	744	834	854	7620
	AC	632	874	1021	288	951	447	362	308	510	5393
	Capacity need	**220**	**-82**	**-35**	**48**	**255**	**568**	**382**	**526**	**344**	**2227**
Sum											**17,427**

When the data above is compared with the EA relevant data, for example, on incineration (table 14), for the same year, there is further validation that available infrastructure has been correctly calculated, with the surplus on incineration in table 13 probably down to the type of data used (permitting capacity). Similarly the sum of all regional needs (indicating lack of infrastructure in 2009/10) is equivalent of the amount of LACW that was sent to landfill for the same year (as reported by the EA). This is as expected, since landfill was not included in our infrastructure treatment capacity. This confirmation of regional variation offers further validation for the approach (figure 12). The further comparison of the findings of this approach and the one in Defra's forecasting report demonstrate the limitations of the latter approach.

Table 14: EA data on actual incineration inputs for 2010 (thousand tonnes) (source: EA waste database)

Incineration Type	**North East**	**North West**	**Yorks & Humber**	**East Midlands**	**West Midlands**	**East of England**	**London**	**South East**	**South West**	**England**
Municipal and/or Industrial & Commercial*	296	84	383	157	979	0	891	1.236	2	**4.028**

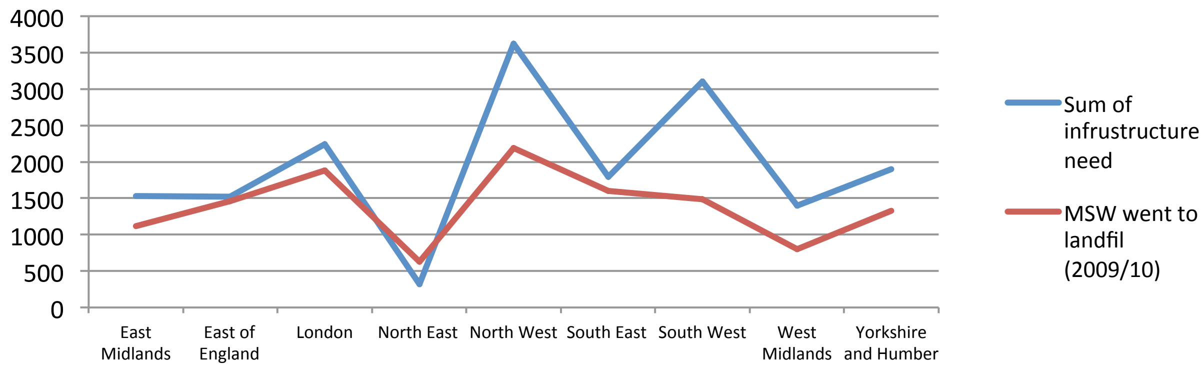

Figure 12: Sum of calculated infrastructure need per region in comparison to MSW in landfill (2009/10) (thousand tonnes)

The forecasting approach used by Defra clearly underestimated infrastructure needs (table 15). Using initial arising for LACW corrected to the same levels, and applying the assumptions in their methodology, it becomes clear why an overcapacity was forecast, and based on the improvements of the method delivered here, it is evident why it is misleading. With the Imperial approach, by taking into account that only animal and food waste and non-metallic wastes are biodegradable (100%)[5], it can be calculated that out of the 10.2 million tonnes that can go to landfill according to the EU Landfill Directive, the amount of biodegradable waste totals 4.04 million tonnes allowing another 6.15 million tonnes to go to landfill. As can be seen in table 15, with Defra's approach there is an estimated overcapacity of 3.8 mt by subtracting from the capacity need the BMW that can be sent to landfill to meet the targets. But in this study the initial arising is altered to 46.18 million tonnes (theoretical required capacity) after subtracting the BMW that goes to landfill. Then after subtracting the potential BMW that can still go to landfill to meet the targets (6.15 million tonnes) there is clearly a total deficit in available capacity equal to 11.28 mt. Therefore, **it seems that Defra's approach to forecasting may have underestimated capacity needs.**

In addition, with recycling treatment requirements around 24,867 thousand tonnes and Composting or Anaerobic Digestion 9,271 thousand tonnes for all LACW, this approach ensures that government national targets for recycling / composting of household waste are addressed.

[5] Although non-metallic waste is not 100% biodegradable, at the same time it was assumed the discarded equipment is 0% biodegradable. That way we take the worst case scenario regarding the biodegradability of those waste streams.

Table 15: Comparison of calculated Capacity Gap with Defra's approach and that of this study (2009/10) (thousand tonnes)

	Defra approach	Imperial approach
Total LACW 2009/10 arising	51,609 (corrected to the same amount for better comparison)	51,609
Available Infrastructure Capacity (EA Data)	28,749	28,749
Theoretical required capacity	35,094 (based on 68% biodegradability)	46,176
Capacity need (before sending to landfill BMW allowed)	6,345	17,427
BMW allowed to landfill to meet 2020 target	10,200	6,150 (reduced by the amount of BMW already sent above)
Capacity need after landfill (2020 target)	**-3,855 (overcapacity)**	**11,275 (undercapacity)**

To further determine the relationship between treatment requirements and available infrastructure, as a better indication of capacity needs, the types and quantities of materials that remain (after use of existing available capacity) requiring treatment were estimated per region. The process first of all involved distributing material streams to suitable treatment options as per table 8 proportionately to their regional arisings. If the available treatment capacity of recycling, composting or AD was insufficient to cover the regional needs, the untreated materials were directed towards incineration subject to the availability of spare capacity, a process which was also carried out proportionately to the regional arisings of the materials. The process of distributing materials to suitable technologies was therefore done following this two step approach. It is noted that if AD capacity was not sufficient to cover the treatment needs for food waste and other organics, these were directed to any spare composting capacity first before incineration. The regional results are further presented according to this two step process.

The approach uses spare residual capacity to process untreated recyclables. In practice, even after the recycling process has taken place any remaining materials will be mixed and not generally suitable for treatment in recycling/composting facilities, and therefore are likely to require residual waste treatment technologies.

The regional profiles dealing with the distribution of waste to the available infrastructure capacity and with identifying the remaining materials are further presented. In each section the regional arisings in contract to the available capacity per region and per technology are presented, since it is up to the LAs to decide how each waste stream should be treated (figures 14, 16, 18, 20, 22, 24, 26, 28, 30)

. Also in each regional profile we show a possible scenario of the distribution of materials into the facilities and the theoretical remaining materials, where household waste goes first into the facilities.

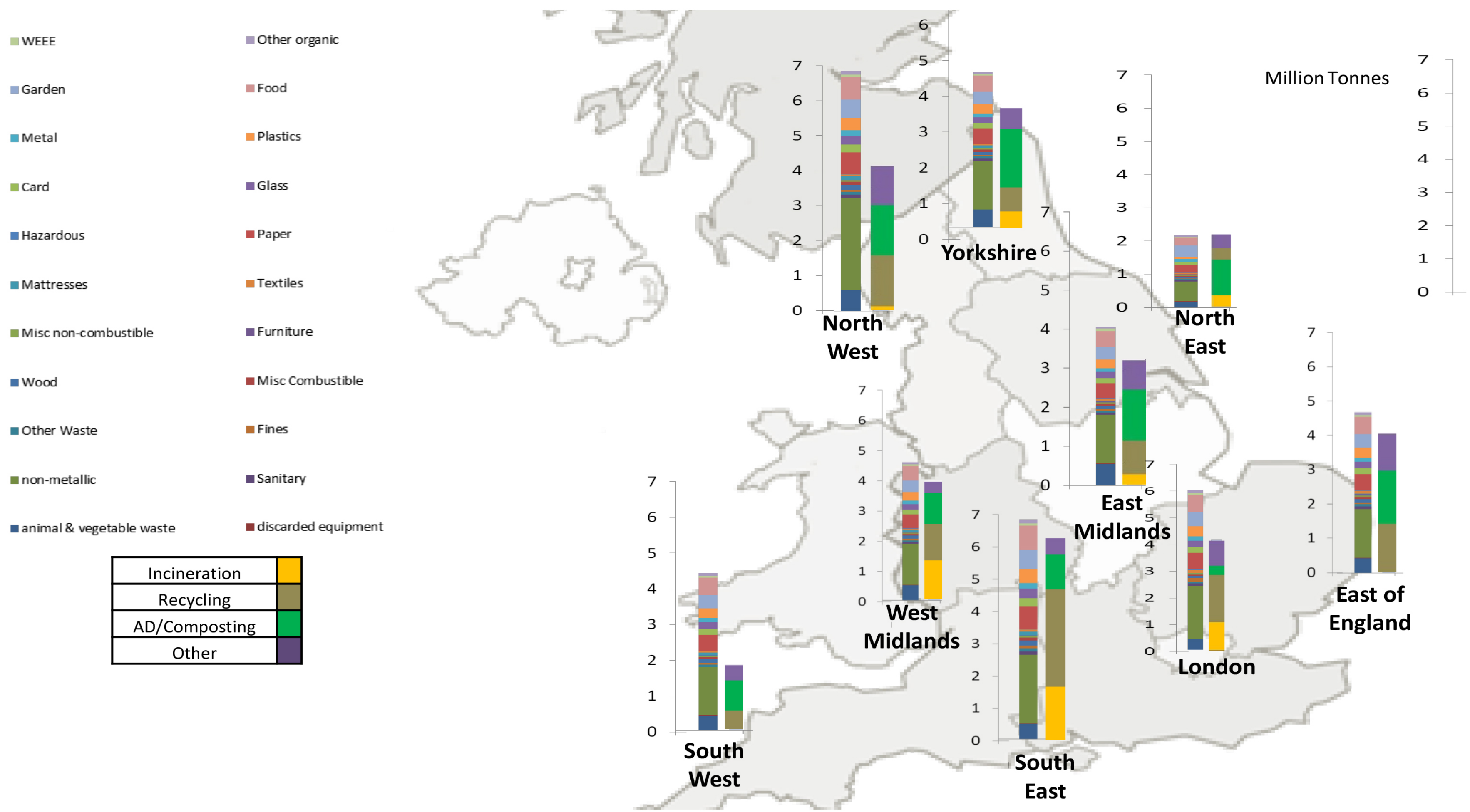

Figure 13: Map of England showing compositional waste arisings and available capacity per technology regionally (million tonnes)

East Midlands

The available capacity in this region is presented in table 16.

Table 16: Permitted treatment capacity in East Midlands

Permitted capacity	Tonnes
WEEE Treatment	507,500
MRF	724,994
Incineration	260,000
Composting	927,493
MBT	125,000
AD	165,000

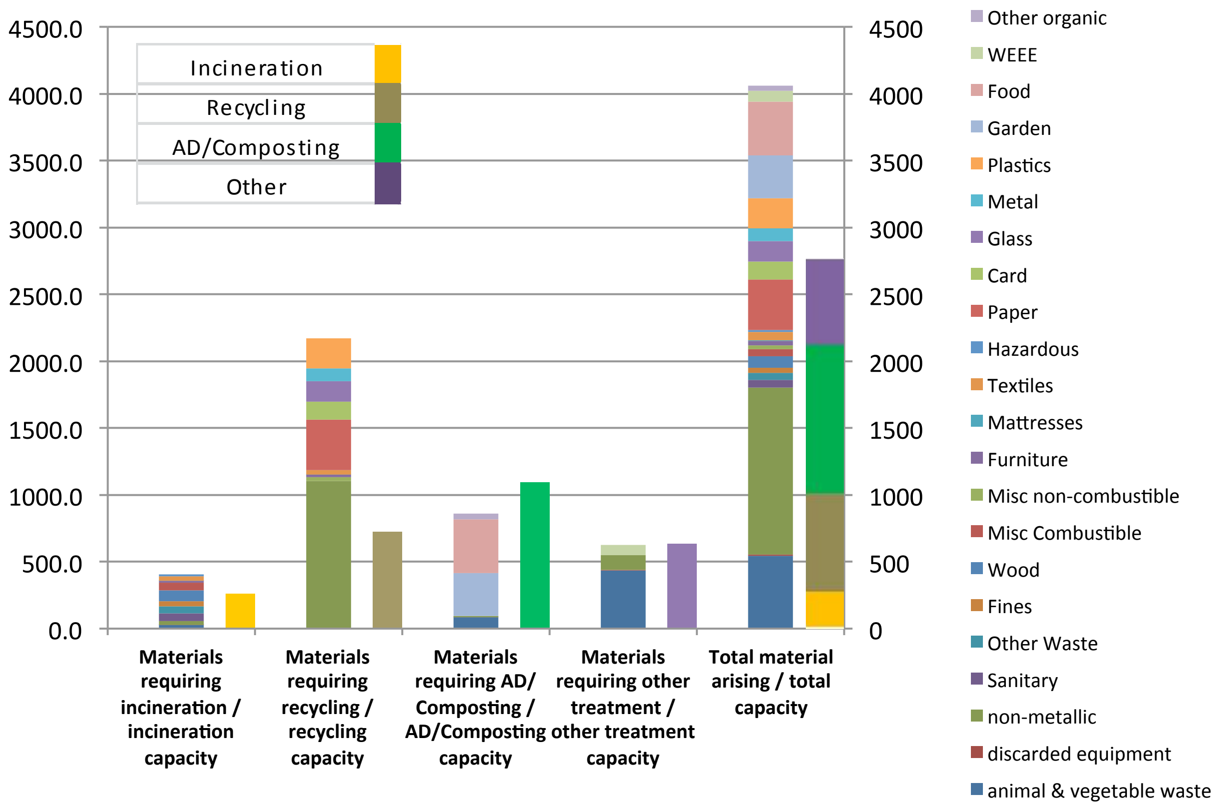

Figure 14: LACW arisings (compositional analysis) in relation to available capacity (per technology) in East Midlands

While distributing waste components to suitable treatment options, AD could only cover part of the requirement for the treatment of food waste, with the remaining amount as well as the other organics being diverted to composting in stage 2, reducing the available composting capacity from 608 to 330. The spare capacity for incineration after step 1 (38 thousand tonnes), was used to treat an equal amount of untreated materials requiring recycling after step 1 (table 17).

The LACMW landfilled is 36 thousand tonnes.

Table 17: Distribution of LACMW to permitted treatment capacity in East Midlands (thousand tonnes)

Technology	Available capacity	Available capacity after the treatment of LACMW waste (step 1)	Remaining waste (step 1)	Available capacity after the treatment of LACMW waste (step 2)	Remaining waste (step 2)
WEEE	507	457	0	457	0
MRF	725	0	345	0	307
AD	165	0	278	0	278
Incineration	385	38	0	0	0
Composting	927	608	0	330	0

The arisings and composition of the untreated materials are shown in figure 15. The actual composition will depend on how the LA chooses to prioritise its waste. As discussed previously in our examples household waste is given priority.

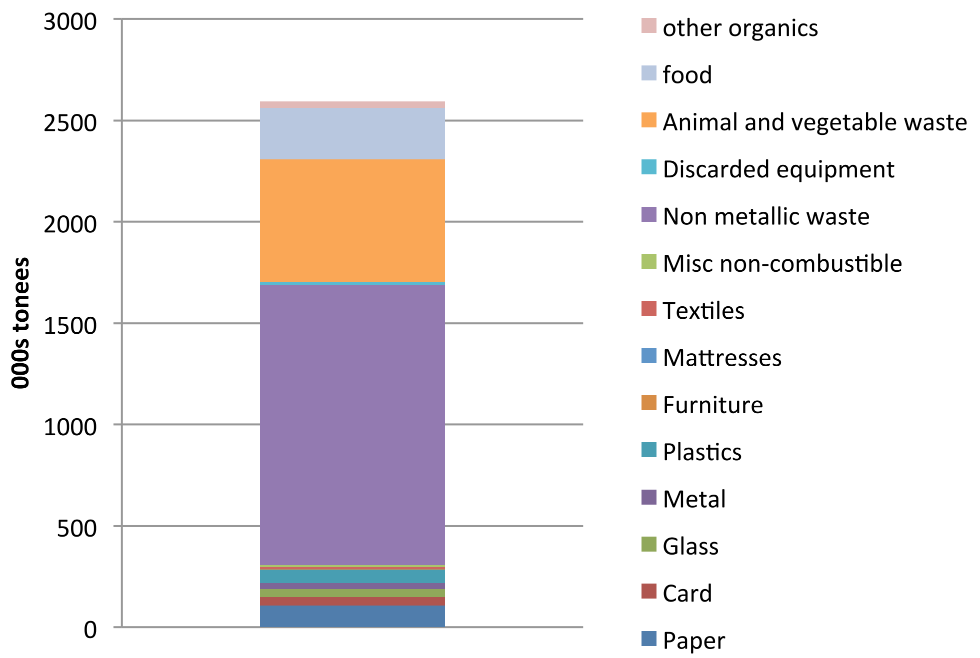

Figure 15: Breakdown of remaining LACW materials in East Midlands

East of England

The analysis was based on combining the information on arisings and waste composition as previously presented and the availability of treatment capacity, the main technologies of which are presented in table 18.

Table 18: Permitted treatment capacity in the East of England

Permitted capacity	Tonnes
WEEE Treatment	458,602
MRF	1,191,499
AD	82,000
MBT	415,000
Incineration	0
Composting	1,194,794

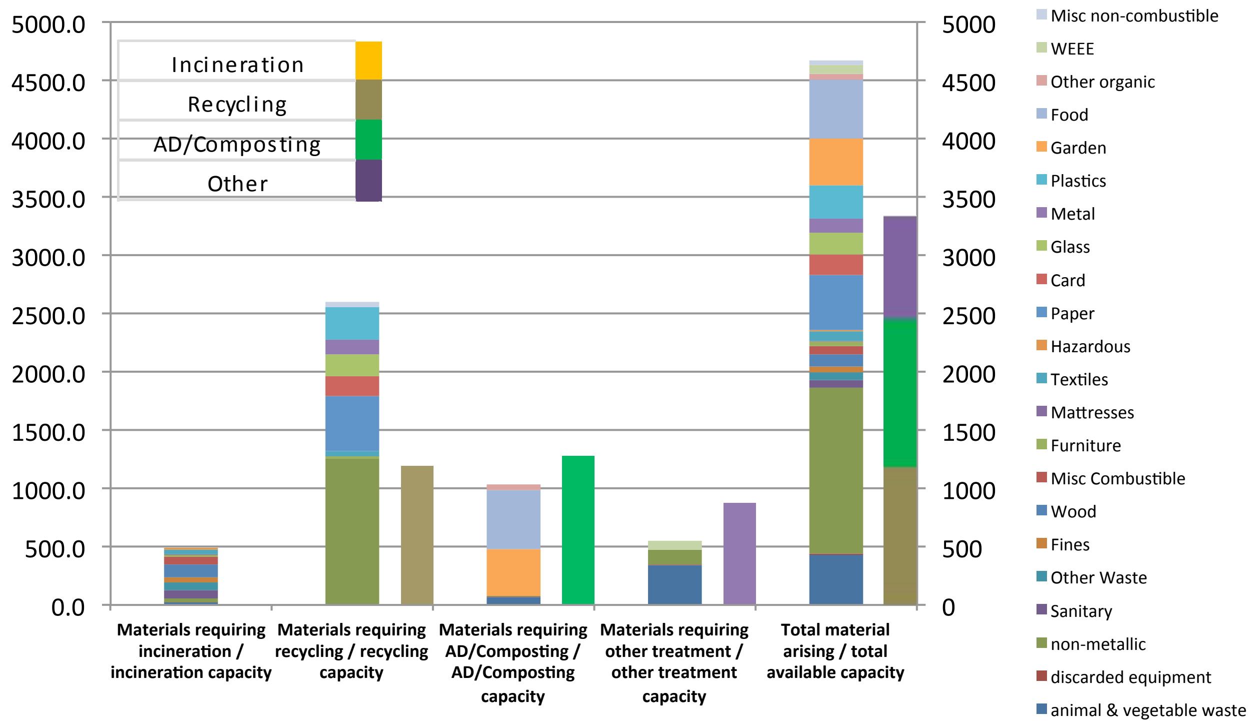

Figure 16: LACW arisings (compositional analysis) in relation to available capacity (per technology) in East of England

The steps that were undertaken to calculate the capacity gap using the arisings of the individual components and progressing through the stages of table 19, were:

- allocation of food waste to AD;
- allocation of garden waste, remaining food waste and organics to composting;
- use of the available MBT capacity for the treatment of materials that require residual treatment based on the proposed approach;

- calculation of the composition and arising of remaining household components requiring treatment (figure 17)

This demonstrates the following:

- MRF capacity was insufficient to treat all materials requiring recycling leaving 151 thousand tonnes untreated;
- there was an observed surplus in composting;
- the waste landfilled, which according to the calculations consists of soil and half of the miscellaneous non combustible materials, is 45 thousand tonnes.

Table 19: Distribution of LACMW to permitted treatment capacity in the East of England (thousand tonnes)

Technology	Available capacity	Available capacity after the treatment of LACMW (step 1)	Remaining waste (step 1)
AD	82	0	0
Composting	1,195	320	0
MRF	1,191	0	151
MBT	415	0	21
WEEE	459	396	0

The composition and arisings of the untreated materials is shown in figure 17.

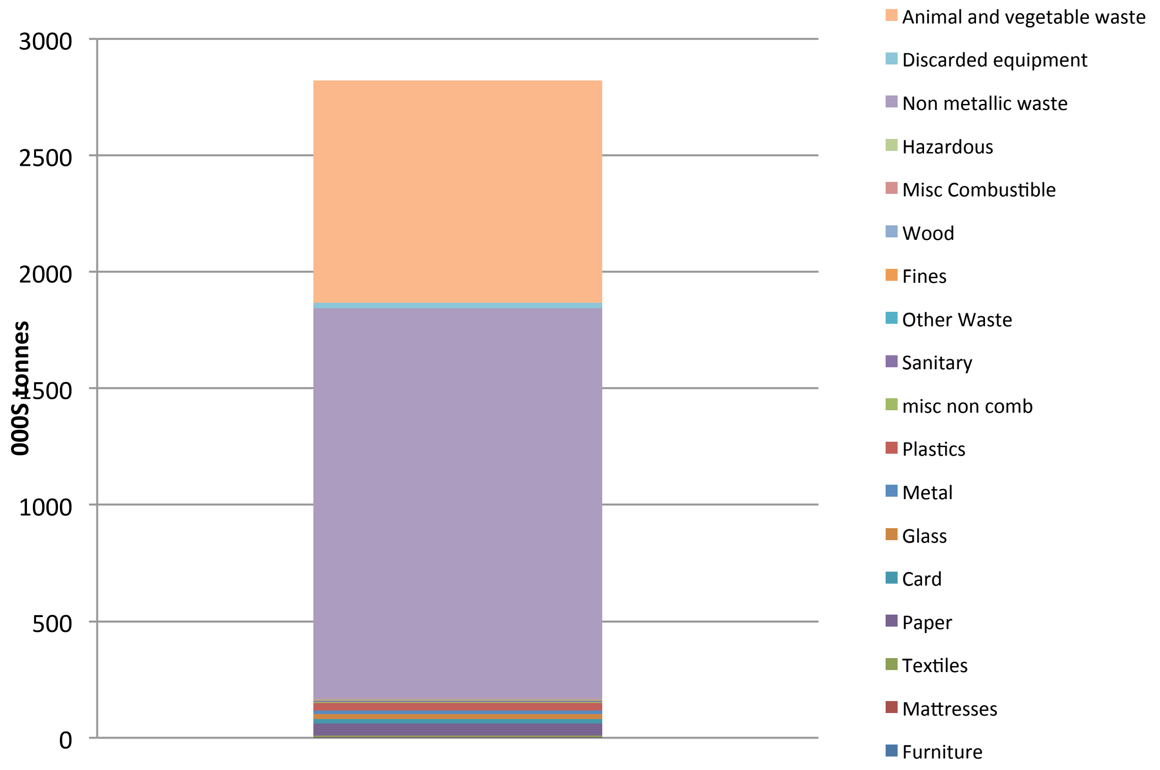

Figure 17: Breakdown of remaining LACW materials in the East of England

London

Results are shown in table 20.

Table 20: Permitted treatment capacity in London

Permitted capacity	Tonnes
WEEE Treatment	458,800
MRF	1,822,430
AD	0
MBT	562,000
Incineration	1,088,000
Composting	353,200

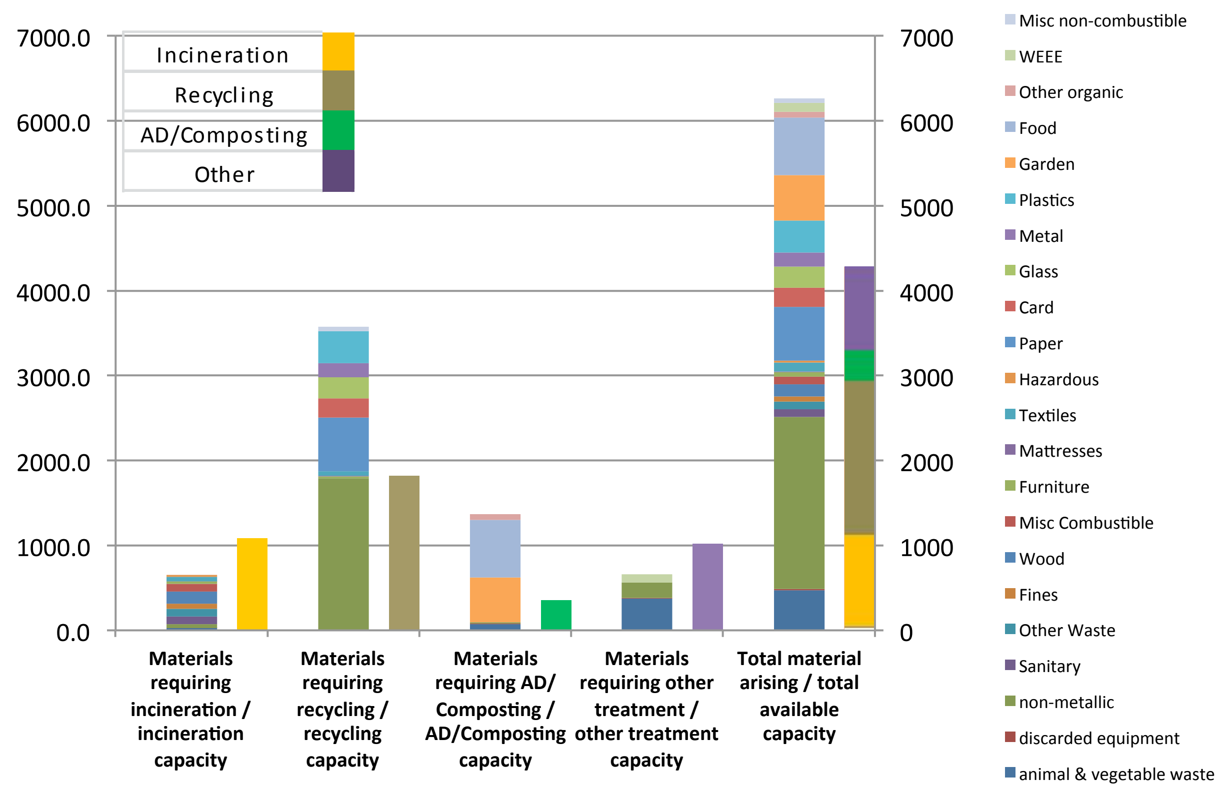

Figure 18: LACW arisings (compositional analysis) in relation to available capacity (per technology) in London

The next step was the distribution of LACMW waste to the available capacity (table 21). The first action was to attribute materials to the most suitable technologies. If recycling or composting/AD treatment capabilities were insufficient to treat their corresponding waste streams these were directed to incineration in the next step. This was done in order to make the greater possible use of existing facilities prior to creating a requirement for additional infrastructure. In this example, composting capacity was insufficient to treat all the organic household material that would ideally need to be handled by it, and the untreated material (181) along with food waste and other organics that have not been treated due to the absence of AD capacity were directed to incineration in step 2, reducing the availability of residual treatment capacity from 1069 thousand tonnes to 146 thousand tonnes.

The LACMW landfilled is 60 thousand tonnes.

Table 21: Distribution of LACMW to permitted treatment capacity in London (thousand tonnes)

Technology	Available capacity	Available capacity after LACMW treatment (step 1)	Remaining waste (step 1)	Available capacity after LACMW treatment (step 2)	Remaining waste (step 2)
MRF	1822	32	0	32	0
Incineration	1650	1069	0	146	0
Composting	353	0	181	0	0
WEEE	459	376	0	376	0

Figure 19 shows the breakdown of the remaining materials, which in this case consists only of materials originating from the LAC&I waste stream.

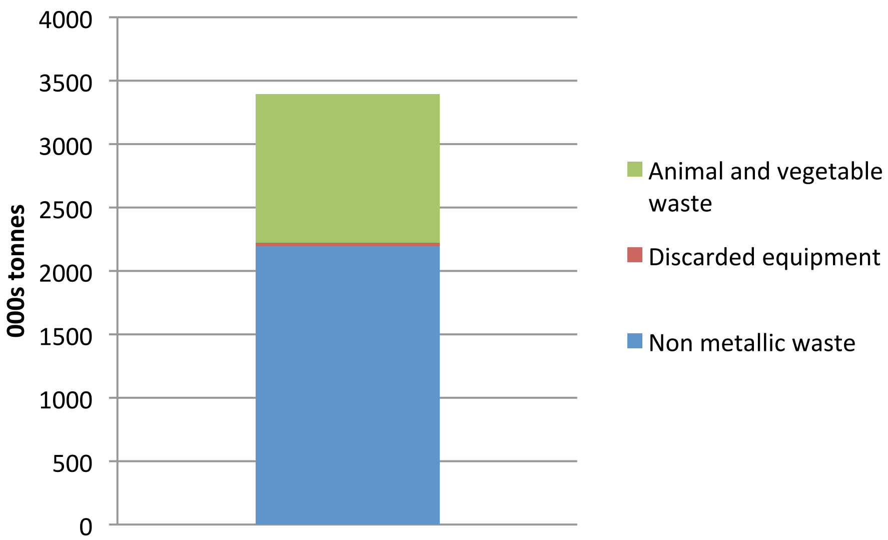

Figure 19: Breakdown of remaining LACW materials in London

North East

Table 22: Permitted treatment capacity in the North East

Permitted capacity	Tonnes
WEEE Treatment	93,000
MRF	1,100,000
AD	0
MBT	195,000
Incineration	375,000
Composting	161,997

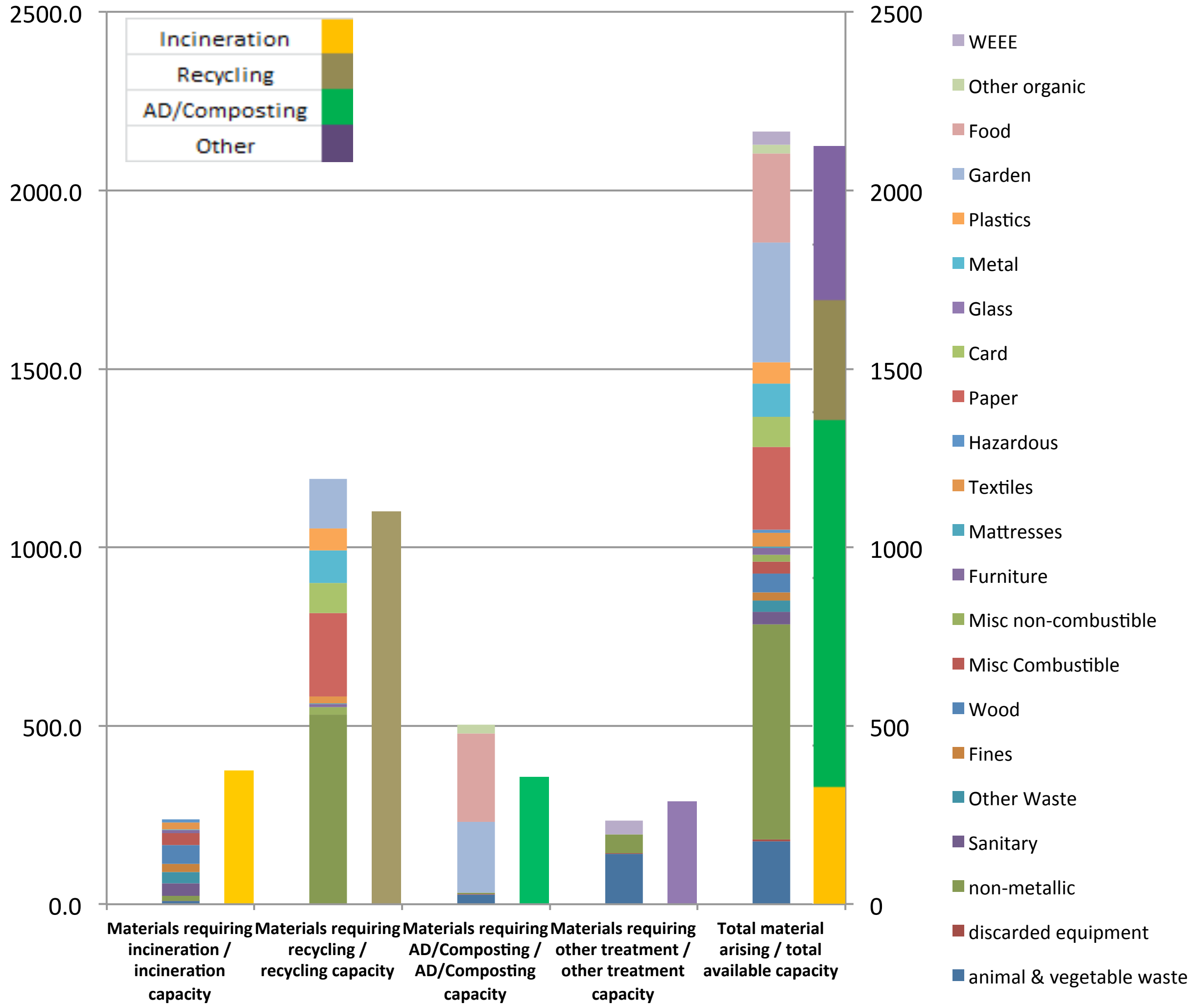

Figure 20: LACW arisings (compositional analysis) in relation to available capacity (per technology) in North East

Following the steps of the calculations, household waste was attributed to suitable facilities (table 23).

Table 23: Distribution of LACMW to permitted treatment capacity in the North East (thousand tonnes)

Technology	Available capacity	Available capacity after the treatment of LACMW waste (step 1)	Remaining waste (step 1)	Available capacity after the treatment of LACMW waste (step 2)	Remaining waste (step 2)
MRF	1100	441	0	441	0
Incineration	570	356	0	48	0
Composting	162	0	35	0	0
WEEE	93	62	0	62	0

As presented in table 23, there was spare capacity in all technologies except for composting. The requirement that cannot be met by composting, as well as food waste and other organics that were untreated due to the lack of AD were directed to residual treatment in step 2.

The LACMW landfilled was 22 thousand tonnes.

Figure 21 shows the breakdown of the remaining materials in the North East.

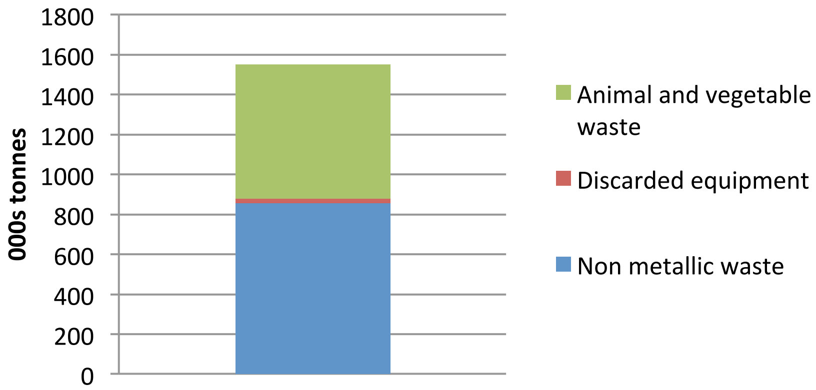

Figure 21: Breakdown of remaining LACW materials in the North East

North West

Table 24: Permitted treatment capacity in the North West

Permitted capacity	Tonnes
WEEE Treatment	409,999
MRF	1,240,497
MBT	540,650
Incineration	127,000
Composting	1,213,993

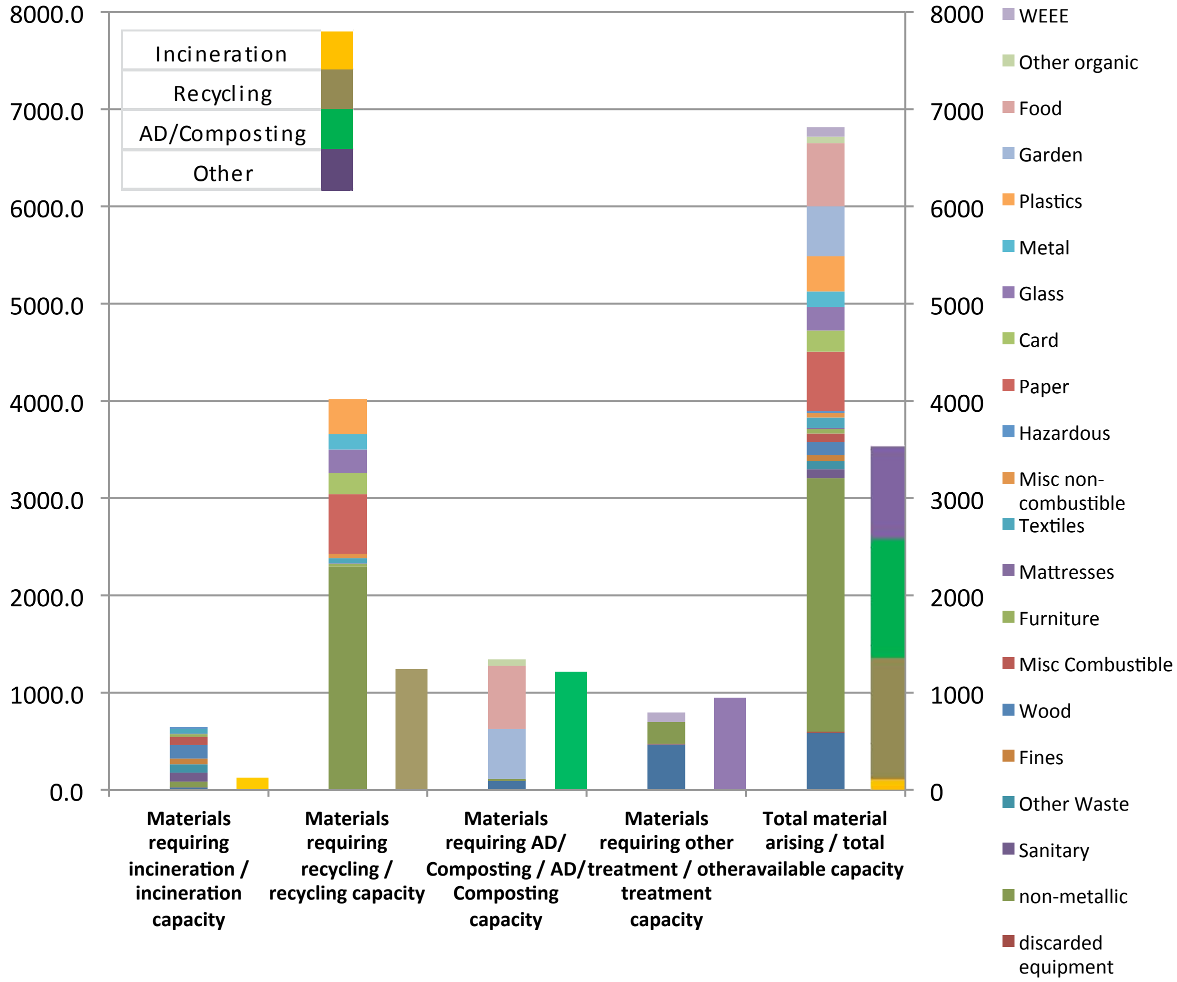

Figure 22: LACW arisings (compositional analysis) in relation to available capacity (per technology) in North West

After step 1, there was an observed shortfall in recycling capacity to meet the need of 484 thousand tonnes. Moreover, after green waste was allocated to composting, and given that there was a considerable amount of spare capacity, food and other organics were further allocated to it, leaving only 14 thousand tonnes of untreated waste. The remaining capacity of residual treatment after step 1 (109 thousand tonnes) was used to cover part of the unmet demand for treatment from recycling and AD.

The LACMW landfilled is 58 thousand tonnes.

Table 25: Distribution of LACMW to permitted treatment capacity in the North West (thousand tonnes)

Technology	Available capacity	Available capacity after the treatment of LACMW waste (step 1)	Remaining waste (step 1)	Available capacity after the treatment of LACMW waste (step 2)	Remaining waste (step 2)
MRF	1240	0	484	0	0
Incineration	668	109	0	0	0
Composting	1214	0	14	0	0
WEEE	410	330	0	62	0

The arisings and composition of available materials can be seen in figure 23.

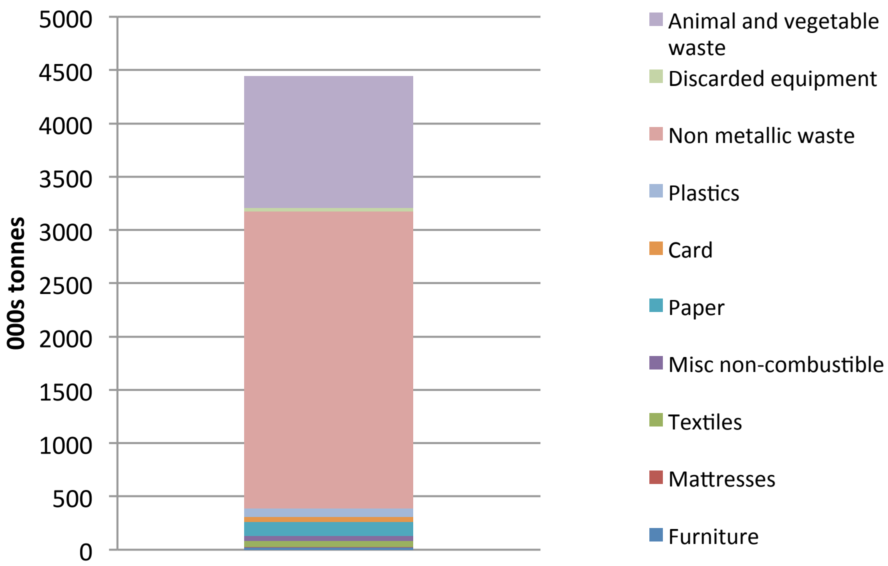

Figure 23: Breakdown of remaining LACW materials in the North West

South East

Table 26: Permitted treatment capacity in the South East

Permitted capacity	Tonnes
WEEE Treatment	246,986
MRF	2,448,521
MBT	200,000
Incineration	1,468,000
Composting	760,876
AD	120,000

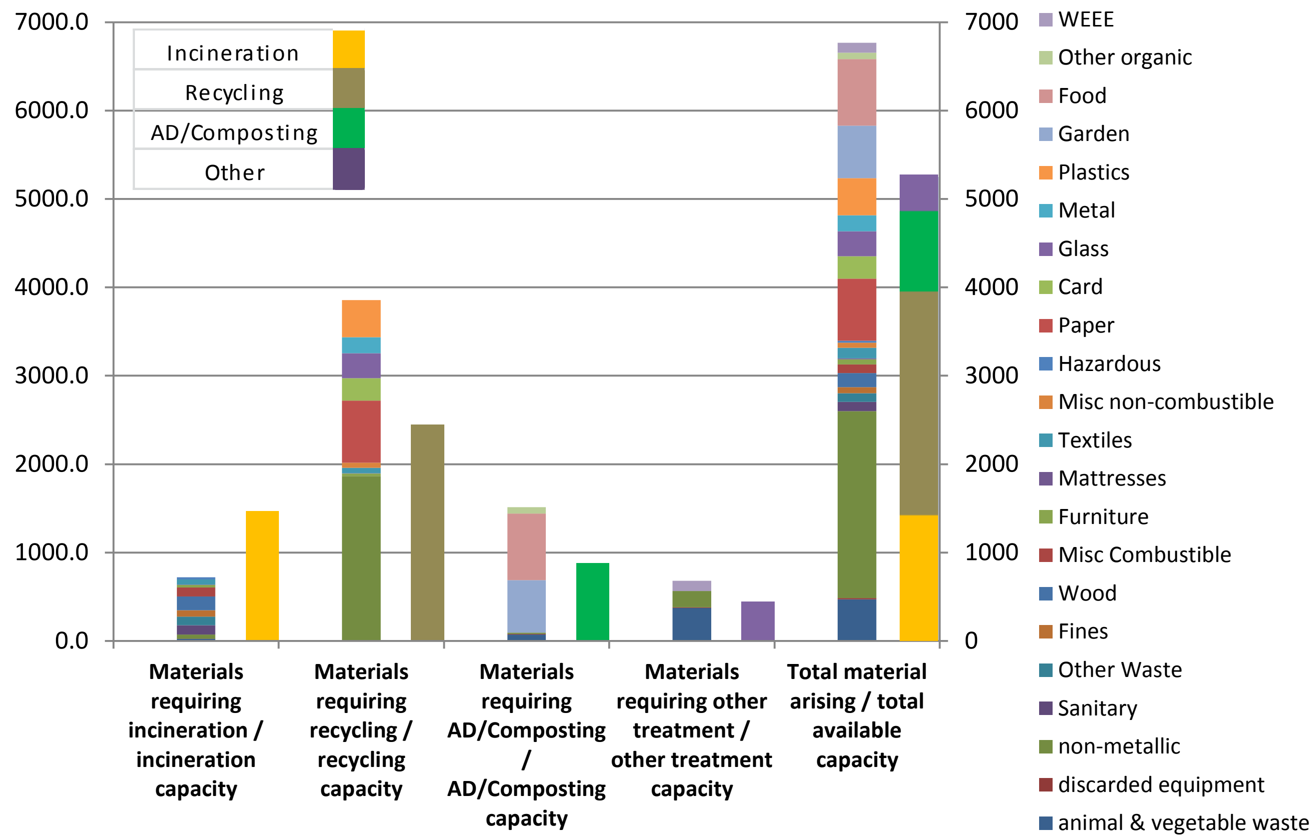

Figure 24: LACW arisings (compositional analysis) in relation to available capacity (per technology) in South East

In the first step green waste was first allocated to composting and given the fact that there was spare capacity (167 thousand tonnes), it was used to treat food and other organics for which there was insufficient AD capacity. This reduced the amount of untreated food and other organics from 705 to 538 thousand tonnes, which was treated in the spare residual capacity in step 2. No material was left untreated.

The LACMW landfilled is 67 thousand tonnes

Table 27: Distribution of LACMW to permitted treatment capacity in the South East (thousand tonnes)

Technology	Available capacity	Available capacity after the treatment of LACMW waste (step 1)	Remaining waste (step 1)	Available capacity after the treatment of LACMW waste (step 2)	Remaining waste (step 2)
WEEE	247	155	0	155	0
MRF	2449	457	0	457	0
AD	1668	0	538	0	0
Incineration	761	1022	0	484	0
Composting	120	0	0	0	0

The arisings and composition of available materials can be seen in figure 25.

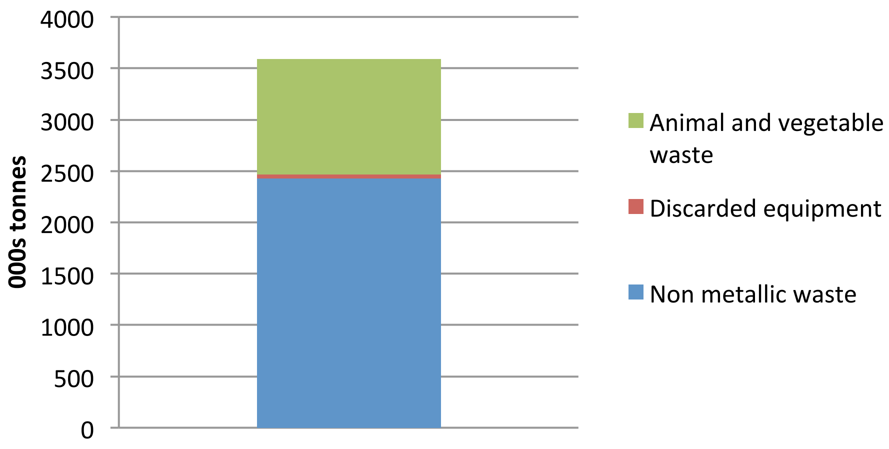

Figure 25: Breakdown of remaining LACW materials in the South East

South West

The permitted capacity per technology for this region is presented in table 28.

Table 28: Permitted treatment capacity in the South West

Permitted capacity	Tonnes
WEEE Treatment	212,450
MRF	440,198
MBT	150,000
Incineration	3,500
Composting	552,995
AD	170,000

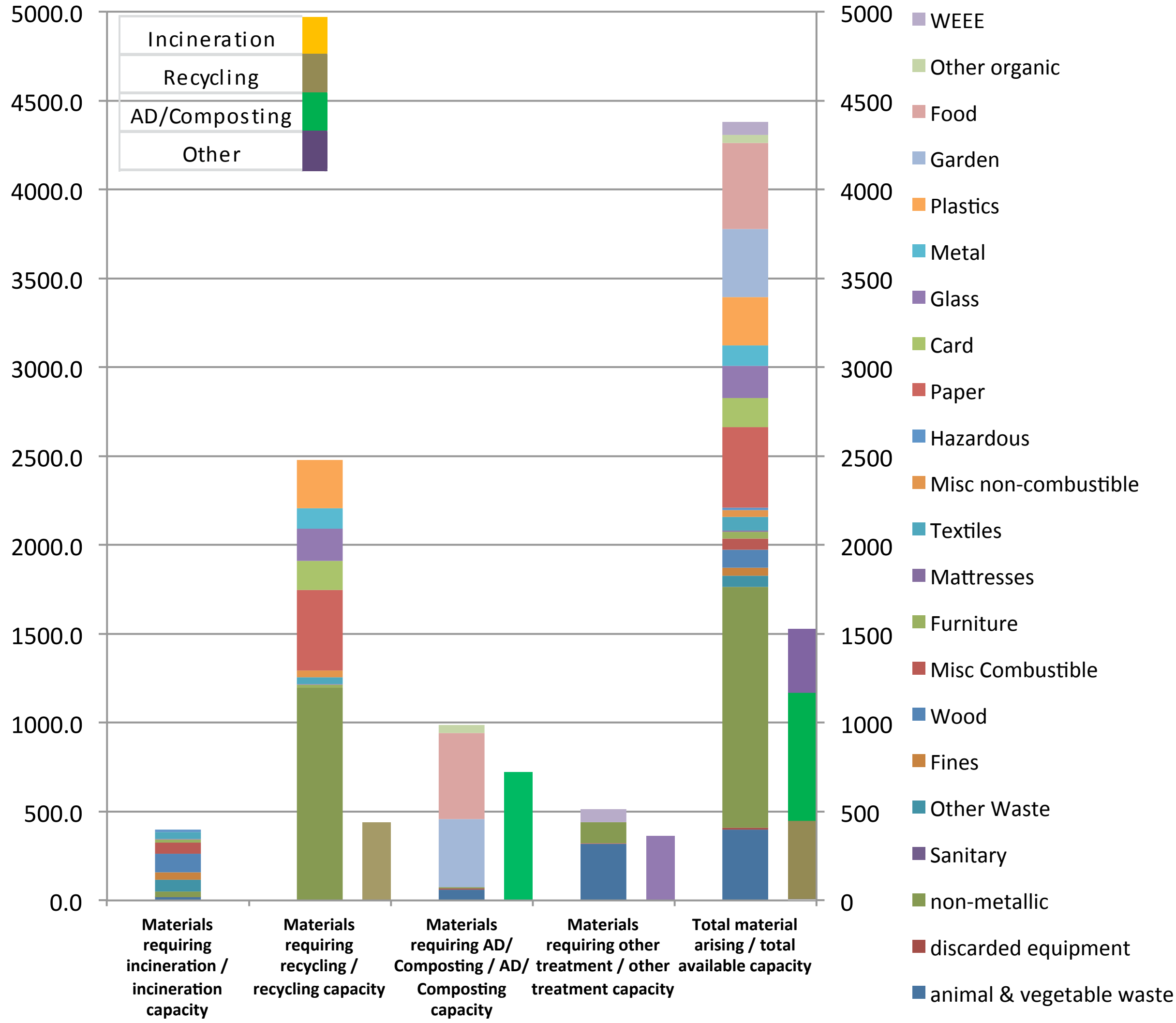

Figure 26: LACW arisings (compositional analysis) in relation to available capacity (per technology) in South West

In the process of distributing materials to suitable technologies, the following can be observed:

- there was a shortfall of MRF capacity, leaving untreated 842 thousand tonnes of recyclables, and other materials that required recycling;
- the treatment shortfall for AD was 361 thousand tonnes (for food waste and other organics), but as part of this waste was further directed to composting for which there was surplus capacity, the final remaining untreated amount of these two materials was 190 thousand tonnes.
- LACMW landfilled was 43 thousand tonnes.

Table 29: Distribution of LACMW to permitted treatment capacity in the South West (thousand tonnes)

Technology	Available capacity	Available capacity after the treatment of LACMW waste (step 1)	Remaining waste (step 1)
WEEE	212	153	0
MRF	440	0	842
AD	170	0	190
Incineration	154	0	262
Composting	553	0	0

The arisings and composition of available materials can be seen in figure 27.

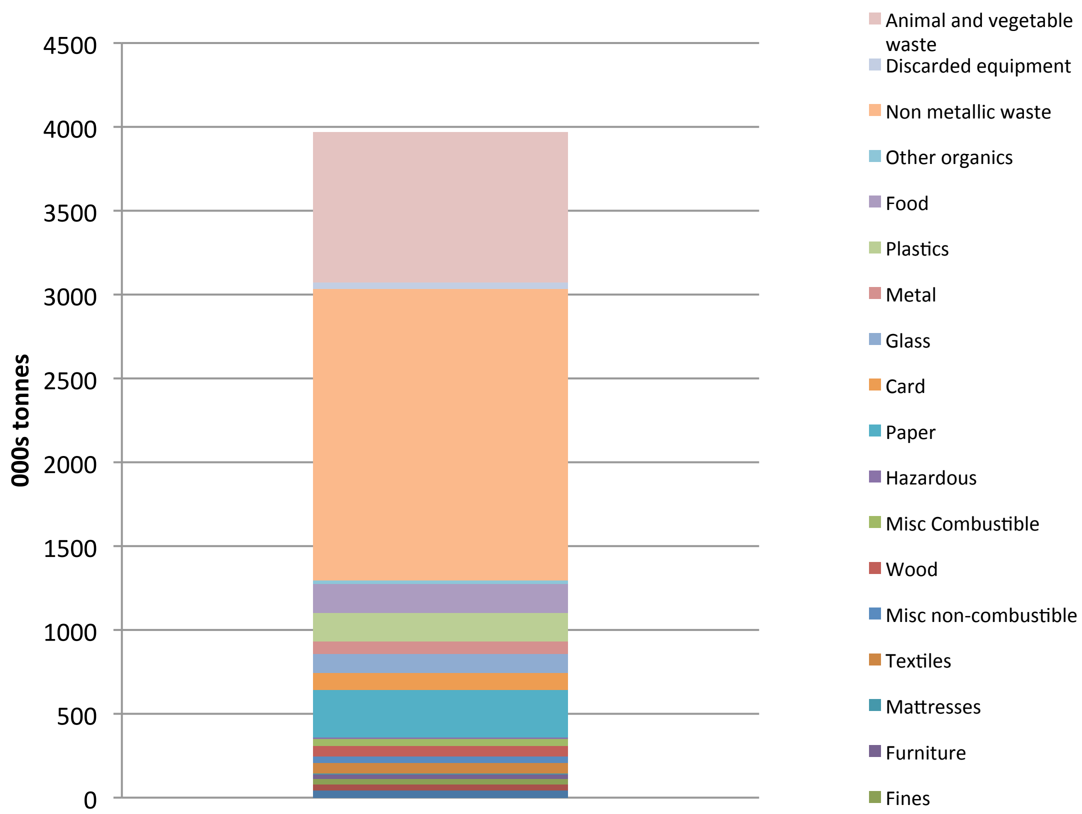

Figure 27: Breakdown of remaining LACW materials in the South West

West Midlands

The permitted capacity in this region is demonstrated in table 30.

Table 30: Permitted treatment capacity in West Midlands

Permitted capacity	Tonnes
WEEE Treatment	307,997
MRF	1,029,000
Incineration	1,140,000
Composting	871,498
AD	5,000

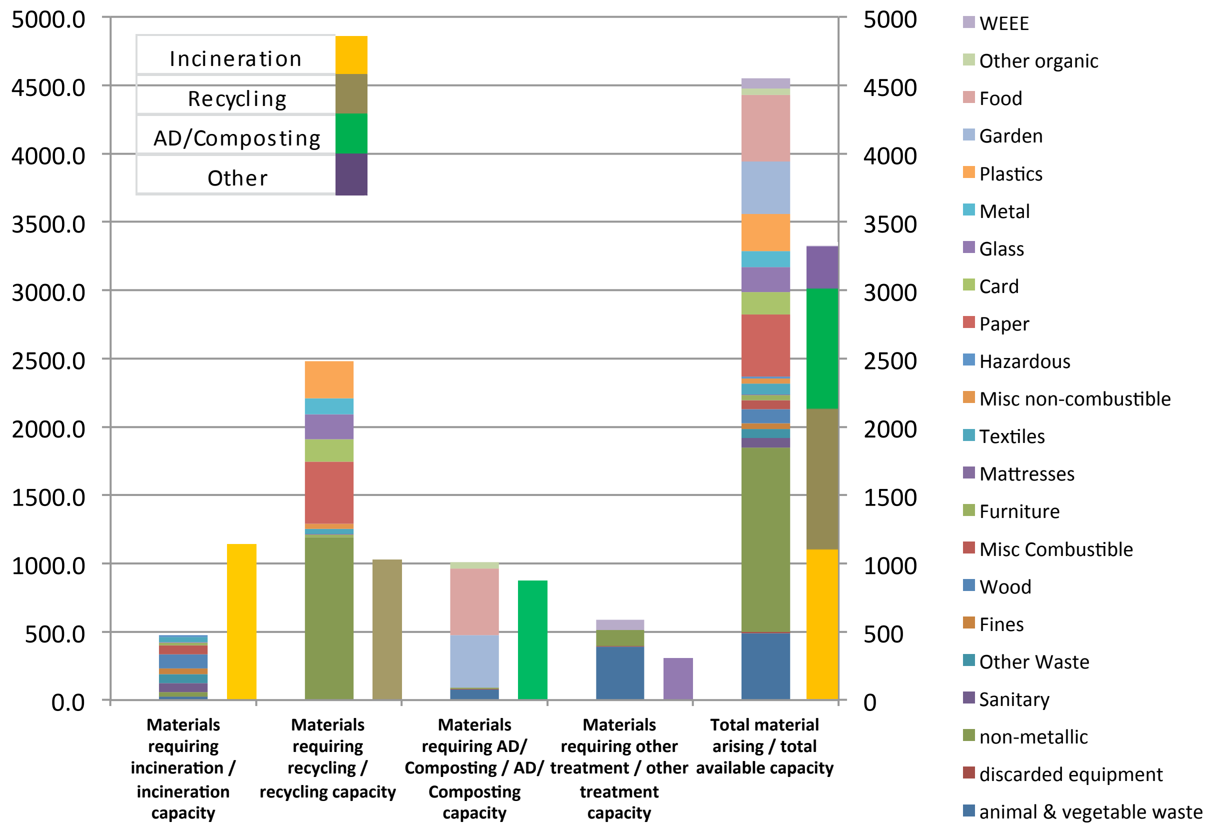

Figure 28: LACW arisings (compositional analysis) in relation to available capacity (per technology) in West Midlands

As can be seen in table 31, residual treatment was available for the materials requiring recycling that could not be treated by the available MRF capacity (261 thousand tonnes of recyclables), as well as food and other organics that could not be treated by either composting or AD.

LACMW landfilled was 43 thousand tonnes.

Table 31: Distribution of LACMW to permitted treatment capacity in the West Midlands (thousand tonnes)

Technology	Available capacity	Available capacity after the treatment of LACMW waste (step 1)	Remaining waste (step 1)	Available capacity after the treatment of LACMW waste (step 2)	Remaining waste (step 2)
WEEE	308	248	0	248	**0**
MRF	1029	0	261	0	**0**
AD	5	0	43	0	**0**
Incineration	1140	721	0	417	**0**
Composting	871	0	0	0	**0**

The arisings and composition of available materials can be seen in figure 29.

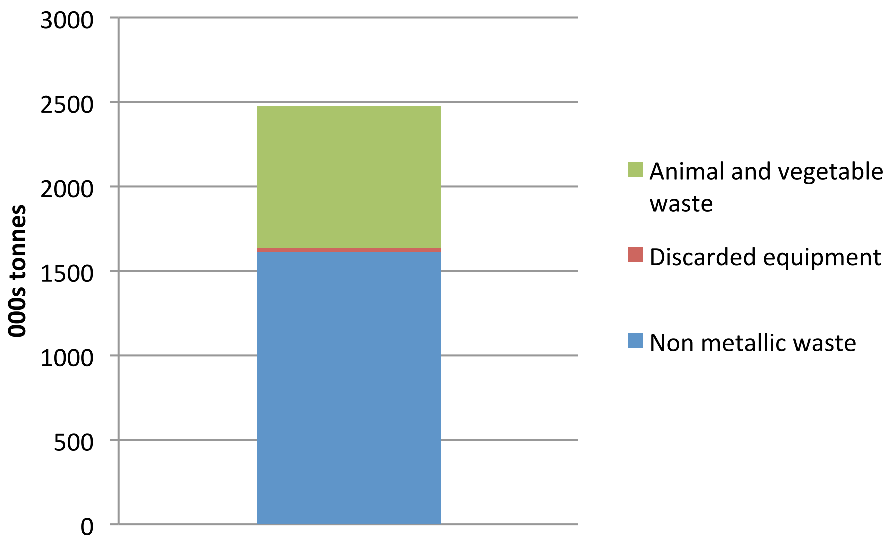

Figure 29: Breakdown of remaining LACW materials in the West Midlands

Yorkshire and Humber

Table 32: Permitted treatment capacity in Yorkshire and Humber

Permitted capacity	Tonnes
WEEE Treatment	344,997
MRF	555,248
Incineration	431,000
Composting	779,994
MBT	165,000

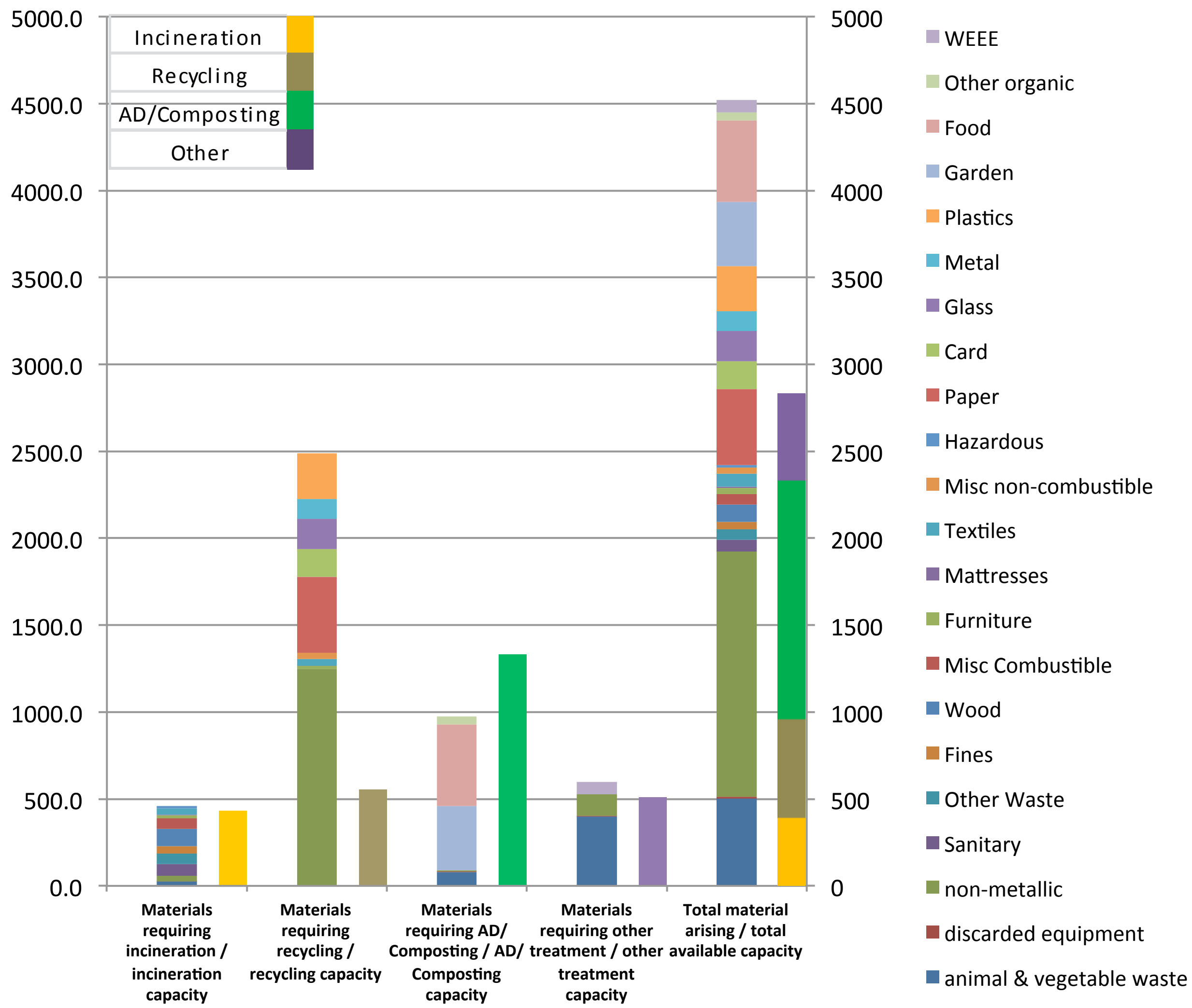

Figure 30: LACW arisings (compositional analysis) in relation to available capacity (per technology) in Yorkshire and Humber

As shown in table 33, there was a shortfall of MRF capacity (684 thousand tonnes) and composting capacity (103 thousand tonnes). The remaining residual treatment capacity (194 thousand tonnes) was used to treat part of the materials that could not be handled in the MRF or composting facilities, therefore the untreated materials at the end amount to 593 thousand tonnes.

The LACMW landfilled was 42 thousand tonnes.

Table 33: Distribution of LACMW to permitted treatment capacity in Yorkshire and Humber (thousand tonnes)

Technology	Available capacity	Available capacity after the treatment of LACMW waste (step 1)	Remaining waste (step 1)	Available capacity after the treatment of LACMW waste (step 2)	Remaining waste (step 2)
WEEE	345	288	0	288	0
MRF	555	0	684	0	515
Incineration	596	194	0	0	0
Composting	780	0	103	0	78

The arisings and composition of available materials can be seen in figure 31.

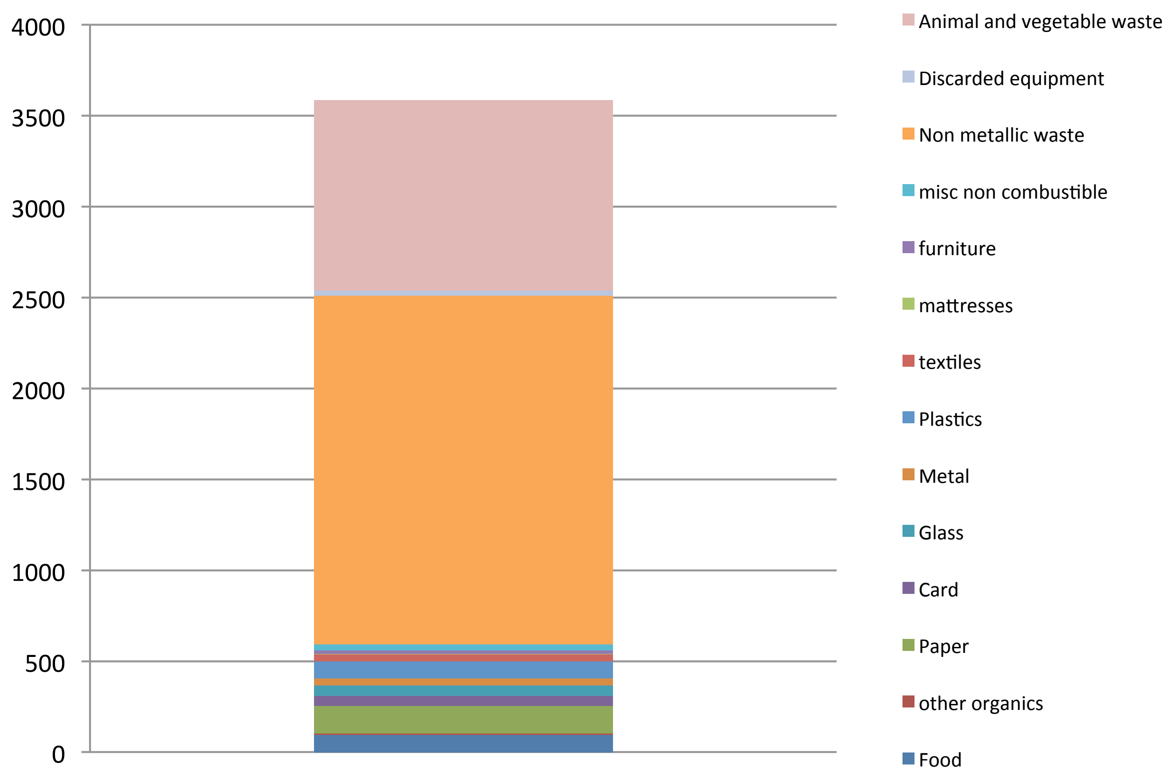

Figure 31: Breakdown of remaining LACW materials in Yorkshire and Humber

3.5 Sensitivity analysis and forecasting potential

The analysis was performed for 2010. In order to investigate the accuracy of the data collated (available infrastructure and waste arisings) sensitivity analysis was performed. This was done both by comparing the waste arisings in 2009/10 (which is the year of reference) with those in 2012 and also by comparing the EA waste infrastructure data for 2010 with the 2012 EA Waste Interrogator Database. The latter did not provide information about incineration capacity and this was therefore sourced from the EA (2012). The differences between these two years were quantified and evaluated.

In terms of waste arisings, these were 25.3 million tonnes of LACMW in 2012 as opposed to 26.228 million tonnes in the reference year, showing that this parameter of the analysis only changed slightly.

It has been identified that in 2012 a total of 167 additional permits were issued (in the categories of AD, composting, MBT, MRF and incineration) the breakdown of which is presented in table 34. Their corresponding operational capacity in 2012 per technology and per region is shown in table 35. In addition to the data presented for 2012 more up to date information on incineration suggested that one additional facility operated in 2013 and also three more are expected to come into operation in 2014. The combined permitted capacity of these four facilities is 1,665 thousand tonnes (Defra, 2013a).

Table 34: Number of permits for main treatment technologies operating in 2012 but not in 2010

	East of England	London	East Midlands	South East	South West	North East	North West	West Midlands	Yorkshire and the Humber
AD	0	0	1	0	1	5	0	1	0
Composting	3	2	8	6	33	0	7	5	10
MBT	0	1	0	1	0	0	0	0	0
MRF	5	3	5	5	11	4	9	5	5
Incineration	0	1	0	2	0	0	0	0	0

Table 35: Capacity per technology from 2010 to 2012 per region (tonnes)

	East of England	London	East Midlands	South East	South West	North East	North West	West Midlands	Yorkshire and the Humber	Total
MRF	68,066	102,496	164,192	127,471	150,294	17,130	308,156	108,750	174,162	**1,220,717**
AD			618		5,476			10,464		**16,558**
MBT		196,963		149						**197,112**
Incineration		700,000		280,000						**980,000**
Composting	20,368	101,293	67,289	95,719	178,794	47,892	117,103	25,870	62,969	**717,297**
Total	88,434	1,100,753	232,099	503,339	334,564	65,022	425,259	145,084	237,13	**3,131,685**

Despite the fact there appeared to be a large number of additional facilities in 2012, it was observed that the waste processed by the facilities was highly variable, with many facilities having processed a very small amount of waste (<500 tonnes). This suggested that the number of new permits was not a reliable metric of change over time, and it was further investigated.

The additional total capacity as displayed in table 36 was compared with the 2010 capacity that was included in the analysis for the technologies of AD, Composting, MBT, MRF and incineration to see how significant the difference was. For these technologies the 2010 capacity was 25,709 thousand tonnes with the 2012 additional capacity (3,131 thousand tonnes) representing an increase of about 12.1%. This is not a large increase over the two year period suggesting that the findings were equally applicable in 2012. Some caution was however required when evaluating this figure as the additional 2012 data capacity represented the waste that was actually received by the facilities in that year (incineration is an exception for which permitted capacity was used instead), whereas the 2010 data are the permitted capacity and, likely to be higher than the operational one.

The percentage increase in capacity per type of facility and per region was also calculated to provide an indication of the relative differences among regions and technologies. The results are presented in table 36. It is worth noting that the North East and the East of England have the lowest increases in infrastructure within the country; and that there was no increase in incineration availability apart from London.

Table 36: Percentage increase of capacity per technology from 2010 to 2012 per region

	East of England	London	East Midlands	South East	South West	North East	North West	West Midlands	Yorkshire and the Humber	Total
MRF	5.7	5.6	22.6	5.2	34.1	1.5	24.8	10.6	31.4	11.6
AD	0.0	0.0	0.4	0.0	2.9	0.0	0.0	200.0	0.0	1.6
MBT	0.0	35.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	8.4
Incineration	0.0	64.3	0.0	19.1	0.0	0.0	0.0	0.0	0.0	20.0
Composting	1.7	28.6	7.2	12.6	32.4	29.6	9.6	3.0	8.1	10.5
Regional Total	4.0	38.2	6.1	10.1	25.4	3.5	13.6	4.8	9.5	12.2

4. Summary of results

The aim of the work was to evaluate how sensitive the Defra findings were to the assumptions made in Defra's 2020 Forecasting Report and if their approach might restrict the wider application to support decision making. **The methodological approach is critical as the potential of the findings to support decision making will depend on the validity of the assumptions** and the calculations used.

The methodological approach used in this report to address the limitations of Defra's 2020 Forecasting Report offers many advantages. First and foremost this study focuses on regional analysis to determine appropriate infrastructure needs and estimates arisings of waste materials and their treatment needs. Therefore it helps empower local authorities to make best use of existing infrastructure and determine demand for additional infrastructure.

Findings demonstrated that using quantities of materials arising at a regional level was more realistic, using compositional data for household and specific waste-streams for Commercial and Industrial sources. A more robust approach for forecasting total quantities of material arising and the consequent demand for facilities was proposed that addressed the main limitations of adding different tonnages. A more appropriate method for calculating treatment capacity requirements for each region was proposed. This way, more informed assumptions about how inputs are prioritised to different facilities can be made (e.g. sorted recyclables go to MRFs, residual material goes to ERFs), so that by subtracting the relevant existing treatment capacity from calculated regional requirements, the composition of the waste remaining untreated and subsequent future infrastructure needs could be more reliably estimated.

It is important to remember that the provision of treatment plants (location, type and scale) required to address these needs is determined by a combination of factors e.g. the characteristics of the area: spatial density of waste arising, composition of the waste, the presence of manufacturing industries in the area that could recover recyclates and generally the presence of other end users for the outputs of the processes (e.g. energy), and the arisings of different waste streams that could be merged in single treatment. There is need for integrated planning of household, commercial, business and (where relevant) agricultural wastes. Equally importantly, waste management needs to be integrated with energy strategies in order to maximise the regional benefits that can be delivered from waste management facilities. This approach can provide economic benefits particularly where waste streams that require treatment are mixed and options for further segregation/recycling are costly and/orlikely to perform poorly. Moreover, it will be possible for these facilities to contribute to crucial and legally binding renewable energy generation targets.

In Defra's 2020 Forecasting Report, the national aggregated figures do not reflect true needs. The assumptions made almost imply that waste can be transferred over whatever distance and to any facility in the country regardless of location, practical constraints and sustainability implications.

5. Overall discussion and conclusion

The EC Landfill Directive (99/31/EC) is seeking to avoid waste generation and to use waste as a resource, and should help move the EU closer to a "recycling society". In particular, the Sixth Community Environment Action Programme calls for measures aimed at ensuring the source separation, collection and recycling of priority waste streams. In line with that objective and as a means to facilitating or improving its recovery potential, waste should be separately collected if technically, environmentally and economically practicable, before undergoing recovery operations that deliver the best overall environmental outcome.

Member States are asked to support the use of recyclates, such as recovered paper, in line with the waste hierarchy and with the aim of a recycling society, and whenever possible should not support the landfilling or incineration of such recyclates. In order to implement the precautionary principle and the principle of preventive action enshrined in Article 174(2) of the Treaty, it is necessary to set general environmental objectives for the management of waste within the Community. By virtue of those principles, it is for the Community and the Member States to establish a framework to prevent, reduce and, as far as possible, eliminate from the outset the sources of pollution or nuisance by adopting measures whereby recognised risks are eliminated. It is necessary, in order to enable the Community as a whole to become self-sufficient in waste disposal and in the recovery of mixed municipal waste collected from private households and to enable the Member States to move towards that aim individually, to make provision for a network of cooperation regarding disposal installations and installations for the recovery of mixed municipal waste collected from private households, taking into account geographical circumstances and the need for specialised installations for certain types of waste. Effective schemes need the flexibility to design, adapt and operate systems in ways which best meet current social, economic and environmental conditions. These are likely to change over time and vary by geography. The need for consistency in quality and quantity of recycled materials, compost or energy, the need to support a range of disposal options and the benefit of economies of scale, all suggest that integrated waste management should be organized on a large-scale, regional basis. Any scheme incorporating recycling, composting or waste-to-energy technologies must be market-orientated. There must be markets for products and energy. There is also a strong argument for national coordination if national targets are to be met.

Ongoing discussion as to whether there will be sufficient waste treatment capacity in the UK in 2020 was the driver for this work, which aimed to evaluate infrastructure needs for resource management in the future. It is therefore worth restating that this is not about taking a position as to who is right or wrong in these discussions, in other words, this is not a question of underestimating or overestimating treatment capacity but of understanding infrastructure needs in the future. It is important to understand such needs before strategies change following any quantification (prediction) that takes place. In that respect the framing of the whole discussion is possibly rather misleading, as it seems that its main question has focused simply on whether there will be theoretical overcapacity or undercapacity of residual waste treatment in the future rather than first understanding what the needs are now. Providing infrastructure for resource management is a much more complex issue.

Limited and poor information on waste generation provides an incomplete and scattered picture of waste arisings, and conflicting data on treatment capacity make it difficult to make reliable estimates of infrastructure needs. Taking into account the uncertainty associated with forecasting, any attempt to base policy making and investment decisions on such 'predictions' seems futile. The resulting uncertainty can have widespread consequences on market stability and business engagement, critical conditions not just for any forecasts of overcapacity to realise but for that capacity to be put in place in the first place.

Forecasting how much waste will be generated in the future is a process that involves estimating future behaviour of individuals and businesses and the markets within which they operate, all influenced by a range of policy and fiscal drivers both locally, nationally and internationally. With producer responsibility initiatives for packaging having recently been extended to other products, e.g. batteries, electrical goods and electronic equipment and vehicles; waste prevention initiatives (e.g. light-weighting of packaging within industry and commerce) and national and local campaigns to encourage the public to use, food and resources more efficiently and reduce the waste they generate; possible effects of end-markets for recycled materials; and increased collections and services for recycling and composting, forecasting waste generation reliably seems a real challenge. This was demonstrated only recently by the potential difference of 33.6 million tonnes, between the 52.8 million tonnes of waste that required thermal, organic or sorting treatment reported by Ricardo-AEA for the CIWM, reduced in the future as a result of new waste treatment facilities coming online resulting to a 15.3 million tonnes of capacity gap in 2020, comparing it to the 12 million tonnes of excess capacity by 2020 that the UK would potentially have, as forecasted by Defra.

In order to establish needs for the future it is necessary to understand the position now, as it is the difference between the current state in terms of infrastructure and what is required in the future that will determine the 'need'. The first step is to gain an understanding of how much waste requires management, and where it comes from. An understanding of the materials that make up this waste stream allows a more detailed analysis of the types of facilities that are required. This is the need for the right infrastructure to treat the right type of resources (out of your MSW) and in the right geographical context not just to meet regulatory drivers but to provide society with a net benefit in terms of environmental, economic and social considerations.

In this sense, municipal waste (or any subsequent residual wastes) should not be seen as a homogeneous mass but a combination of resources. MSW composition and collection practices are critical to the selection of treatment required and the spatial distribution of available treatment facilities is an important factor in identifying infrastructure needs. This is even more critical in the case of residual waste, as both its arisings and need for treatment depend on the parameters above.

The variation between local authority collections, market uncertainties with regards to resources recovery, and even regulatory changes with regards to definitions[6] increase the uncertainty of stochastic methods of calculating or predicting future infrastructure needs. Any benefits from doing this are shadowed by the potential costs attached to the resulting underestimation or overestimation of those needs.

[6] The Commission recently considered views on issues such as whether to have a single target and calculation method based only on the quantity of municipal waste collected, which would mean that there would also need to be a consistent definition of 'municipal waste'; should targets reflect environmental weightings for materials (for example, through reference to greenhouse gas savings achieved through recycling)? ; should recycling targets be extended to include additional waste streams such as wood, food waste and textiles?; should businesses be required to sort a range of waste materials for recycling and composting/anaerobic digestion?

Findings of this study indicate that regional variations and variations in technology selection may undermine the reliability of some previous predictions of waste treatment capacity. Results demonstrate a high probability of not having enough or not having enough of the right capacity where this is needed (per region). This analysis, taking waste composition into account, suggests that the variation behind the agglomeration of infrastructure needs may result in an underestimation of the capacity gap, predicted to be a more significant deficit rather than a marginal surplus as presented in one of the studies. Although there is merit in transfer of waste between some regions, these should be based on realistic assumptions and should take into account additional costs and burdens such as transport.

To be able to predict infrastructure needs in the future, one should start with understanding those needs now. And this is not just a matter of reliable data but also a function of an integrated and coherent national strategy. It comes down to waste management delivering for real sustainability targets rather than mere regulatory requirements. This study using compositional data to understand treatment capacity requirements for LACW and similar C&I per region, attempting to maximise resource recovery and minimise what goes to Landfill.

In order to successfully plan for waste treatment infrastructure a number of parameters have been identified as important:

1. Types and quantities of waste materials. Obtaining compositional information may be essential for a proper analysis. Integrated consideration of commercial/industrial, household waste and potentially agricultural wastes is needed in order to see what wastes could be combined in single streams and appropriately treated. Moreover, waste management planning should be integrated with energy strategies in order to maximise regional/national benefits delivered by the waste management facilities, and so that such facilities can contribute to achieving binding EU renewable energy targets. This may mean prioritising energy recovery over recycling particularly where further recycling is very costly and/or the environmental benefit is limited.
2. Location of waste arisings, including information on how waste is contained and how frequently it is collected.
3. Type and location of existing waste treatment facilities and other reprocessing facilties or end markets that could make use of the produced outputs (recyclates, energy etc).
4. Sustainability assessment of alternative management options (e.g. distance of waste transportation and related impacts, local social and environmental impacts).

These consequently necessitate a level of flexibility in interpretation of findings.

This analysis suggests that stochastic forecasts of 2020 Waste Arisings and Treatment Capacity should not be the sole input for decision making regarding investment. Instead, an integrated waste management infrastructure strategy should be developed and reviewed in the light of these findings. The optimised development of an integrated waste infrastructure cannot smoothly derive from the indirect targets of increasing recycling, or biowaste diversion from landfill, or from economic incentives that do not have by themselves the power to rationalise plant distribution, number and scale, and any attempt to base decisions solely on forecasts of demand and capacity is likely to fail. Acting on the findings of the work outside the context of existing strategies comes with associated risks that have not been the subject of our work. Providing infrastructure for resource management is a much more complex issue.

Regional planning bodies or local authorities or the private industrial sector cannot by themselves solve the problem of rapidly building an integrated infrastructure for managing waste when decisions on investments are taken this way.

Thorough strategic planning is vital when seeking to meet challenging objectives, and strategies should both reflect community aspirations and ensure cost-effective compliance with all existing statutory obligations. The development of the Municipal Waste Management Strategy must be a dynamic process and should result in a clear framework for the management of municipal waste and waste from other sectors as appropriate. This should set out how authorities intend to optimise current service provision as well as providing a basis for any new systems or infrastructure that may be needed. Any study that offers new findings on predictions in terms of waste arisings or facilities should really be used to inform and support the preparation of local development plan documents by the Waste Planning Authorities involved or affected by the study.

Existing and under-construction facilities might suggest that the demand might be met, but often the scale of the proposed plants is suboptimal and the location not finalised. Without the possibility of contributing to specific national goals, local authorities and waste disposal authorities have been planning for a massive number of thermal treatment plants and confronting citizens' opposition in the absence of a national policy reference framework. As a result of this lack of direction, we have seen that the PFI projects have proposed, sometimes without selecting any, three very different energy from waste strategies:

- energy recovery from established combustion;
- pre-treatment of residual waste followed by energy recovery from Solid Recovered Fuel (SRF) in a newly built dedicated thermal plant;
- pre-treatment of residual waste to produce 'fuel from waste' (SRF) to be recovered elsewhere.

Klaus Koegler, head of unit of sustainable production and consumption at the European Commission, has said that waste management could contribute to reducing environmental pressure. "*That can be done by making less waste and by using the waste that we are creating in a more efficient way. A main step in doing that is of course to improve the way and to improve the efficiency with which we are re-using waste in the sense of recycling and energy recovery*."[7]

The Waste Hierarchy lays down a priority order of what constitutes the best overall environmental option in waste legislation and policy, while departing from such a hierarchy may be necessary for specific waste streams when justified by life cycle analysis, for reasons of, inter alia, technical feasibility, economic viability and environmental protection. In other words, the Waste Hierarchy has little scientific or technical basis. There is no scientific reason, for example, why materials recycling should be preferred to energy recovery. In an integrated waste management system, the hierarchy cannot suffice, for example, to decide whether composting combined with incineration of the residues would be preferable to materials recycling plus landfilling of residues. What is needed in

[7] http://www.euractiv.com/node/188903

practice is an overall assessment of the whole system, and the Waste Hierarchy cannot provide or address its costs and therefore cannot help assess the economic affordability of waste systems. In Defra's Forecasting 2020 Report, life cycle analysis (LCA) is not mentioned once. The LCA necessary to compare the full range of environmental impacts of waste management systems in order to improve processes, support policy and provide a sound basis for informed decisions have been replaced by stochastic models that leave little space for experts to be able to evaluate the approach taken or for the public to understand what has been done. Moving away from life cycle analysis cannot be a sustainable move for anyone. LCA has a great potential to support planning and strategy development and should be used in decision making.

This study has not aimed to provide absolute amounts, but to evaluate the limitations of the Defra's 2020 Forecasting Report. Findings demonstrated that there is an additional unmet requirement for treatment in some regions and that the most important thing is for local authorities to ensure that they have planned for the right number and type of facilities in the right place as part of an integrated waste management strategy that goes beyond just meeting regulatory requirements but also delivers real sustainability benefits.

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Appendix

Figures A1-A9 present the calculated composition of arisings in England,

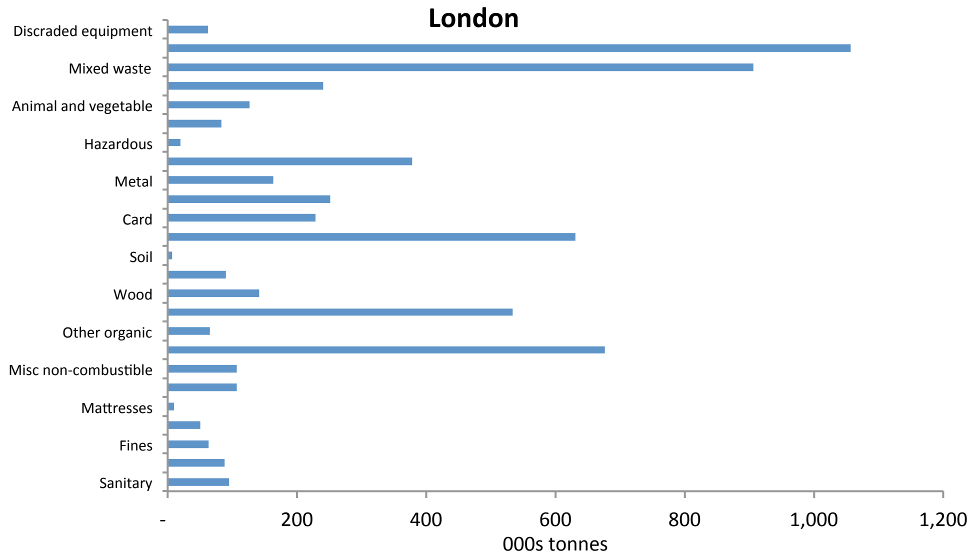

Figure A1: Material arisings in London

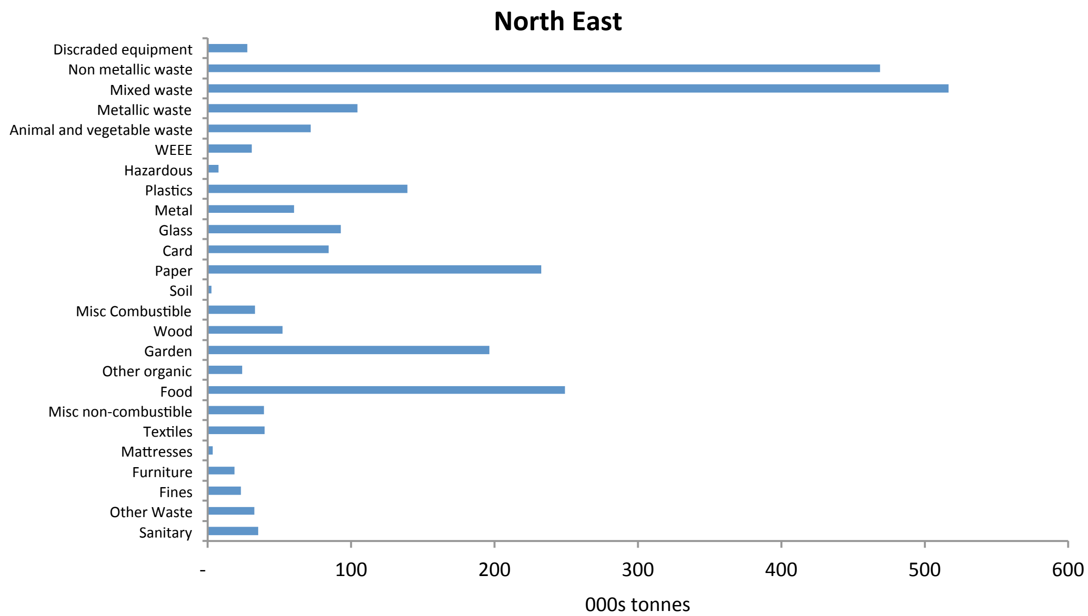

Figure A2: Material arisings in the North East

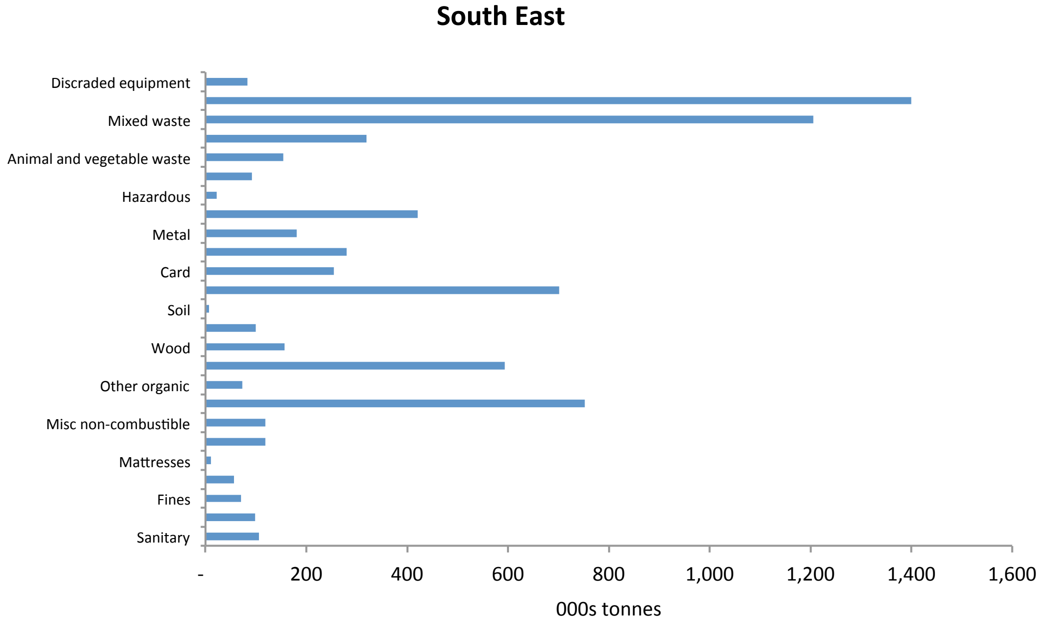

Figure A3: Material arisings in the South East

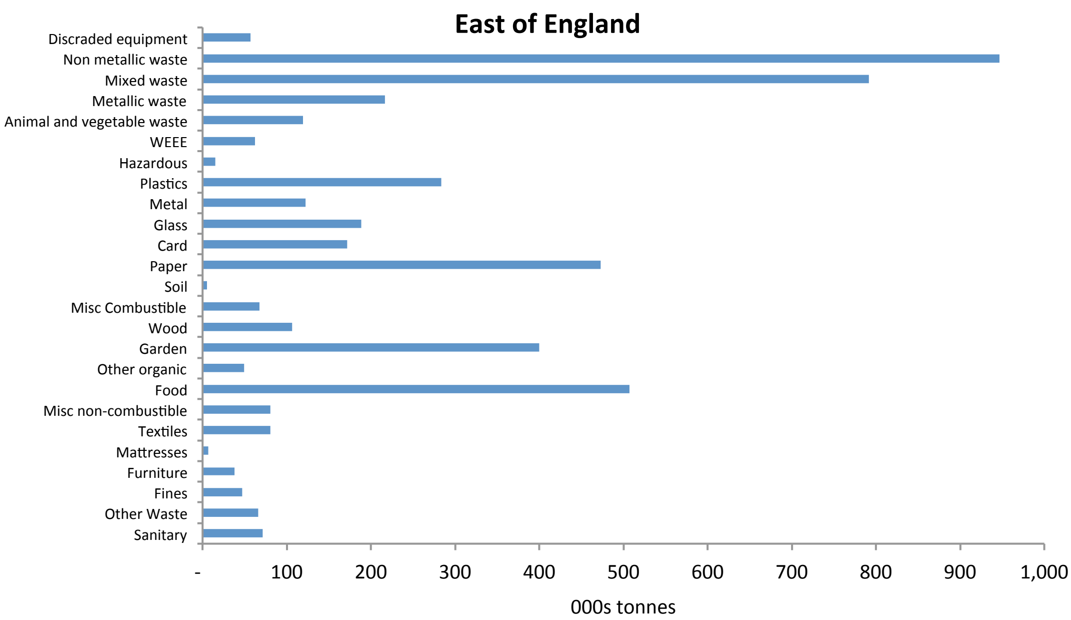

Figure A4: Material arisings in the East of England

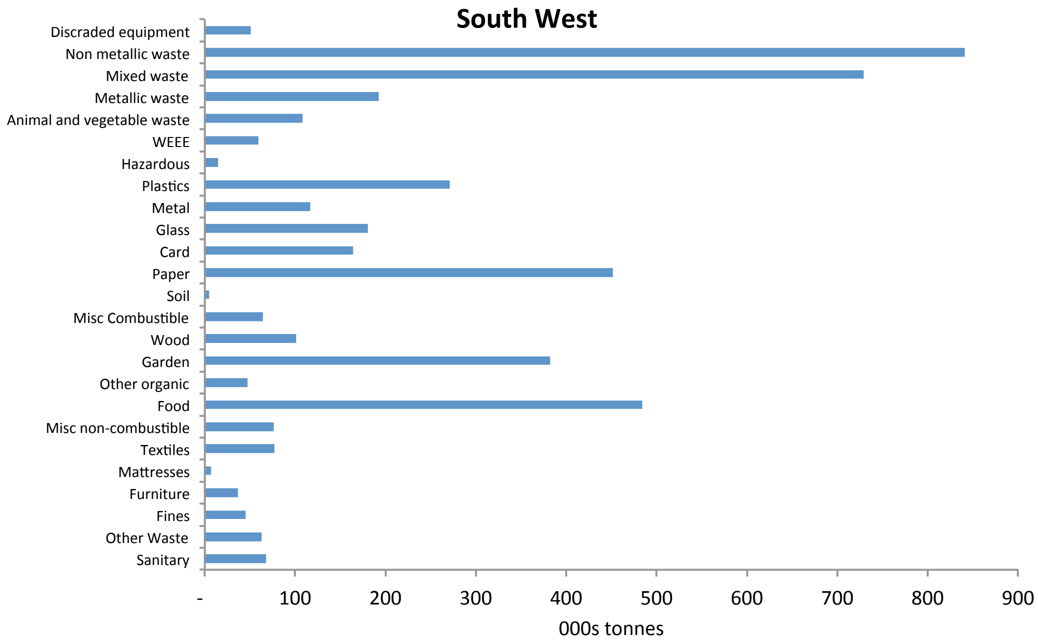

Figure A5: Material arisings in the South West

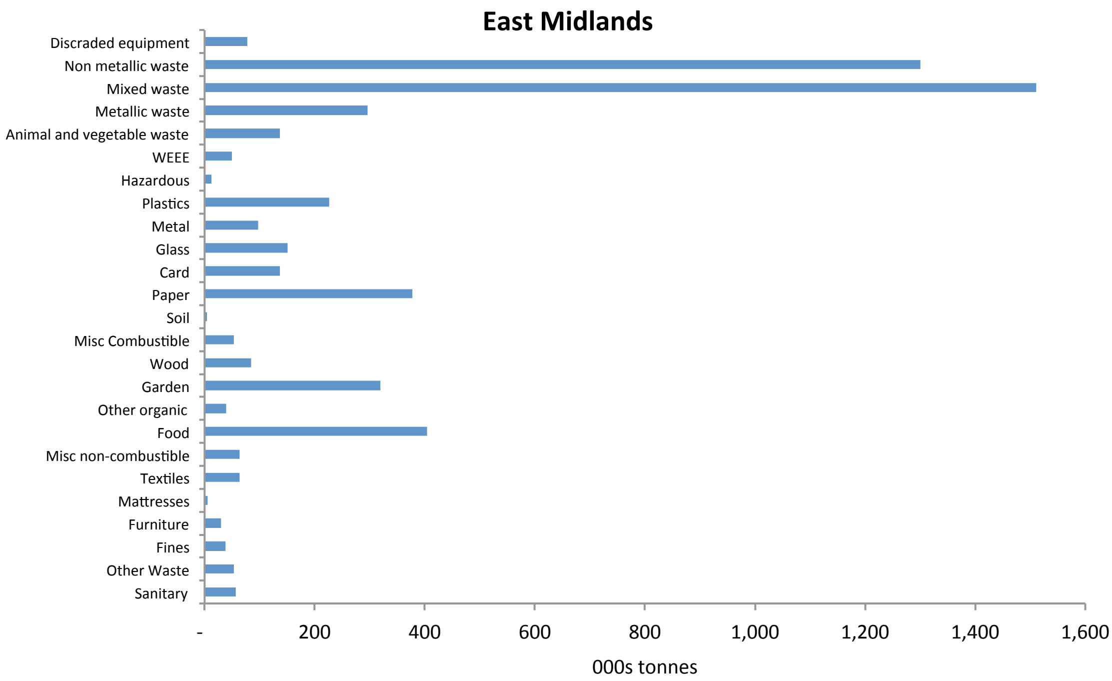

Figure A6: Material arisings in East Midlands

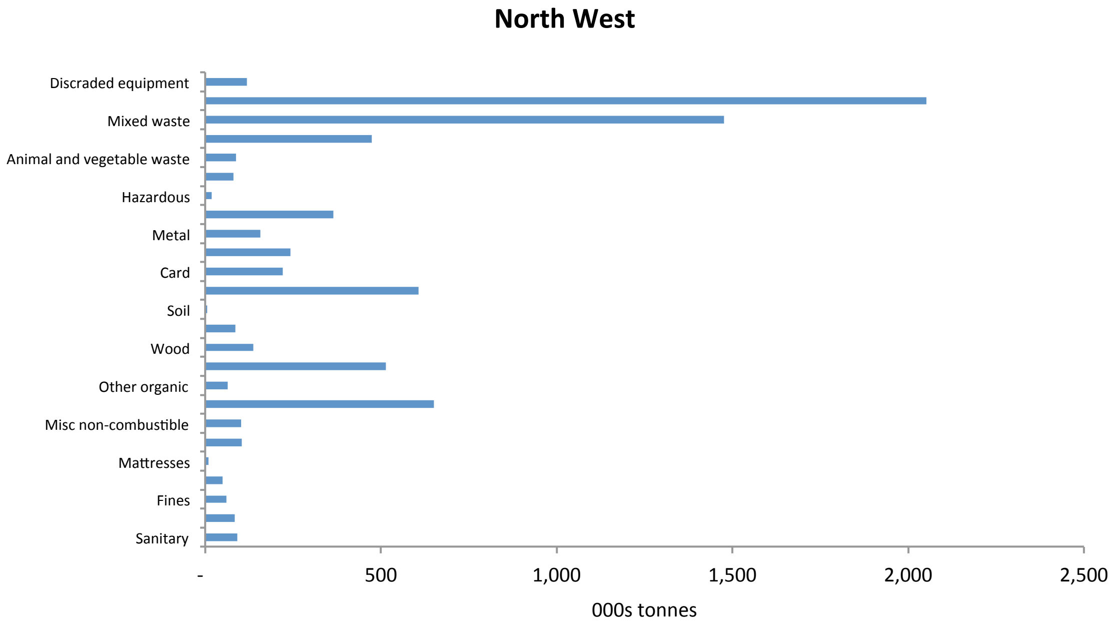

Figure A7: Material arisings in the North West

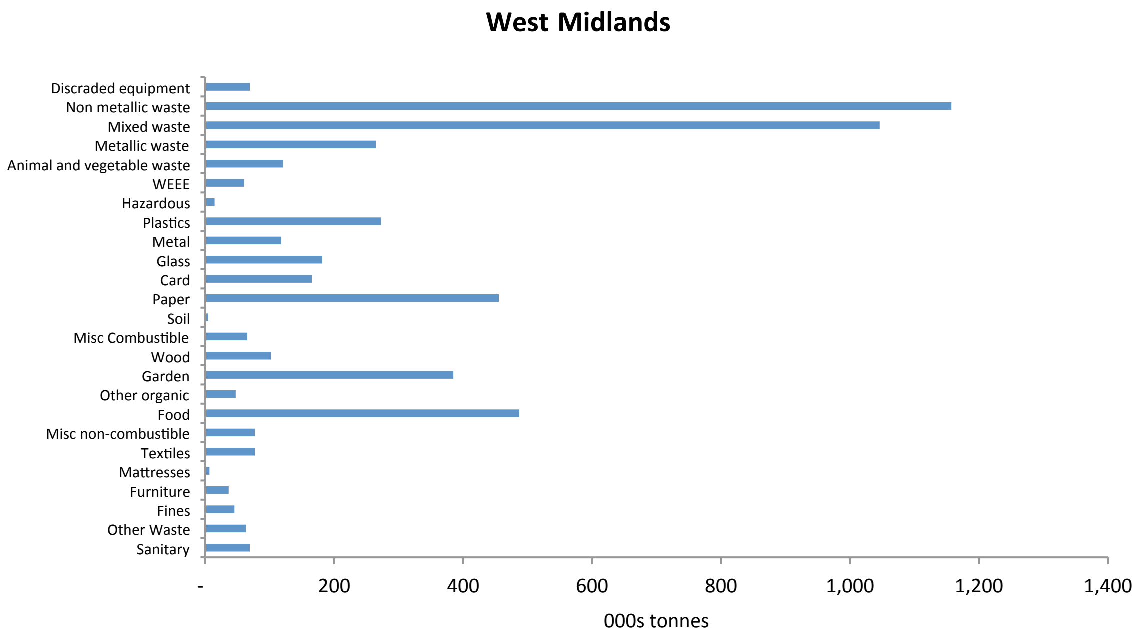

Figure A8: Material arisings in the West Midlands

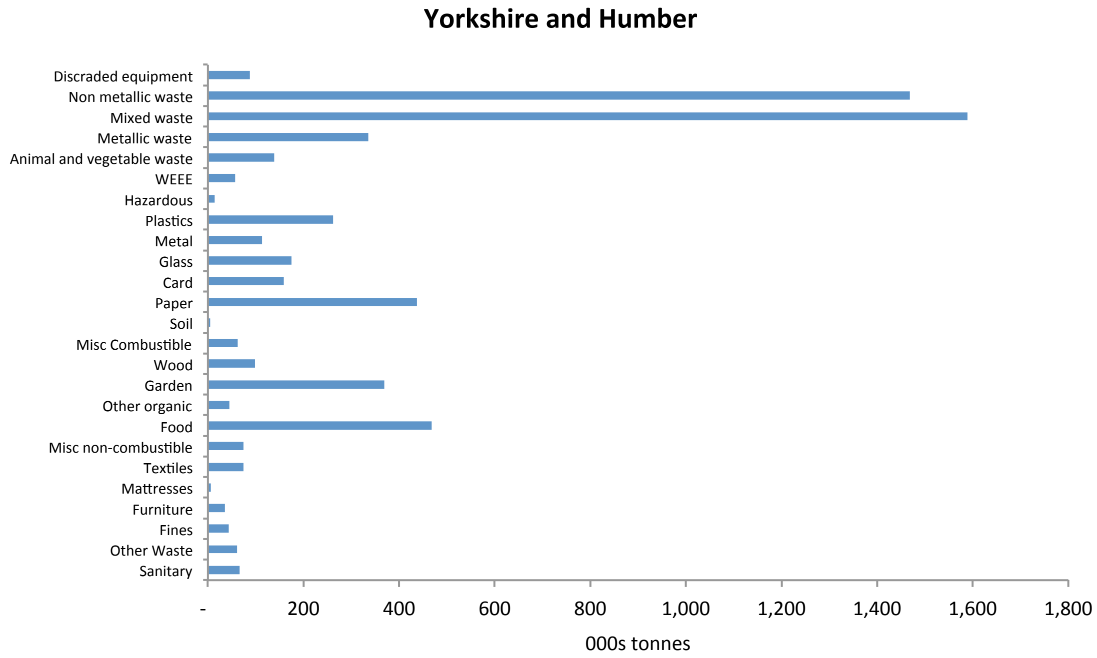

Figure A9: Material arisings in Yorkshire and Humber