The Further Benefits of Business Resource Efficiency

Oakdene Hollins A research report completed for the Department for Environment, Food and Rural Affairs

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Glossary

BAU	business as usual
BRC	Better Retailing Climate
C&I	commercial and industrial
CCA	Climate Change Agreement
CCC	Committee on Climate Change
CDEW	construction, demolition and excavation waste
CILT	Chartered Institute of Logistics and Transport
CO_2e	carbon dioxide equivalent
CRC	Carbon Reduction Commitment
DBIS	Department for Business Innovation and Skills
DECC	Department of Energy & Climate Change
Defra	Department for Environment, Food and Rural Affairs
EA	Environment Agency
ECA	Enhanced Capital Allowance scheme
ETS	Emissions Trading System
FDF	Food and Drink Federation
FHC	Federation House Commitment
GHG	greenhouse gas
HGV	heavy goods vehicle
KPI	key performance indicator
Ktoe	thousand tonnes of oil equivalent
LGV	light goods vehicle
MAC	marginal abatement cost
MAS	Manufacturing Advisory Service
M m^3	million cubic metres
Mt	million tonnes
NAO	National Audit Office
NFDC	National Federation of Demolition Contractors
ONS	Office of National Statistics
SEPA	Scottish Environment Protection Agency
SWMP	Site Waste Management Plan
UKQAA	UK Quality Ash Association

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Executive Summary

In September 2007 Defra published a report prepared by Oakdene Hollins and Grant Thornton on the quantification of the no cost / low cost savings opportunities associated with resource efficiency in the UK, taking 2006 as the base year. Supplementary studies undertaken in 2009 converted the financial savings into emissions savings. This study builds on the previous studies by firstly, assessing how the UK has performed since the base year of 2006 in realising these savings and secondly, investigating resource efficiency in its wider context to identify the savings opportunities which are not constrained to a one year payback. The eight project objectives are listed below:

1. What are the total potential financial and environmental (energy/waste/water/raw materials etc) savings for UK business from implementing resource efficiency measures requiring investment with less than a one year payback period? (This is to provide updated baseline figures.)

2. What are the total potential financial and environmental (energy/waste/water/raw materials etc) savings for UK business from implementing resource efficiency measures requiring investment with greater than a one year payback period?

3. What are the potential savings (environmental and financial) broken down by the resource efficiency measures/interventions identified?

4. How has existing Government policy addressed the potential for resource efficiency savings? Are there gaps remaining outside existing policies that could be exploited? Where there are existing policies, have these left further scope for improvement over and above what these policies were set up to achieve?

5. What differences in savings can be achieved by applying solutions further up the waste hierarchy, i.e. should Defra focus its resources on simply diverting waste from landfill to recycling and composting or does focusing/embedding resource efficiency/waste minimisation into industry have a higher impact?

6. What are the technological, process, economic (i.e. market failures) and behavioural barriers to these savings being realised?

7. How does the size of an organisation present different opportunities and barriers for resource efficiency?

8. What would be the effect of the resource efficiency measures/interventions identified on the competitiveness of the UK economy and individual sectors, and in creating new demand/business?

Study Approach

The approach taken in this study to quantify the no cost / low cost savings (Objective 1) differed from that used in generating the 2006 estimates, since it did not involve the use of case studies or site audit data. Instead the study investigated the change in resource efficiency in each business sector since the 2006 baseline. This was considered a necessary change since very few company, or sector-level resource efficiency case studies and site audits were undertaken by delivery bodies (such as Envirowise) between 2006 and 2009, due to a change in government focus.

It should be noted that for energy, waste and water differing datasets are available, and consequently differing analysis methods have been used. Attempts have been made to harmonise the approaches where possible, however these differences mean that the resource figures may not be directly comparable, although they do provide a good estimate of their relative magnitudes.

Objectives 2 to 7 were delivered via literature reviews, drawing upon the results and methodologies used within other studies. For example, Objective 2 investigating the opportunities requiring investment with greater than a one year payback focused heavily on the work undertaken as part of the UK's low carbon commitment. For Objective 8, which focused on the competitiveness of the UK economy, the same methodology as the baseline study was used, which analysed the opportunities as a proportion of a sector's GVA.

Overall Study Results

Table 1 shows that the no cost / low cost savings opportunity has been estimated at a total of around **£23 billion**, with around £18 billion savings opportunity in waste and around £4 billion savings opportunity in energy. Savings opportunities with a payback greater than one year have been estimated at around £33 billion. This gives a total opportunity of around **£55 billion** (note, figures have been rounded). The carbon benefits achievable from implementing these resource efficiency measures are estimated at about 90 $MtCO_2$. This represents around 13% of the UK's annual greenhouse gas emissions, which stood at 700 $MtCO_2e$ in 2008[1].

Table 1: Summary of estimated resource efficiency opportunities for 2009

Type	Resource	Estimated Savings Opportunity	
		£bn	$MtCO_2$
No cost / low cost	Energy	4	13
	Waste	18	16
	Water	1	0
	Sub-Total	***23***	***29***
Payback greater than 1 year	Energy	7	30
	Waste	22	29
	Water	4	1
	Sub-Total	***33***	***61***
GRAND TOTAL		**55**	**90**

Note: Figures have been rounded

Significant Sectors

Table 2 shows the sectors that accounted for the greatest proportion of the no cost / low cost opportunities in 2009 for each of the resources. In common with the study for 2006, the largest opportunity within energy was identified in Road freight. This opportunity is estimated to have increased significantly due to a broadening of the sector boundaries, i.e. the inclusion of the 'mainly own account', which was considered to be a significant omission from the previous study for 2006. On a like-for-like basis, using the sub-sectors included in the previous study, the Road freight opportunities have reduced from £2 billion to £1.9 billion. The barriers to the realisation of this opportunity are significant, and can lie outside the control of the sector e.g. customers changing delivery specifications or have a

[1] ONS Statistical Bulletin (June 2010), *Environmental Accounts 2010*

low persistence level e.g. driver training. Other interventions include increased collaborative working among the SMEs operating within the sector.
For waste there is a re-ranking of the significant sectors, as a result of the progress made in sectors such as Food and drink and Retail; and from the inclusion of new opportunities from Lean manufacturing. The most significant four sectors are Chemicals / non-metallic minerals, Metals manufacturing, Power and utilities and Construction, which between them account for 78% of the savings opportunities. For the metal manufacturing sector the opportunity originates from waste arisings increasing in the recent C&I waste survey, although it is unclear as to exactly what the increase represents. In terms of emissions, significant opportunities still exist in diverting waste from landfill, with a mean carbon saving of 0.32 tCO_2 per tonne. Although this is much lower than the 0.99 tCO_2 per tonne available for waste reduction, there are high volumes of waste diversion opportunity across the sectors; some of which is unavoidable waste e.g. for Construction, Mining and Power and utilities. The financial savings of waste diversion are however limited, with a mean saving of £42 per tonne, in comparison to waste reduction which has a mean saving of £593 per tonne.

The sectors with significant savings opportunities for water are Public administration, Agriculture and Food and drink, which together represent 60% of the total water savings opportunities.

Table 2: A summary of the no cost / low cost opportunities for significant sectors in 2009

Energy

Sector	Estimated Savings Opportunity (£M)	% of Energy Savings
Freight: Mainly own account	1,050	27%
Freight: HGV	1,027	27%
Freight: LGV	686	18%
Retail	140	4%
Commercial offices	101	3%
Hotels	99	3%
Others	717	19%
TOTAL	**3,820**	

Waste

Sector	Estimated Savings Opportunity (£M)	% of Waste Savings
Chemicals / non-metallic minerals	4,396	24%
Metal Manufacturing	3,675	20%
Power & utilities	3,499	19%
Construction	2,601	14%
Textiles / wood / paper / publishing	1,388	8%
Transport & storage	912	5%
Others	1,789	10%
Total	**18,260**	

Water

Sector	Estimated Savings Opportunity (£M)	% of Water Savings
Public administration	154	29%
Agriculture	84	16%
Food & drink	76	14%
Other services	43	8%
Education	37	7%
Health & social work	27	5%
Others	106	20%
Total	**524**	

Comparison of 2006 and 2009 Estimated Savings Opportunities
Table 3 compares the estimated opportunities for no cost / low cost savings for 2006 and 2009. Opportunities that were able to be estimated in 2009 but not in 2006 have not been included: the notable additions in coverage for the 2009 estimates being Lean manufacturing (in waste savings) and 'mainly own account' Road freight (in energy savings).

The overall estimate of possible financial savings has been revised downwards by 19% since 2006, while the estimate for potential carbon emissions savings through no cost / low cost interventions is now 37% lower. (This difference is partly due to a re-evaluation of the road freight emissions and significant price rises for energy and water since the last study.)

Table 3: Like-for-like comparison of 2009 and 2006 estimated savings opportunities

Resource	Estimated Savings Opportunity				% Change in Estimated Savings Opportunity	
	2006		2009			
	£bn	$MtCO_2$	£bn	$MtCO_2$	£M	$MtCO_2$
Energy	3	19	3	11	-17%	-43%
Waste	3	15	2	10	-28%	-29%
Water	0	0	1	0	19%	-4%
Total	**6**	**34**	**5**	**21**	**-19%**	**-37%**

Note: Figures have been rounded

The results indicate that there has been significant progress in realising resource efficiency savings between 2006 and 2009. Some improvement in resource efficiency should be expected naturally as a result of technological change – an average of around 1% per year[2] - but clearly significant progress above that rate has been achieved.

Long Term Savings
The long term analysis shows annual savings opportunities estimated at around £33 billion or about 60 $MtCO_2$, which means they are nearly one and a half times larger than the no cost / low cost interventions in financial terms and more than twice as high in carbon terms. Material resource efficiency represents the most significant opportunity; accounting for 68% of the total financial savings and 48% of the emissions savings, with Lean manufacturing representing the greatest opportunity, accounting for about £9.9 billion of the £22 billion financial savings. Technological changes within the Transport sector account for about £5 billion of the £7 billion savings opportunity from energy efficiency. However, based upon the results of other studies it is thought that around 70% of the interventions may be achievable cost-effectively using current technologies[3].

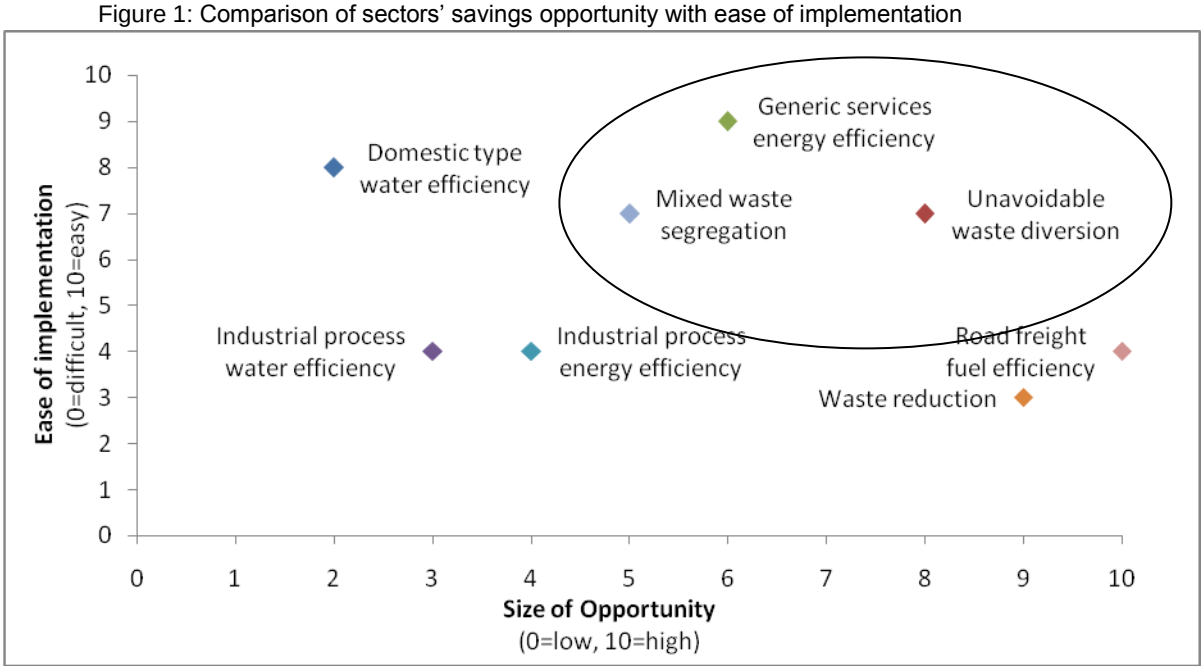
Competitiveness
Resource efficiencies will maintain UK companies' competitiveness if they are realised at a rate above that of their international competitors, and at the very least will help maintain the status quo. The impact of resource efficiencies implemented by a sector on its international competitiveness is a function of its exposure to international markets as well as the potential increase in gross profits from efficiency measures. The study explores the size of these two factors for Industrial and Service sectors, as well as for the sub-sectors with the greatest savings opportunities. Manufacturing of Chemicals and Non-metallic mineral products, and Metal and metal products have large opportunities as well as significant international exposure.

[2] Stockholm Environment Institute and the University of Durham for Defra (2009), *Understanding Changes in UK CO_2 emissions 1992-2004: A structural decomposition approach*
[3] McKinsey Quarterly (2007 Number 1), *A cost curve for greenhouse gas reduction*, quoted in the Stern Review

Barriers and Opportunities to Achieving Savings

The literature review on the motivations and barriers to implementing resource efficiency interventions showed that decisions are typically taken on economic grounds. In many cases the decision-making process is based only on the visible costs and savings, and hence the true financial opportunity is not quantified. The hidden costs include the cost of labour to implement the opportunity. The study shows that this can be significant, for example for SMEs implementing energy savings opportunities. However it is worth noting that the hidden savings associated with waste reduction interventions can be significant, especially in cases where the raw material savings have not been considered. Figure 1 shows the relationship between the resource efficiency opportunities in terms of financial return and the ease of implementation, taking the barriers to implementation into account. The interventions shown in the top right quadrant are those that are regarded as 'quick wins'; namely generic energy efficiency within services, waste diversion for unavoidable waste and the segregation of mixed waste. The other types of intervention tend to be more difficult to implement due to the need for specialist advice or because of the prevalence of behavioural barriers.

Figure 1: Comparison of sectors' savings opportunity with ease of implementation



Policy Review

The policy review showed that several policies (EU ETS, CRC, CCAs) look specifically on energy use across a number of sectors. This showed that:

- there is a high level of duplication between the EU ETS and the CCA (14%)
- CRC is focusing on energy consumers not covered by other policies
- 24% of energy consumption is not covered by any of the three policies.

Waste is covered by a number of policies and voluntary agreements, notably Landfill Tax and Integrated Pollution Prevention and Control, which cover multiple sectors; and the Courtauld Commitment and Halving Waste to Landfill, which include the Retail and Construction sectors respectively. The evidence shows that the Landfill Tax has had strong impact on landfill volumes, even if some of this effect can likely be attributed to other policies. For water efficiency there is a heavy reliance on voluntary agreements such as the Federation House Commitment (FHC) focused on water efficiency within the Food and drink sector.

As for initiatives, the BREW programme reported outcomes included £495 million of cost savings and carbon savings of 7.05 $MtCO_2$ between 2005/06-2007/08; DfT Freight Best Practice is estimated to have saved £83.3 million and 0.24 $MtCO_2$ in 2007; and the ECA has saved 9.45 $MtCO_2$ over the lifetime of the assets. Under voluntary agreements: WRAP reports the Courtauld Commitment Phase 1 prevented 1.2 Mt of food and packaging waste, saving £1.8 billion and 3.3 $MtCO_2$ over the five years to 2010; early indications of WRAP's Halving Waste to Landfill scheme show that the companies involved have decreased waste to landfill by over 40%; and sectoral agreements by the FDF and BRC are on target to meet or exceed commitments on CO_2 emissions reduction, waste to landfill and water efficiency.

Key Sensitivities and Caveats

Due to the nature of the study in bringing together data and existing research from numerous sources it has not been possible to generate robust confidence intervals for the estimated savings opportunities. Wherever possible, ranges have been quoted to provide an indication of the accuracy of the results obtained. A number of key sensitivities are important to bear in mind when interpreting the results:

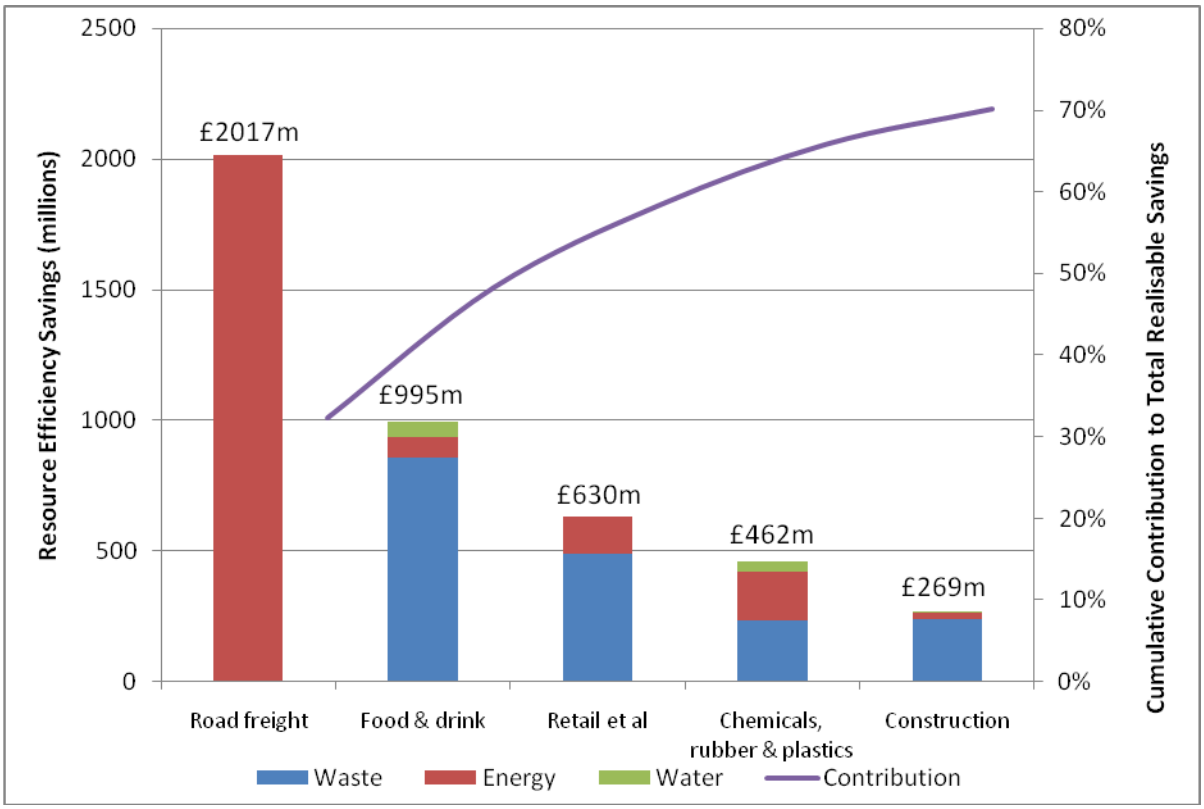
- The study focussed on quantifying the savings opportunity from resource efficiency. As such the interventions considered within the scope of the study were those that were either cost-neutral or would generate a financial saving. Due to poor accounting of hidden costs and savings, there is significant scope for error in this assessment.
- In terms of the costs required to make the investment in resource efficiency measures this study is limited by the information provided with the different sources of data. As stated above it is estimated that 70% of the interventions are achievable cost-effectively using current technologies, however, no further data is available as to specific costs.
- Given the volatility in commodity prices during 2009, it is possible that GVA may not accurately reflect physical output in some sectors. The fall in prices could understate output and resource efficiency in commodity producers, and overstate output and resource efficiency in commodity consumers.
- As with the original study, water consumption data were considered the least robust dataset, especially for non-public water abstraction and the long term forecasts, which rely on top-level estimates.
- Long term forecasts differ in the methodology used. Waste represents the scenario-testing of a selection of different interventions, and energy savings opportunities represent a technology review.
- It should be noted that there will often be tradeoffs when analysing the benefits of resource efficiency. A manufacturing process could be made more efficient in terms of energy use, but produce more physical waste as a result. Similarly a focus on reducing packaging may end up being less efficient if more goods being damaged are damaged in transit, for example. This type of analysis was not factored into the data used in this study and is therefore not accounted for in these results.

1 Context

1.1 Background

In 2007 it was estimated that the UK savings opportunities associated with no cost / low cost resource efficiency interventions, i.e. the 'quick wins', were £6.4 billion for 2006. Five sectors were found to account for around 70% of the estimated savings: Road freight, Food and drink, Retail, Chemicals, rubber and plastics and Construction, as shown in Figure 2.

Figure 2: Top 5 sectors with no cost / low cost resource efficiency opportunities within the UK for 2006



Source: Oakdene Hollins & Grant Thornton for Defra (2007), *Quantification of the business benefits of resource efficiency*

Further work revealed that, if the opportunities were to be realised, the total annual resource efficiency benefits of £6.4 billion would be the equivalent of more than half the average year-on-year growth in profitability of the total UK economy that was achieved in the five years to 2006. The study also found that several business sub-sectors could benefit disproportionately, in terms of profitability, by taking immediate low- or no-cost resource efficiency measures. These sub-sectors and the suggested focus areas are listed in Table 4 together with estimates of the potential savings as a percentage of the sectors' profits.

Table 4: Competitiveness improvements available from focus areas for resource efficiency activity for 2006

Sub-sector	Focus area(s)	RE saving from focus area(s) as % of sector's profit in 2006
Road freight transport	Energy	40.4
Agriculture	Energy & Water	9.4
Food, drink & tobacco	Waste	7.4
Warehousing	Energy	5.5
Chemicals	Energy & Waste	4.2
Retail	Waste	1.6

Source: Oakdene Hollins for Defra (2009), *Competitiveness improvements potentially available from resource efficiency savings*

The estimated carbon savings associated with the resource efficiency opportunities was 33.7 $MtCO_2e$. This represents 6.1% of total UK CO_2 emissions of 551 Mt in 2006 and 8.4% of total UK emissions when emissions of 148 Mt from residential sources are excluded, although it was noted that up to 50% of the waste-related emission savings may occur outside the UK. Table 5 shows that energy savings account for 56%, waste savings 44% and water savings less than 1% of the total savings identified. 44% (14.7 $MtCO_2e$) of the total estimated savings were within the EU ETS and 56% (19.0 $MtCO_2e$) from non-EU ETS sources.

Table 5: Estimated carbon savings of resource efficiency opportunities for 2006

Resource	Estimated Savings Opportunity ($MtCO_2$)	Savings allocated to EU ETS ($MtCO_2$)	Savings allocated to non-EU ETS ($MtCO_2$)
Energy	18.7	9.2	9.5
Waste	14.7	5.5	9.2
Water	0.2	0.0	0.2
Total	**33.7**	**14.7**	**19.0**

Source: Oakdene Hollins for Defra (2009), *Quantification of the potential CO_2 savings from resource efficiency in the UK*

1.2 The study

The aims of this study are to provide an update on the previous Defra work using a 2009 base year to determine the broader benefits from resource efficiency beyond that of the no cost / low cost opportunities. The context for the work is that of the Climate Change Act and the legally binding target to reduce the UK's greenhouse gas emissions to at least 80% below 1990 levels by 2050. The eight project objectives are listed below:

1. What are the total potential financial and environmental (energy / waste / water/ raw materials etc) savings for UK business from implementing resource efficiency measures requiring investment with less than a one year payback period? (This is to provide updated baseline figures.)

2. What are the total potential financial and environmental (energy / waste / water / raw materials etc) savings for UK business from implementing resource efficiency measures requiring investment with greater than a one year payback period?

3. What are the potential savings (environmental and financial) broken down by the resource efficiency measures/interventions identified?

4. How has existing Government policy addressed the potential for resource efficiency savings? Are there gaps remaining outside existing policies that could be exploited? Where there are existing policies, have these left further scope for improvement over and above what these policies were set up to achieve?

5. What differences in savings can be achieved by applying solutions further up the waste hierarchy, i.e. should Defra focus its resources on simply diverting waste from landfill to recycling and composting or does focusing/embedding resource efficiency/waste minimisation into industry have a higher impact?

6. What are the technological, process, economic (i.e. market failures) and behavioural barriers to these savings being realised?

7. How does the size of an organisation present different opportunities and barriers for resource efficiency?

8. What would be the effect of the resource efficiency measures/interventions identified on the competitiveness of the UK economy and individual sectors, and in creating new demand/business?

1.3 Terms of reference

The study focuses on four key resources:

- materials
- waste
- water
- energy

Within the study, materials and waste are frequently analysed together since they can be associated in the context of resource efficiency. For example, waste reduction at source naturally implies material reduction. Therefore, the combining of these two focus areas reduces the likelihood of double counting the savings opportunities.

Resource efficiency is defined within this study as any action or intervention that results in a reduction in overall material usage or greenhouse gas emissions that is either cost neutral or cost negative.

Financial savings have been quantified as the annual cost savings that could be achieved by businesses as a result of resource efficiency measures. It is noted that other definitions and metrics can be used such as social savings and present values.

Emphasis is placed on secondary data sources, such as government, trade association and company reports and statistics etc, with a 2009 base year.

Focus is placed on production or supply-side resource efficiency opportunities and not on consumer or demand-based interventions.

2 Conclusions and interpretation

2.1 No cost / low cost savings opportunities

The values of the no cost / low cost resource efficiency savings opportunities for 2009 have been estimated at **£23 billion or 29 $MtCO_2$**, however the majority of this opportunity represents an extension of the coverage of the opportunity to include such areas as Lean manufacturing (waste) and 'mainly own account' Road freight (energy).

A like-for-like comparison of the 2006 and 2009 estimates of no cost / low cost savings opportunities, however, reveals that significant progress has been achieved in the realisation of the resource efficiency savings opportunities between 2006 and 2009 (Table 6). Some improvement in resource efficiency should be expected naturally as a result of technological change, on average at around 1% per year[4], but clearly significant progress above that rate has been achieved. In financial terms the estimated savings opportunity has fallen by 19%, although in carbon terms the opportunity fell by 37%. This divergence between the financial and carbon realisation is due to a re-evaluation of the road freight emissions and significant price rises within energy and water. The following sub-sections provide more details for each of the three resources.

Table 6: Like-for-like comparison of 2009 and 2006 estimated savings opportunities

Resource	% Change in Estimated Savings Opportunity	
	£M	$MtCO_2$
Energy	-17%	-43%
Waste	-28%	-29%
Water	19%	-4%
Total	**-19%**	**-37%**

2.1.1 Energy efficiency

The 2006 baseline study valued the energy efficiency savings opportunity at £3.35 billion and this study estimates a savings opportunity in 2009 of £3.82 billion. Table 7 shows the ten sub-sectors with the highest CO_2 savings opportunity. These ten sub-sectors account for 89% of the total identified financial savings and 80% of total CO_2 savings. The 'mainly own account – HGV and LGV' sub-sector was not included in the original study and hence was considered a significant omission. Removing this from the analysis (to enable a like-for-like comparison to be made between the two studies) shows that the savings opportunity dropped to £2.77 billion, which suggests that £0.58 billion or 17% of the 2006 savings opportunity had been realised by 2009.

Table 7 shows that six of the ten sub-sectors are from the Service sector, three from Road freight and one from the Industrial sector. The interventions within the Service sector are generic, energy-efficiency type interventions such as running 'switch off' campaigns or turning down thermostats etc. The Carbon Reduction Commitment (CRC) introduced in 2010 provides a driver for the larger energy consumers within the Service sector.

[4] Stockholm Environment Institute and the University of Durham for Defra (2009), *Understanding Changes in UK CO_2 emissions 1992-2004: A structural decomposition approach*

Table 7: Summary of no cost / low cost energy efficiency savings opportunity for 2009

Sub-sector	Savings opportunity (Ktoe)	Savings opportunity (£M)	Savings opportunity ($KtCO_2e$)
Mainly own account – HGV and LGV	920	1,050	2,630
HGV – mainly public haulage	900	1,027	2,580
LGV – mainly public haulage	600	686	1,720
Retail	164	140	704
Chemicals, chemical products & man-made fibres	195	90	638
Hotels	167	99	559
Commercial offices	152	101	549
Warehouses	124	79	437
Education	139	71	426
Government	135	72	422
Sub Total	**3,496**	**3,415**	**10,665**
TOTAL	**4,253**	**3,820**	**13,335**

The interventions within the Road freight sectors differ, and face considerable barriers to realisation. For example, the LGV sector is dominated by SMEs with a low engagement in environmental issues. The HGV sector is led by customer demand and requires increased collaboration across the supply chain and within the road freight fraternity if the savings opportunities are to be realised.

The Industrial sector has traditionally been a heavy energy consumer, and hence the focus of numerous government policies such as CCA and EU ETS. The interventions in this area are process-related, e.g. efficiency improvements to pumps, motors, boilers, etc.

2.1.2 Waste or material resource efficiency

The 2006 baseline study valued the waste savings opportunity at £2.66 billion or 14.7 $MtCO_2$. Table 8 shows that this study estimates the savings opportunity in 2009 at £18.3 billion or 15.8 $MtCO_2$. This significant increase in the financial savings opportunity comes as a result of extending the analysis to include additional opportunities in waste reduction and Lean manufacturing that had been underestimated in the 2006 estimate due to a lack of available case studies at the time. A like-for-like comparison of the progress made, however, reveals that the opportunity has fallen by 28% between 2006 and 2009, showing that significant progress has been achieved over the period.

Of the financial opportunity, four sectors (Chemicals / non-metallic minerals, Metal manufacturing, Power and utilities and Construction) account for 78% of the financial savings opportunity. For the metal manufacturing sector the opportunity originates from waste arisings increasing in the recent C&I waste survey, although it is unclear as to exactly what the increase represents. On the carbon side, significant opportunities still exist in diverting waste to landfill, with a mean carbon saving of 0.32 tCO_2 per tonne. Although this is much lower than the 0.99 tCO_2 per tonne available for waste reduction, there are high volumes of waste diversion opportunity across the sectors. Much of this opportunity, in terms of volume, originates in sectors where there is a high degree of unavoidable waste e.g. Construction, Mining and Power and utilities. The financial savings of waste diversion

are however limited with a mean saving of £42 per tonne, in comparison to waste reduction which has a mean saving of £593 per tonne.

Table 8: Summary of no cost / low cost waste savings opportunity for 2009

Sector	Savings opportunity (£M)	Savings opportunity ($KtCO_2e$)
Chemicals / non-metallic minerals	4,396	1,570
Metal manufacturing	3,675	4,896
Power & utilities	3,499	1,247
Construction	2,601	1,638
Textiles / wood / paper / publishing	1,388	404
Transport & storage	912	246
C&I Landfill	445	5,402
Agriculture, forestry & fishing	362	161
Mining & quarrying	361	115
Food, drink & tobacco	219	100
Sub Total	**17,859**	**15,780**
TOTAL	**18,260**	**15,881**

2.1.3 Water efficiency

The 2006 baseline study valued water savings opportunity at £441 million or 0.24 $MtCO_2$. This study valued the savings opportunity in 2009 at £524 million or 0.23 $MtCO_2$. Table 9 shows that six sub-sectors account for 75% of the total financial savings and 76% of the emissions savings.

Table 9: A summary of no cost / low cost water savings opportunity 2009

Sub-sector	Water supply (input) savings		Estimated total savings including wastewater (£M)
	Estimated savings (%)	Estimated savings (£M)	
Public administration	26.5	76.9	153.8*
Agriculture	27.5	41.8	83.6*
Food & drink	15.5	30.5	75.5
Education	23.5	18.4	36.8*
Health & social work	15.5	13.3	26.6*
Real estate, renting & business activities	26.5	10.9	21.8*
Sub total		**191.8**	**398.1**
TOTAL		**254.7**	**524.2**

*Note: No data were found on the expenditure on waste water management in these sectors and hence it was assumed that the cost of waste water management was equal to the cost of water supply.

Water savings interventions can be split into domestic-type water savings opportunities and process-type opportunities. It is suggested that water companies and organisations such as

Waterwise focus on the domestic-type water savings since a very high percentage is sourced from the public water supply. For process-type water it is suggested that delivery bodies such as WRAP and MAS and the Environment Agency are best placed, since non-public water supply is the main source.

2.2 Savings opportunities with a payback of greater than one year

The longer term savings opportunities can be regarded as a scenario-testing exercise, in terms of the possible savings opportunities should certain technologies be introduced or resource efficiency techniques (such as Lean manufacturing) be widely adopted. Table 10 shows the estimated annual savings opportunity from the interventions with a payback of greater than one year. This shows the savings are considerably higher than the 29 $MtCO_2$ and £23 billion estimate for the no cost / low cost opportunities. The analysis shows that material resource efficiency represents the most significant opportunity and Lean manufacturing (£9.9 billion) and waste reduction (£4.7 billion) are the two most significant interventions. The barriers to realising these savings are significant since both Lean manufacturing and waste reduction require a process focus driven by production management, whereas conventionally environmental issues are driven by environmental managers or facilities managers with a focus on waste management.

Table 10: Summary of long term resource efficiency savings 2009

Sector or intervention	**Savings opportunity**	
	$MtCO_2$ saving	**Total saving £M**
Material resource efficiency	29.2	22,061
Transport – energy	13	5,330
Non domestic buildings – energy	11.2	1,113
Industry - energy	5.9	640
Water efficiency	1.3	3,500
Total	**60.6**	**32,644**

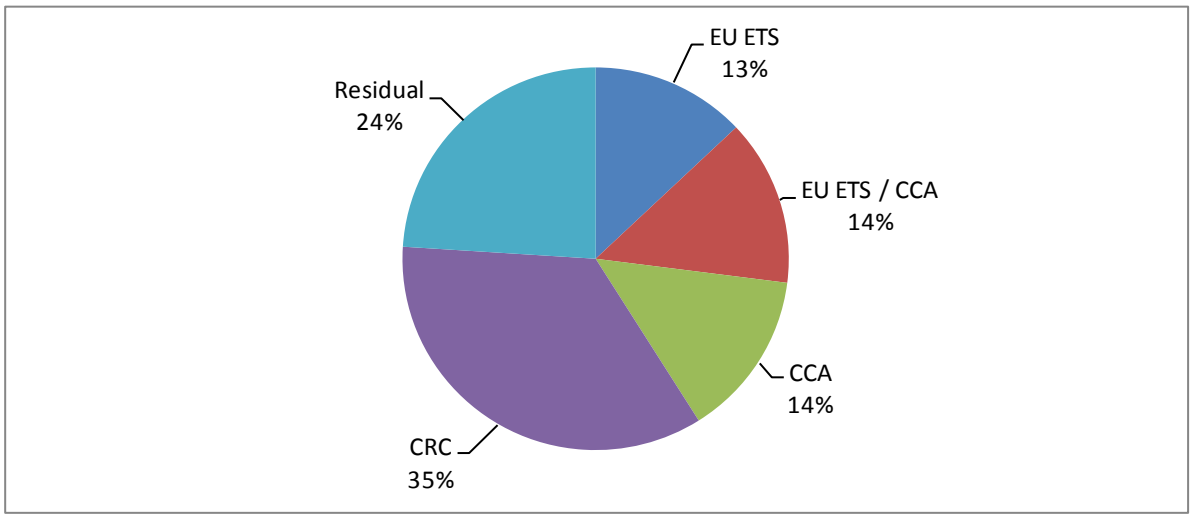
2.3 Policy interventions

The policy review showed that several policies specifically cover energy use across a number of sectors. Figure 3 shows the coverage of the EU ETS, CCA and CRC in terms of energy consumption. The observations that can be drawn from the chart include:

- 24% of energy consumption is not covered by any of the three policies (39% of the Commercial sector and 13% of the Industrial sector)
- CRC is meeting its objective of focusing on energy consumers not covered by other policies (57% of the Service sector and 18% of the Industrial sector)
- There is a high level of duplication between the EU ETS and the CCA (14%).

Consumers not covered by any of the three policies are the low energy consumers such as commercial outlets where the energy savings opportunities are very similar to those in the domestic sector.

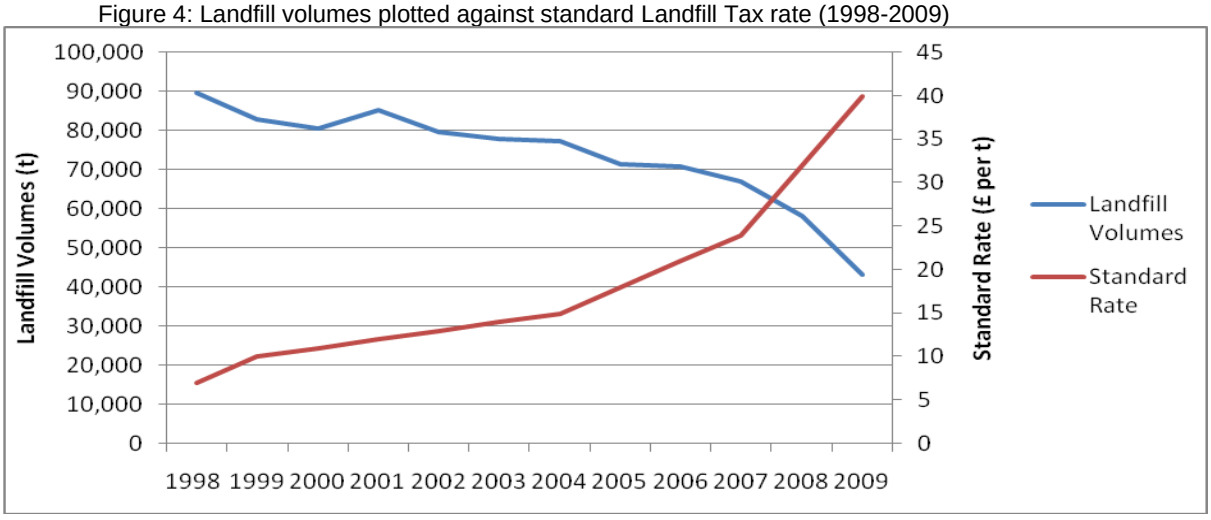
Figure 3: A summary of policy coverage by the EU ETS, CCA and CRC



Source: Produced using data contained in AEA Technology and Databuild for DECC (2010), Assessing the carbon dioxide emissions and cost effective carbon savings potential for organisations not covered by EU ETS, CCAs or CRC

Landfill Tax analysis showed that the correlation between the standard rate of Landfill Tax and the landfill volumes is very high at -0.99, i.e. almost perfect negative correlation (Figure 4). The impact of the Landfill Tax on landfill volumes appears therefore to have been very strong, although some of this effect can be attributed to other policies and the effect of other drivers on waste volumes. On the impact of Landfill Tax, the 2009 Budget reported that the tax would generate a 0.7 $MtCO_2e$ saving in 2012[5]. The Landfill Tax is considered a key driver to the realisation of the savings opportunities associated with the diversion of unavoidable waste from landfill and on improving the economics of recovering the low volume wastes from commercial premises. The pattern of results for the impact of the IPPC is less clear cut, with IPPC companies reducing their waste faster than non-IPPC companies in the Metals sector, but the reverse being true for the Chemicals / non-metallic minerals sector.

Figure 4: Landfill volumes plotted against standard Landfill Tax rate (1998-2009)



Source: HMRC (2010), *Landfill tax bulletin*

[5] HM Treasury (2009), *2009 Budget*

The study also demonstrated that initiatives and voluntary agreements can have significant impacts on resource efficiency:

- The BREW programme reported outcomes included £495 million of cost savings and carbon savings of 7.05 $MtCO_2$ between 2005/06-2007/08
- DfT Freight Best Practice is estimated to have saved £83.3 million and 0.24 $MtCO_2$ in 2007
- The ECA has saved 9.45 $MtCO_2$ over the lifetime of the assets
- WRAP's Courtauld Commitment Phase 1 prevented 1.2 Mt of food and packaging waste, saving £1.8 billion and 3.3 $MtCO_2$ over the five years to 2010
- WRAP's Halving Waste to Landfill agreement shows early indications that the companies involved achieved a decrease of over 40% of waste to landfill
- Sectoral agreements are on progress to meet or exceed targets:
    - The FDF through their Five-fold Commitment (including the Federation House Commitment) have reduced CO_2 emissions by 19% and saved almost 500,000 m^3 of water
    - BRC through their Better Retailing Climate agreement have reduced energy use by 18%, increased measurement of water to 75% and reduced the proportion of waste sent to landfill to 23%.

2.4 Barriers to realising the resource efficiency opportunities

The literature review on the barriers and motivations to realising resource efficiency opportunities reached a number of conclusions that are summarised here.

For financial barriers the evidence is that these are more severe for SMEs than for larger companies for two reasons. The first is that SMEs use higher discount rates in their investment decisions because of a higher cost of credit and a lower company survival rate[6]. The second relates to a more pronounced lack of access to capital for SMEs. For 'hidden' costs the evidence is that management time for environmental issues is more limited and it is likely that transaction costs are higher.

For market failures the evidence does point to a greater burden for SMEs. Under 'externalities', large companies may have greater ability to trial new technologies. Under 'information', the evidence points to large companies being better informed. SMEs are often informed solely by information acquired from the media or from within their own networks[7]. Large companies, however, have access to more diverse sources of information[8] and benefit from having specialist managers for environmental issues. Under 'split incentives' as many as 90% of SMEs operate from rented offices[9] meaning this failure is likely to be more acute for SMEs. However SMEs do not have the 'split incentives' problem of allocating budgets between departments.

For 'behaviour and motivation' the evidence for a greater burden on SMEs is more mixed. On the one hand, management time tends to be more stretched at SMEs, but on the other hand the bureaucratic nature of larger organisations means that SMEs can make decisions more quickly, requiring the support of fewer individuals. For large companies the latter point

[6] BIS (2010), *Green light? A review of regulatory barriers to small businesses' resource and energy efficiency*

[7] IPTS (2007), *Promoting Environmental Technologies in SMEs: Barriers and Measures*

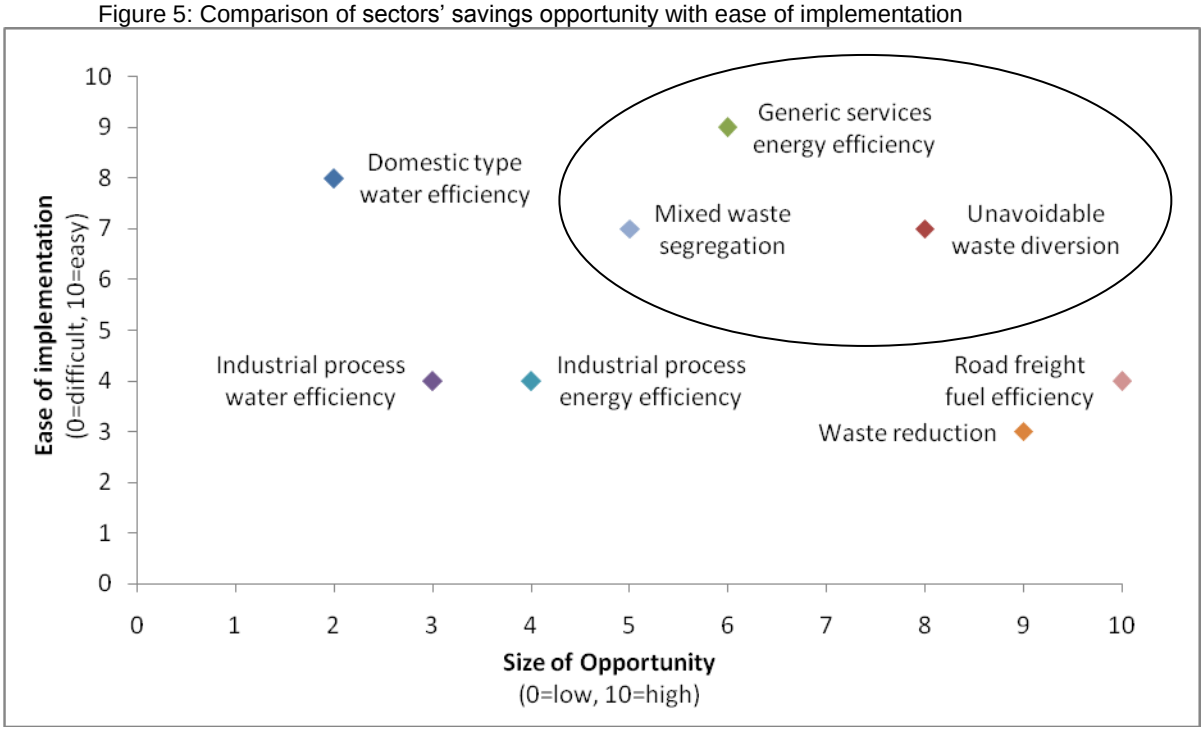
[8] Defra (2010), *Resource Efficiency Delivery Landscape Review*

[9] Scrase (2001), *Research for the Association for the Conservation of Energy*, cited in NERA & Enviros for Defra (2006)

can be a real issue, particularly for multinationals where strategic decisions may be taken overseas limiting the options for UK subsidiaries[10]. Evidence from the Food and drink sector showed that these bureaucratic issues are important. Resource efficiency is often the responsibility of an individual without sufficient power and influence to implement waste reduction or Lean manufacturing, which requires embedding a new culture into the mindset of the whole organisation. Such major changes in working practices require strong leadership involving senior management. By contrast, end-of-pipe waste management solutions tend to be easier to implement. However, other evidence points towards SMEs having limited internal motivation towards environmental issues. Reasons for this include management and ownership being concentrated in the same hands, and a feeling that the issues are not related to the core business[11].

Figure 5 shows the relationship between the resource efficiency opportunities in terms of financial return and the ease of implementation, taking the barriers to implementation (referred to above) into account. The interventions shown in the top right quadrant are those that are regarded as 'quick wins', namely, generic energy efficiency within services, waste diversion of unavoidable waste and the segregation of mixed waste. The other types of intervention tend to be more difficult to implement due to the need for specialist advice or because of the prevalence of behavioural barriers.

Figure 5: Comparison of sectors' savings opportunity with ease of implementation



[10] *Determining cost-effective action for business to reduce emissions*, PwC for BIS (2009)

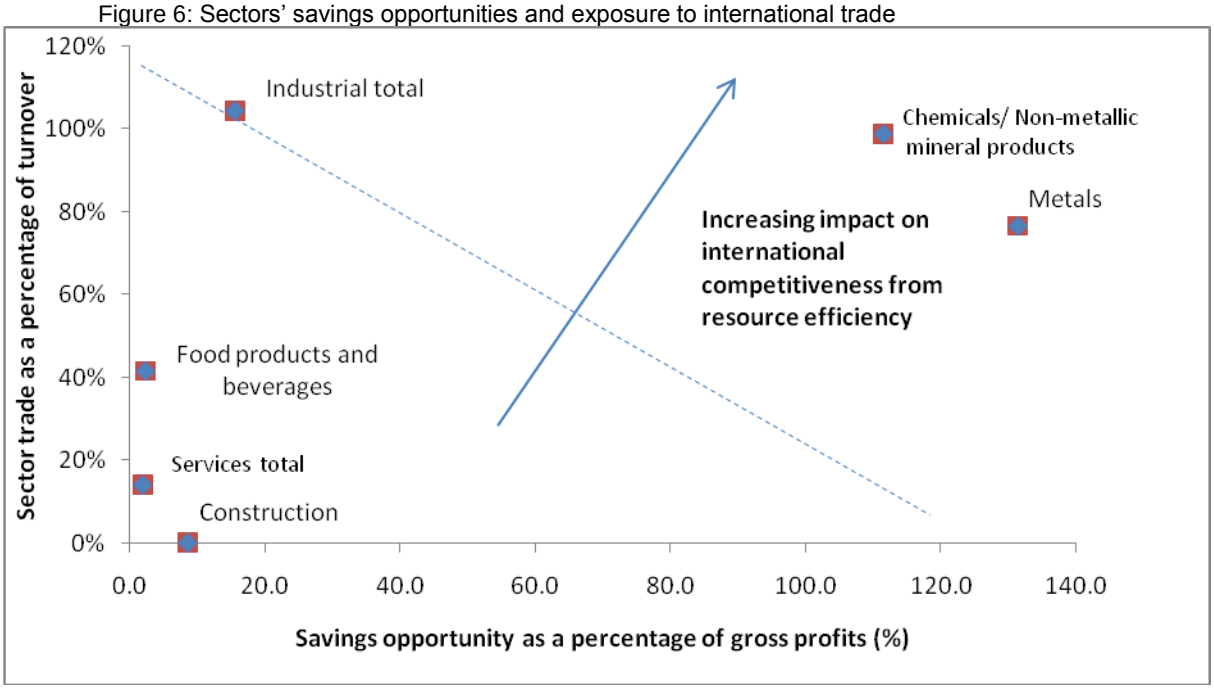
[11] *Promoting Environmental Technologies in SMEs: Barriers and Measures*, IPTS (2007)

2.5 Competitiveness

On competiveness, Figure 6 shows the sectors' savings opportunities as a percentage of gross profits and compared to their exposure to international trade. Service sectors are inherently domestically orientated. Even excluding the transport sector, trade in private sector services is only 14% of sector turnover, and the savings opportunity is only 2% of profits.

On the other hand, industrial sectors' average total trade to turnover is 104%, and the savings opportunity as a percentage of gross profits (assuming all waste and low-cost water and energy opportunities are realised) is 2.6%. Manufacturing of Chemicals/ Non-metallic mineral products, and Metals and metal products stand out in terms of the opportunity (both over 100% of profits) as well as having significant exposure to international trade. The very large opportunity for the Metals sector originates mostly from waste as a result of waste arisings increasing in the recent C&I waste survey. The opportunity within Chemicals / non-metallic mineral products comes largely from lean production savings estimated by WRAP, so a portion of this saving may be forward looking.

Figure 6: Sectors' savings opportunities and exposure to international trade



3 Methods and approach

The eight study objectives listed in Section 1.2 were split into six work streams. The work streams are:

1. Determination of the low cost resource efficiency savings opportunities, broken down by the type of resource efficiency measures/interventions.
2. Determination of the resource efficiency savings opportunities requiring capital investment with a payback of greater than one year, broken down by the type of resource efficiency measures/interventions.
3. Assessment of the impact existing Government policies has on resource efficiency.
4. Determination of the significance of the waste hierarchy in terms of resource efficiency interventions; cost and impact.
5. Determination of the technological, process, economic and behavioural barriers for resource efficiency and assessment of the impact the size of the organisation presents with respect to the different opportunities and barriers.
6. Determination of the effect the resource efficiency measures / interventions have on the competitiveness of the UK economy and individual sectors.

The methods and approach for each work stream is detailed below with the results shown in Sections 4 to 10 of this report.

3.1 Determination of the low cost resource efficiency savings opportunities broken down by the type of resource efficiency measures/interventions

This work stream provides an update on the Defra *Business Benefits* study which estimated the no cost / low cost resource efficiency opportunities in 2006. Ideally this current study would have used the same methodology and approach as used in the previous study, to provide continuity between the two studies. However, a number of the datasets and sources used in that study have not been updated or better alternatives are now available, and hence the method and approach was modified.

The general approach used within this study is:

- Step 1: Quantify overall energy and water consumption and waste generation by UK economic sector in 2009.
- Step 2: Determine the causative factors for any changes in consumption or generation since 2006, i.e. is the change in consumption/generation between 2006 and 2009 due to changes in sector output or intensity based changes (improved efficiencies)?
- Step 3: Quantify the no cost / low cost intensity based interventions (payback less than one year) realised between 2006 and 2009.
- Step 4: Determine the 2009 no cost / low cost resource efficiency opportunity using the information gathered in Steps 1 to 3.

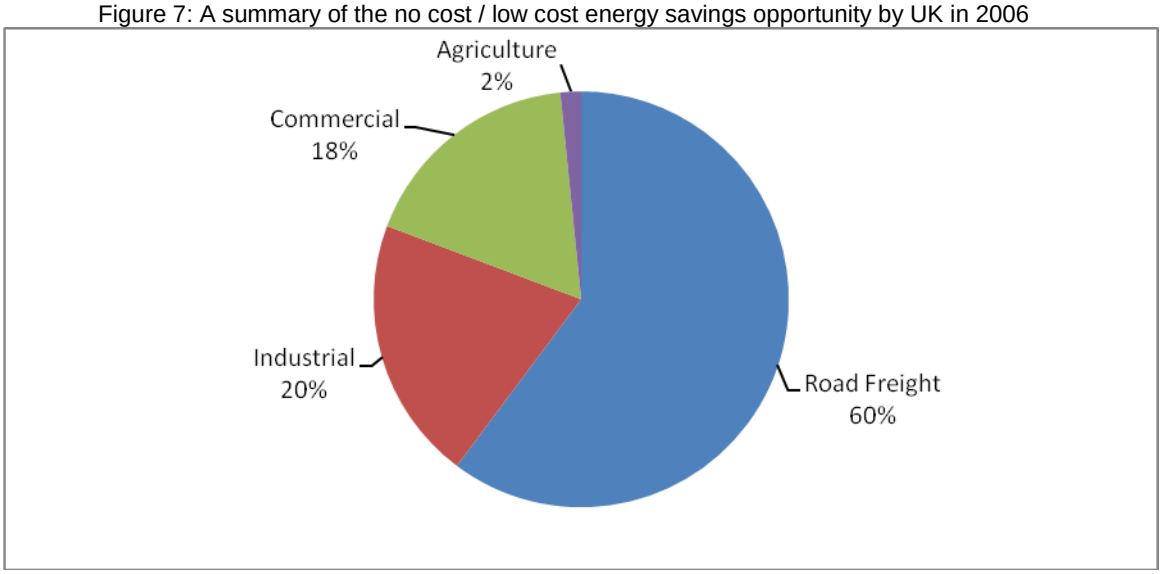
It is noted that Step 3 includes a review of any innovation in no cost / low cost resource efficiency interventions that have occurred between 2006 and 2009. The findings from the Defra work on structural decomposition were used as a proxy to identify the sectors in which innovation was most likely to occur (Annex A). The five key focus sectors are Construction, Electricity, Hotels and catering, Public administration and defence, and Education.

3.1.1 Energy

3.1.1.1 Background

The Defra *Business Benefits* study valued the UK's low cost energy savings opportunity in 2006 at £3.3 billion. Figure 7 shows that Road freight dominated the savings opportunity accounting for 60% of the savings.

Figure 7: A summary of the no cost / low cost energy savings opportunity by UK in 2006



Source: Oakdene Hollins & Grant Thornton for Defra (2007), *Quantification of the business benefits of resource efficiency*

3.1.1.2 Method and approach

In determining the no cost / low cost energy efficiency opportunities in 2009 this study will determine:

- the change in total sector energy intensity between 2006 and 2009
- the proportion of the change in energy intensity due to no cost / low cost interventions.

The initial approach used to identify the change in intensity was to use Department of Energy and Climate Change (DECC) annual energy consumption data tables for the UK[12] combined with monetary output data from the Office for National Statistics' Blue Book[13] (ONS). However this approach gave volatile results (see Annex B) due to Service sector reclassifications[14] and possible distortions introduced by using monetary output as a proxy for underlying activity in the Industrial sector.

An alternative approach was developed based on a study by the Carbon Trust[15] which identified the savings opportunities for the Services, Retail, Public and Chemicals sectors in 2009. These were calculated by taking the savings opportunities in 2006/07, and the implementation rate of the corresponding 18,448 savings recommendations made to 2,132 organisations in this year, to 2009. Furthermore, since the opportunities are defined by

[12] DECC (2010), *Energy Consumption in the UK, Industrial (Service; Transport) Data Tables: 2010 update*

[13] ONS (2010), *The Blue Book – UK National Accounts: 2010 edition*

[14] DECC, personal communication

[15] Carbon Trust (2010), *Breaking through the barriers: Unleashing energy efficiency in the UK*.

payback period, the data can be used to identify the implementation rate for low cost measures as a percentage of the total.

The implementation or realisation rate of low cost measures for each sub-sector was multiplied by the opportunity that existed in 2006, which in turn was multiplied by the energy consumption in 2009 (DECC, 2010[13]) to derive the current low cost savings. This was given a financial value by applying the weighted average unit cost of energy for each sub-sector, which was derived from DECC data on each sub-sectors' energy mix[13] and the unit cost of each type of energy[16]. The carbon dioxide equivalent (CO_2e) savings are derived using conversion factors calculated in the previous Defra study for 2006[17]. These are tonnes of oil equivalent (toe) to tCO_2e for each source of energy.

For the **Service** sector the Carbon Trust data were applied directly to sub-sectors defined as either Retail, Other private sector services, or Public sector services.

Within the **Industrial** sector, Carbon Trust data exist only for the Chemicals sub-sector and so the above methodology could only be applied directly to this sector. For the other industrial sub-sectors the change in overall energy intensity was derived from data on sector-level Climate Change Agreements (CCAs). Unlike with the DECC/ONS approach, the data on energy consumption and output for CCAs are inextricably linked. Not all companies in industrial sub-sectors for which CCAs exist are party to them, and since companies outside of CCAs are likely to have lower reductions in energy intensity, this was factored into the calculation.

CCAs do not exist for the Coke and petroleum products sector, but because they are part of the energy supply chain, DECC provide consumption and output data on its component parts (petroleum refineries; coke manufacture). Not only are both data series comparable in terms of constituents, but their outputs are measured in terms of unit energy allowing accurate measurement of changes in energy intensity.

To calculate the proportion of the change in energy intensity due to low cost interventions for industrial sub-sectors other than Chemicals, the initial approach was to conduct a literature review and approach the relevant trade associations. This did not provide robust answers, and therefore the low cost ratio was taken to be between that for the Chemicals sector and the average for all four sectors (Services, Retail, Public and Chemicals) in the Carbon Trust analysis. This methodology was based on the assumption, supported by the Carbon Trust[16], that as an energy intensive sector, the Chemicals sector had already realised many efficiencies prior to 2006. Therefore if its low rate of low cost interventions after 2006 were applied to other, less energy-intensive industrial sub-sectors, the result might overstate the remaining opportunity to those sectors in 2009. On the other hand, it is likely that all these sectors will have been at least as energy efficient as the average of the Public, Services, Retail and Chemicals sectors, and so applying this rate of low cost interventions would produce the most conservative estimate of their remaining opportunity.

In addition there is a risk that using the savings opportunity identified in the Carbon Trust study may represent an overestimate of the savings realisation rate and therefore an underestimate of the remaining potential sector savings opportunities, since any organisation engaged with the Carbon Trust is likely to have improved its efficiency more than the sector average. It has not been possible to challenge this hypothesis, due to a lack of comparative

[16] DECC (2010), *Quarterly Energy Prices*, available at URL http://www.decc.gov.uk/en/content/cms/statistics/publications/prices/prices.aspx [accessed 25 October 2010]

[17] Oakdene Hollins for Defra (2009), *Quantification of the potential CO_2 savings from resource efficiency in the UK*

data. However an offsetting factor is that the base period (2006/07) from which the realisation rate has been measured by the Carbon Trust is slightly more recent than the base year for the initial opportunity (2006).

The Road freight sector accounted for over £2 billion or 60% of the total energy efficiency opportunities identified in the report for 2006. It was therefore considered important to validate the 2006 estimates prior to estimating the change in opportunities between 2006 and 2009.

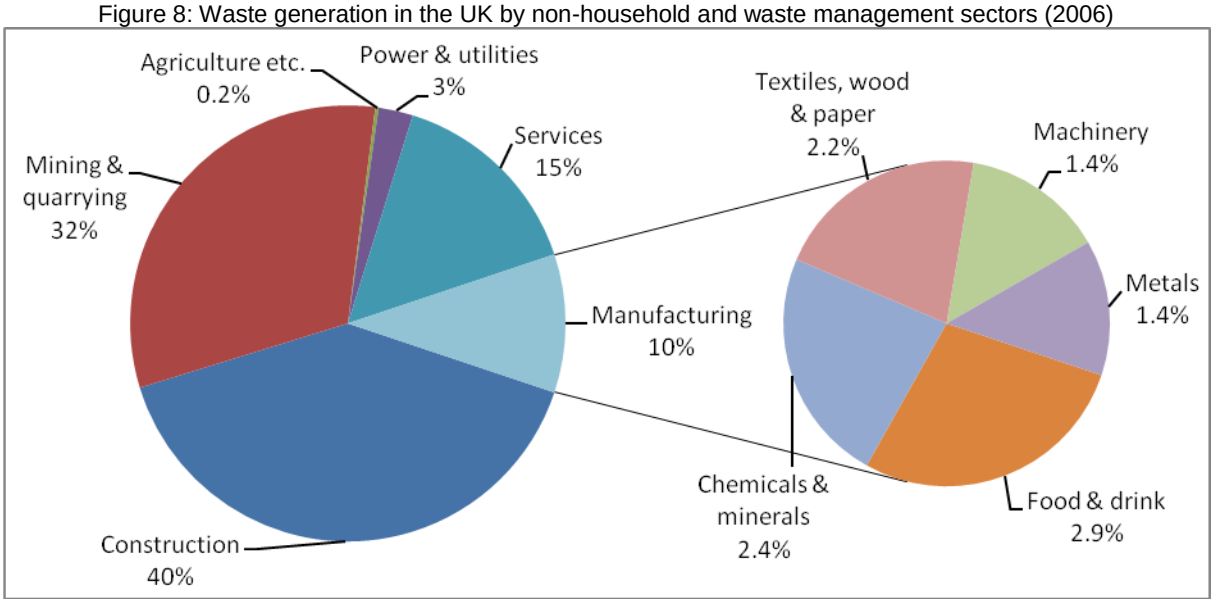
3.1.2 Waste

3.1.2.1 Background

In terms of UK waste generation, Defra's submission to Eurostat provides an estimate for 2006. These estimates are largely based upon projections from the 2002/03 C&I Waste Survey, which affects their reliability. However because no alternative estimates for the 2006 base year are available, this data has been used as the baseline for the waste estimates within this study.

Excluding waste generated by the household and within the Waste management sector, total arisings amounted to 273 Mt. Figure 8 shows the sector breakdown. This shows that Construction - which comprises construction, demolition and excavation waste (CDEW) (109.6 Mt or 40.1%) - and Mining and quarrying (86.8 Mt or 31.8%) dominate, accounting for 71.9% of total waste arisings.

Figure 8: Waste generation in the UK by non-household and waste management sectors (2006)



Source: Defra submission to Eurostat (2006)

The waste resource efficiency opportunities identified for 2006 in the Defra *Business Benefits* report are shown in Table 11. In total 38.7 Mt of opportunities were identified, of which 33.2 Mt was diversion of waste from landfill[18], and 5.5 Mt was waste reduction. Construction and Mining and quarrying accounted for 69% of the savings opportunity with the better management of unavoidable waste being the key opportunity.

[18] For details of the alternative waste management options modelled for the diversion of waste from landfill, the reader is referred to the previous study: Oakdene Hollins & Grant Thornton for Defra (2007), *Quantification of the business benefits of resource efficiency*

Table 11: Identified waste resource efficiency opportunities by sector (Mt) in 2006

Sector	Resource efficiency intervention		Total
	Diversion from landfill	Waste reduction	
Agriculture & fishing	0.10	0.0	0.10
Construction	19.66	2.24	21.90
Mining & quarrying	4.85	0.0	4.85
Energy supply	1.90	0.0	1.90
Food, drink & tobacco	0.80	0.92	1.72
Textiles / wood / paper / publishing	0.38	0.27	0.65
Chemicals / non-metallic minerals	0.44	0.47	0.91
Metal manufacturing	0.25	0.0	0.25
Machinery & equipment (other)	0.76	0.0	0.76
Retail & wholesale	1.00	0.82	1.82
Public sector	0.49	0.02	0.51
Hotels & catering	0.75	0.32	1.07
Transport & storage	0.29	0.00	0.29
Other services	1.14	0.14	1.28
Waste management	0.67	0.0	0.67
Total	**33.48**	**5.20**	**38.68**

Sources: Oakdene Hollins & Grant Thornton for Defra (2007), *Quantification of the business benefits of resource efficiency*, & Oakdene Hollins for Defra (2009), *Quantification of the potential CO_2 savings from resource efficiency in the UK*

3.1.2.2 The method and approach

The method and approach used in this study is to evaluate the progress made between 2006 and 2009 in realising the resource efficiency savings opportunities with particular focus the two largest sectors in terms of waste arisings and identified waste savings opportunities:

- Construction, demolition and excavation
- Mining and quarrying.

Together these two sectors accounted for 71.9% of the waste generated in 2006.

To make an evaluation of the progress made in the other Commercial and Industrial sectors, data from national C&I waste surveys will be used. The methodology used for this examines the trends in waste and landfill volumes for each sector between 2006 and 2009. GVA data from the ONS *UK National Accounts: The blue book* will then be used to develop Business As Usual (BAU) scenarios to assess the progress made on waste reduction and waste diversion.

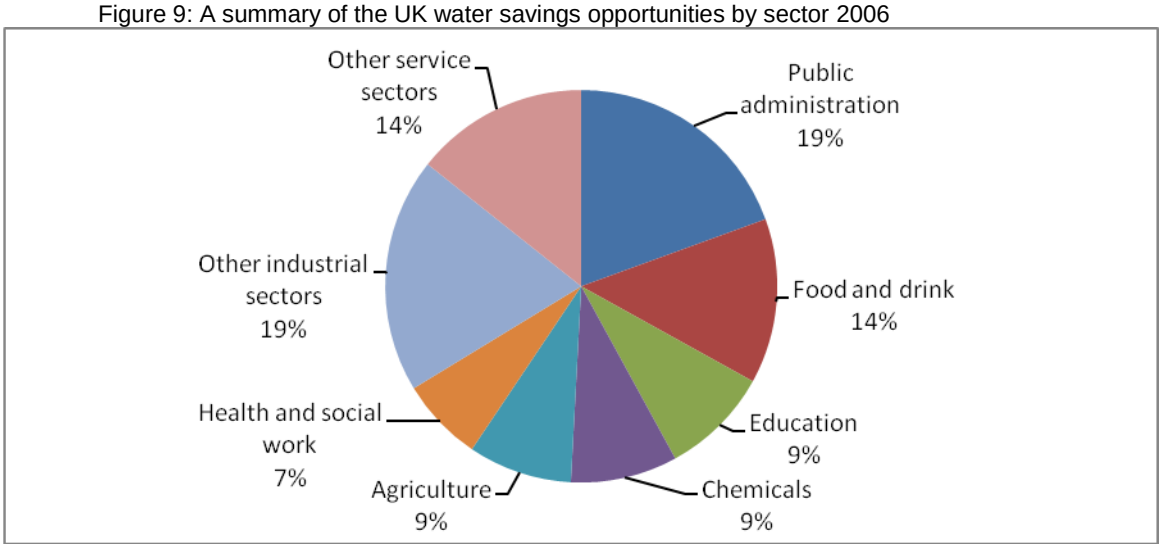
In addition ‘quick win’ material savings to 2020 identified by Stockholm Environment Institute and the University of Durham in their study for WRAP, *Meeting the UK climate change challenge: The contribution of resource efficiency* (2009), have been included.

3.1.3 Water

3.1.3.1 Background

The original Defra *Business Benefits* study, undertaken by Oakdene Hollins for 2006, valued the no cost / low cost water efficiency savings opportunities for 2006 at £440 million with Public Administration, Food and drink, Education, Chemicals and Agriculture accounting for 60% of the identified savings opportunity (Figure 9 and detailed in Annex C).

Figure 9: A summary of the UK water savings opportunities by sector 2006



Source: Oakdene Hollins & Grant Thornton for Defra (2007), *Quantification of the business benefits of resource efficiency*

The quantification of the no cost / low cost water savings opportunities within the original study is considered the least robust of the three focus resources due to the lack of robust data on the consumption of water by sector. In addition, many of the water audits undertaken within each sector focused predominantly on specific issues and not on total water use.

In light of the difficulties experienced when taking a bottom-up approach, this study adopts a top-down approach with the starting point being total water consumption in the UK.

3.1.3.2 Method and approach

For this study, focus is placed on the consumption of water from freshwater users. Freshwater users are broken down into two main categories:

- Public water supply: Water abstracted by water companies and distributed to end users.
- Non-public supply abstraction: Water abstracted directly by end users.

The significant exclusion from the study is tidal water, since it is abstracted largely for the electricity supply sector for cooling purposes with the majority being non-consumptive, i.e. returned to the water course after use.

Government statistics on water consumption from freshwater users were used and, where necessary, extrapolated up to derive the 2009 water consumption estimates and to estimate the top level changes in water consumption made between 2006 and 2009.

There are two key government sources of data on water consumption:

- Defra – e-digest of statistics[19]
- Defra/ONS – Environmental Accounts[20]

The two datasets differ considerably with the e-digest of statistics providing annual top level water consumption data and the Environmental Accounts providing a detailed breakdown of water consumption at sector level with the aim of providing a clear understanding of the sources, stocks, exchanges and flows of the water cycle in order to effectively manage water sources. Unfortunately, the detailed analysis is not undertaken annually with the last estimate made in 2006/7 and the next planned for 2014. A combination of these two datasets were used within this study.

Alternative data sources, such as sector level studies, were used to estimate the change in water consumption that can be attributed to a change in efficiency (intensity) rather than a change in sector level output.

To establish the economic valuation of the derived water savings opportunity, the United Kingdom Input – Output Analyses were used to determine the change in water supply costs. The Environmental Accounts were used to derive the wastewater management costs.

3.2 Determination of the resource efficiency savings opportunities with a payback of greater than one year

The original Defra *Business Benefits of Resource Efficiency* study for 2006 focused solely on the no cost / low cost resource efficiency opportunities, i.e. resource efficiency interventions with a payback of less than one year. An objective of this study (Objective 3 shown in Section 1.2), however, is to determine the total annual savings opportunities, which includes both the quick wins and the longer term interventions.

This section of the study relies heavily on the recent work undertaken to determine the contribution resource efficiency can make to the delivery of the UK greenhouse gas (GHG) emissions reduction targets outlined in the Climate Change Act of 2008, committing the UK to reducing its annual carbon emissions by at least 80% below 1990 levels by 2050.

It must be stressed that projecting or forecasting the resource efficiency savings opportunities using a 40-year time span is inevitably going to be less accurate than the estimate of savings from shorter term interventions, and hence these estimates should be treated with caution and regarded as only 'ballpark' estimates.

3.2.1 Energy

The Committee on Climate Change (CCC) produced the first of its reports *Building a low carbon economy – the UK's contribution to tackling climate change* in December 2008 with the main focus of the report on energy abatement potential within key economic sectors, including Transport, Non-domestic buildings and Industry.

[19] http://www.defra.gov.uk/evidence/statistics/environment/inlwater/iwabstraction.htm

[20] ONS (2010), Environmental Accounts, Feb 2010 update

http://www.statistics.gov.uk/downloads/theme_environment/ea-feb10.pdf

Sectors excluded from this section of the study include the Power sector and Agriculture. The DECC *2050 Pathways Analysis (July 2010)* reports, based on Ofgem's *Project Discovery*, that significant investment (estimated at £100 billion) will be required within the Power sector over the coming decade to facilitate the move to a low carbon economy.

Consequently, the need for such capital investment within the Power sector was considered counter to the general underlying requirement within this study for all resource efficiency interventions to be environmentally beneficial and, at least, cost neutral. The *2050 Pathways Analysis* study also states that reducing the emissions within the Agriculture sector poses a particularly difficult challenge since technological solutions that exist in most other sectors, to a large extent, do not yet exist within Agriculture. The report concludes that:

"While there is clearly scope to realise significant improvements in efficiencies in production to reduce emissions per unit of production, the initial analysis suggests that the scope to reduce emissions in the agriculture and land use sectors may be limited compared to other sectors"

3.2.1.1 Transport

For freight transport, the study and general focus of the CCC has been on road freight. The CCC/DfT report *Low carbon transport: a greener future (July 2009)* states:

"Emissions from freight movements stem primarily from the road sector. HGVs represent 20% and vans 11% of total domestic transport greenhouse gas emissions. Focusing our policies on reducing emissions from road freight therefore makes the most sense"

The same approach is therefore taken within this study.

The CCC study categorised emissions reduction potential into three scenarios (Current Ambition, Extended Ambition and Stretch Ambition). The study took a technology based approach; quantifying the environmental and economic benefits from alternative technology based interventions.

Marginal abatement cost (MAC) curves were produced in the study for the current and extended ambition scenarios and these were used in this current study to determine the emissions savings opportunity by intervention. To derive the economic cost savings the raw material (fuel) savings calculated in the *Business Benefits* study were used, i.e. £410 per tonne of CO_2.

Unlike the two previous scenarios, no economic analyses (i.e. MAC curves) were produced on the stretch ambition scenario. The study does however quantify the level of potential environmental savings. This current study used these potential environmental savings to provide an estimate of the economic savings opportunity in this scenario.

3.2.1.2 Non-domestic building and industry

The savings opportunity within Non-domestic buildings and Industry were not determined by scenario-building. Instead a single MAC curve was produced by the CCC for each of the two focus areas. These MAC curves were used in a similar way to those for Transport, discussed above. *Please note: only the interventions resulting in a financial saving were considered.*

3.2.2 Waste

The overall aim of the WRAP-funded research: *Meeting the UK climate change challenge: The contribution of resource efficiency* (2009) was to understand the contribution material resource efficiency and sufficiency could make to the UK's 80% GHG emission reduction target by 2050. *Please note: it is reported within the study that transport and energy generation were excluded from this study since it was felt that they had been covered comprehensively in other studies. This provided a level of confidence that double counting of savings opportunities across the data sources used within this section of the report would be minimal.*

3.2.3 Water efficiency

Unlike Energy and Waste no detailed reports could be found on the water efficiency opportunities in the UK. Consequently, top level estimates reported by the Environment Agency[21] were used.

3.3 Assessment of the impact existing Government policies has on resource efficiency

The objective of this section is to determine the impact that Government policies, initiatives and voluntary agreements have had on achieving resource efficiency savings to enable Government to undertake a review of the mix of interventions. The approach taken for this objective was a literature review of evaluations that have been conducted on the various interventions, including:

- Government policies:
  - Landfill Tax
  - IPPC
  - Carbon Reduction Commitment (CRC).
- EU Emissions Trading System (EU ETS)
- Business Resource Efficiency and Waste Programme (BREW)
- The Freight Best Practice programme, run by the DfT
- Enhanced Capital Allowance Scheme (ECA)
- Voluntary agreements:
  - The Courtauld Commitment
  - Halving Waste to Landfill (in construction)
  - The FDF Five-fold commitment including the Federation House Commitment.
- British Retail Consortium's 'Better Retailing Climate'.

Please note: the Climate Change Agreement (CCA) is discussed in detail in Section 4.1.2 and hence is excluded from this analysis.

3.4 Determination of the significance of the waste hierarchy in terms of resource efficiency interventions; cost and impact

The principle of the waste hierarchy - that waste prevention is better than waste disposal - was first introduced into European Policy in the 1970s. The objective of this section is to provide quantitative evidence on the magnitude of the environmental and economic savings

[21] Environment Agency Website available at URL http://www.environment-agency.gov.uk/news/109641.aspx, [accessed 19th June 2010]

that can be achieved by moving up the waste hierarchy based upon a review of the existing literature. Within this section:

- The carbon benefits of recycling are summarised.
- The savings from waste diversion are compared to those estimated to be available from waste reduction for two materials, food and glass.
- Additional benefits from reuse and remanufacturing are quantified.

For the economic benefits, evidence is reported for two materials: food and cardboard.

3.5 Determination of the barriers for resource efficiency

The first part of the report has quantified the resource efficiency opportunities available for business. However many studies cite the barriers to realising them in practice. The objective of this section is to understand the barriers that exist and limit the uptake of resource efficiency measures that are cost effective for business. The approach taken here is to review the existing literature and evidence on barriers, including the issues regarding the size of the organisation. The key barriers identified and discussed were:

- financial costs
- 'hidden' costs
- market failures and
- behavioural and motivation.

3.6 Determination of the effect the resource efficiency measures / interventions have on competitiveness.

The methodology follows that of the original Defra study for 2006. This compared the total savings opportunity to a sector's turnover, GVA and gross profit. This study will focus on gross profit since it is the level at which the cost saving will have the greatest impact.

Gross profit is defined as GVA less employment costs, with both data sets available from the Annual Business Inquiry produced by the Office for National Statistics.

Having calculated the ratio of savings to gross profit, this study goes on to identify which sectors are most exposed to international competition and therefore will see the greatest benefit from an increase in competitiveness. The globalisation of a sector is defined as total trade i.e. imports plus exports. Using net exports may mask significant levels of trade if both imports and exports happened to be similar.

4 Determination of the low cost resource efficiency savings opportunities

This section of the report provides an update on the Defra *Business Benefits* study which estimated the no cost / low cost resource efficiency opportunities in 2006 for energy, waste and water using the methodologies set out in Section 3.1. Where the coverage of the low cost opportunities has been expanded, this has been noted in order that it is possible to evaluate progress made since 2006 on a like-for-like basis. Wherever possible, ranges have been quoted to provide an indication of the accuracy of the results obtained.

4.1 Energy

This section of the report focuses on:

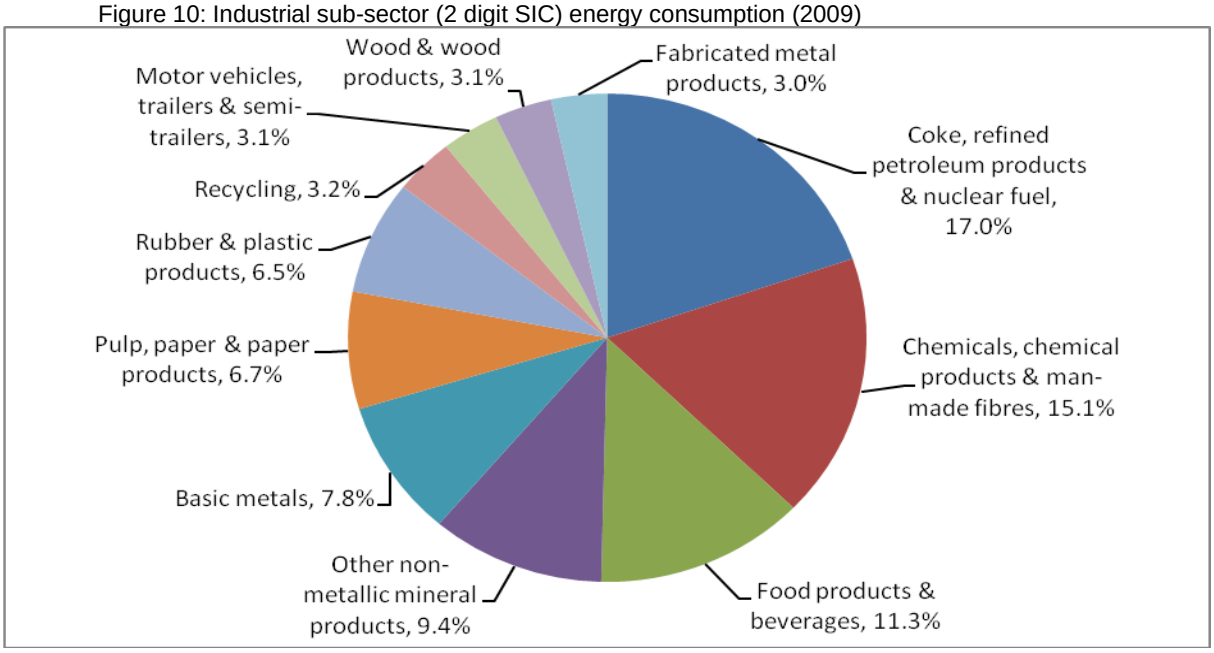
- the Industrial sector
- the Service sector
- Road freight.

4.1.1 The Industrial sector

4.1.1.1 Background

The share of current Industrial sector energy consumption by sub-sector is shown in Figure 10. The analysis shows the top four energy consuming sectors account for over 50% of the total energy consumed.

Figure 10: Industrial sub-sector (2 digit SIC) energy consumption (2009)



Source: DECC (2010), *Energy Consumption in the UK, Industrial (Service; Transport) Data Tables: 2010 update*

The Defra *Business Benefits* for 2006 study aggregated sub-sectors (2 digit SIC code) where the businesses were similar. For example 'Chemical, chemical products and man-made fibres', 'Rubber products' and 'Plastic products' were aggregated to 'Chemicals'. The low-cost savings opportunities for the aggregated sub-sectors according to that study are shown in Table 12.

Table 12: Low cost energy savings for industrial sub-sectors for 2006

Industrial sub-sector	**Estimated savings in 2006 (%)**
Chemicals	7.0
Coke, refined products & nuclear fuel	2.0
Basic metals / Mechanical engineering	4.4
Food & drink	5.5
Paper, printing & publishing	4.5
Vehicles	4.0
Textiles	7.1
Electrical engineering	6.2
Construction	12.4
Other	4.8

Source: Oakdene Hollins & Grant Thornton for Defra (2007), *Quantification of the business benefits of resource efficiency*

To maximise the utility of this study's data, the estimated savings from Defra's study for will be applied to sub-sectors as defined by the 2007 2-digit SIC codes.

4.1.1.2 Quantification of savings

The Chemicals sector can be seen to account for 15.1% of total Industrial sector consumption, Figure 10. When including rubber products and plastic products, as in the previous Defra study for 2006, this increases to 21.6%.

For this study the remaining opportunity for the Chemicals sector was calculated by directly applying the findings from the Carbon Trust[16] study as described in Section 3.1.1. 39% of the Chemicals sector's low cost opportunity existing in 2006/2007 had been realised by 2009. Therefore 61% of the opportunity indentified by Defra (2006) remains.

To calculate the remaining opportunity for the *Coke, refined petroleum products & nuclear fuels* sector, DECC data were used as outlined in Section 3.1.1. The DECC data[22] on the output of 'petroleum refineries' and 'coke manufacture' and their energy consumption, state that the reduction in energy intensity for this sector was -6.1% between 2006 and 2009. This is consistent with -2.0% average annual reductions in energy intensity by companies under sector-level Climate Change Agreements (CCA) between 2006 and 2008.

For the remaining Industrial sectors (other than Chemicals, chemical products and man-made fibres, and Coke, refined petroleum products and nuclear fuels), the change in energy intensity was calculated using sector-level CCA data[23]. Sector-level CCAs exist for companies in five (including Chemicals) of the six sectors with the highest energy consumption in the Industrial sector. The exception is Coke and petroleum products which

[22] DECC (2010), *Digest of United Kingdom Energy Statistics*, Chapter 1, 2010 Edition (and 2009 Edition).

[23] AEA (2009), *Climate Change Agreements – Results of the Fourth Target Period Assessment*,

do not fall under the Climate Change Levy[24]. These five sectors consume an additional 50% of total Industrial sector energy[13], over-and-above the 17% consumed by Coke and petroleum. Therefore in total these six energy-intensive sectors consume 67% of all Industrial sector energy.

For the purpose of this analysis, the CCA data have the benefit of comparing changes in energy use to more appropriate measures of sector output (where this is available), such as tonnes of product for material sectors. It also eliminates distortions to DECC/ONS data introduced by changes in SIC sector coverage since any change in companies party to a sector-level CCA (as opposed to an individual CCA) must be accurately logged in terms of its impact on energy use and output. On the other hand, CCAs are likely to represent the best case improvement in energy efficiency since the incentive to improve is greater (an 80% reduction in the Climate Change Levy). Therefore where the proportion of a sector outside of CCAs is large, then estimates based on the performance of companies' party to these agreements may overstate the overall realisation rate of a sector's energy savings opportunities.

The reduction in energy intensity by companies party to CCAs in the remaining four most energy consuming Industrial sectors (i.e. excluding Chemicals, chemical products and man-made fibres, and Coke, refined petroleum products and nuclear fuels), along with each CCA's share of the corresponding SIC sector's energy consumption, is given in Table 13. Where a number of CCAs are administered by different associations within each Industrial SIC sector, these have been aggregated (for example, within Food and drink manufacturing there is a CCA administered by the Food and Drink Federation, but also several others), and the change in SIC sector energy intensity is the weighted average of the CCAs. A full breakdown of CCA data can be found in Annex B.

The CCA measurement periods are 2002, 2004, 2006 and 2008. To calculate the change in energy intensity between 2006 and 2009, the change between 2006 and 2008 was annualised and then scaled up. To check that the annual change for each sector over this period was not anomalous, it was compared with the annual change between 2002 and 2008. It is acknowledged that companies' party to CCAs are likely to represent best practice for reductions in energy intensity. To compensate for this, we assume that companies not party to CCA agreements have reduced their energy intensity by between zero ('lowest rate of energy intensity change') and the average rate for companies in their sector that are party to CCAs.

For sectors consuming the remaining 33% of Industrial sector energy, we assume that the reduction in energy intensity is between the zero and –6.0%, the average for all CCAs for which energy intensity can be calculated.

To estimate the proportion of a sectors' energy intensity change due to low-cost initiatives, we conducted a literature review and contacted the relevant trade associations[25]. None of the respondents was able to estimate the percentage of energy savings due to such measures. Therefore the proportion of the change due to low-cost interventions was assumed to be between that of the Chemicals sector, and the average of the four sectors in the Carbon Trust study[16]. The study identified that within the overall Chemicals sector energy savings opportunity identified in 2006:

- 19% was from 'carbon and energy management'
- 3.3% from 'heating, ventilation and air conditioning' and

[24] UK Petroleum Industry Association, personal communication

[25] Food and Drink Federation, Mineral Products Association, UK Steel, British Glass and the Confederation of Paper Industries.

- 0.7% was from ‘controls and operations’.

Table 13: Implied change in industrial sub-sector energy intensity 2006-2009 as a result of Climate Change Agreements

SIC (92) code	SIC Sector	CCA Administrator	CCA share of SIC sector energy con-sumption	Intensity change 2006-8 (%)	Implied intensity change 2006-9 (%)	Lowest rate of energy intensity change 2006-9 (%)	Annual change 2006-8 (%)	Annual change 2002-8 (%)
15	Manufacture of food products & beverages	Food and Drink Federation; Other	76%	-4.0	-6.0	-4.5	-2.2	-1.7
21	Manufacture of pulp, paper & paper products	Confederation of Paper Industries	58%	-3.0	-4.4	-2.5	-1.4	-2.1
26	Manufacture of other non-metallic mineral products	Mineral Products Association; British Glass; British Ceramic Confederation; Other	80%	-3.6	-5.3	-4.3	-1.9	-1.6
27	Manufacture of basic metals	UK Steel	100%	-1.8	-2.6	-2.6	-0.9	-1.6

We assume that these all have paybacks of less than one year and therefore 23% of the overall savings opportunity for this sector can be defined as no cost / low cost. The same analysis for the Public, Services, Retail and Chemicals sectors puts the average share of low cost opportunities at 68%.

The study identified that for the Chemicals sector, 39% of the low cost opportunity was realised between 2006 and 2009, compared to 22% of the overall opportunity. This gives a low cost opportunity realisation rate to total opportunity realisation rate for the Chemicals sector of 0.4:1 [(39% of 23% =) 9% to 22%]. Or, for every 1% fall in overall energy intensity, 0.4% is due to low cost initiatives; applying this ratio gives the maximum (‘max’ in Table 14) remaining low cost savings opportunity in 2009.

The average low cost realisation rate for the Public, Services, Retail and Chemicals sector was 46% compared to 39% of the overall opportunity. This gives an average low cost opportunity realisation rate to total opportunity realisation rate of 0.8:1 [(46% of 68% =) 31% to 39%]. Applying this ratio gives the minimum (‘min’ in Table 14) remaining low cost savings opportunity in 2009.

Based on this approach and the estimated changes in energy intensity outlined above, Table 15 summarises the range of remaining low-cost savings opportunity by industrial sub-sector.

The breakdown of energy consumption by fuel, as well as the unit price of each type of fuel, can be found in Annex B. Prices shown exclude the Climate Change Levy, which is not a real economic saving but a reduction in tax. To calculate the financial value for each sub-sector, the range of savings opportunities identified in Table 14 is multiplied by 2009 energy consumption, which is in turn multiplied by the unit price of electricity (Table 15). For Basic metals and Coke and refined petroleum products, ‘manufactured fuels’ such as blast furnace gas represent a significant proportion of the total energy consumption. These have not been included in the weighted average price of electricity for these sectors. This methodology assumes that any reduction in these sectors’ energy use comes from the other sources of energy.

Table 14: 2009 low cost savings opportunity by industrial sub-sector 2009

SIC (92) code	SIC Sector	Share of industrial energy use	Implied intensity change 2006-9 (%)	Lowest rate of energy intensity change 2006-9 (%)	Defra low-cost savings opportunity in 2006 (%)	Range of low cost savings opportunities, 2009 (%)	
						min	**max**
23	Coke, refined petroleum products & nuclear fuel	17%	-6.3	N/A	2.0	0.0	0.0
24	Chemicals, chemical products & man-made fibres	15%	39% of 2006 low-cost opportunity realised		7.0	4.3	4.3
15	Food products & beverages	11%	-6.0	-4.5	5.5	0.7	3.6
26	Non-metallic mineral products	9%	-5.3	-4.3	4.8	0.6	3.1
27	Basic metals	8%	-2.6	-2.6	4.4	2.3	3.3
21	Pulp, paper & paper products	7%	-4.4	-2.5	4.5	1.0	3.5
	Other	33%	-6.0	0.0	4.8	0.0	4.8
	Weighted average					**1.0**	**3.4**

Table 15: The range of low-cost savings opportunities available to each industrial sub-sector 2009

SIC (92) code	Industrial sub-sector	Energy consumption 2009 (Ktoe)	Range of low-cost savings opportunities, 2009 (%)		Range of low-cost savings opportunities, 2009 (Ktoe)		Weighted average energy price (p/kWh)	Range of low-cost savings opportunities, 2009 (£M)	
			min	**max**	**min**	**max**		**min**	**max**
23	Coke, refined petroleum products & nuclear fuel	5,666	0.0	0.0	0.0	0.0	2.98	0.0	0.0
24	Chemicals, chemical products & man-made fibres	4,555	4.3	4.3	194.5	194.5	3.97	89.6	89.6
15	Food products & beverages	3,389	0.7	3.6	23.7	123.3	3.70	10.2	53.0
26	Non-metallic mineral products	2,776	0.6	3.1	15.5	84.8	2.64	4.8	26.0
27	Basic metals	2,498	2.3	3.3	58.0	83.3	4.84	32.5	46.7
21	Pulp, paper & paper products	2,032	1.0	3.5	19.9	70.3	3.75	8.7	30.6
	Other	14,432	0.0	4.8	0.0	692.7	4.68	0.0	376.5
	Total							**145.7**	**622.3**

The carbon dioxide equivalent (CO_2e) savings for industrial sub-sectors, derived using the conversion factors from the previous Defra study for 2006[18], are shown in Table 16. The 'sector conversion factor' is the average of the conversion factors for each energy type weighted according to the energy mix for that sector.

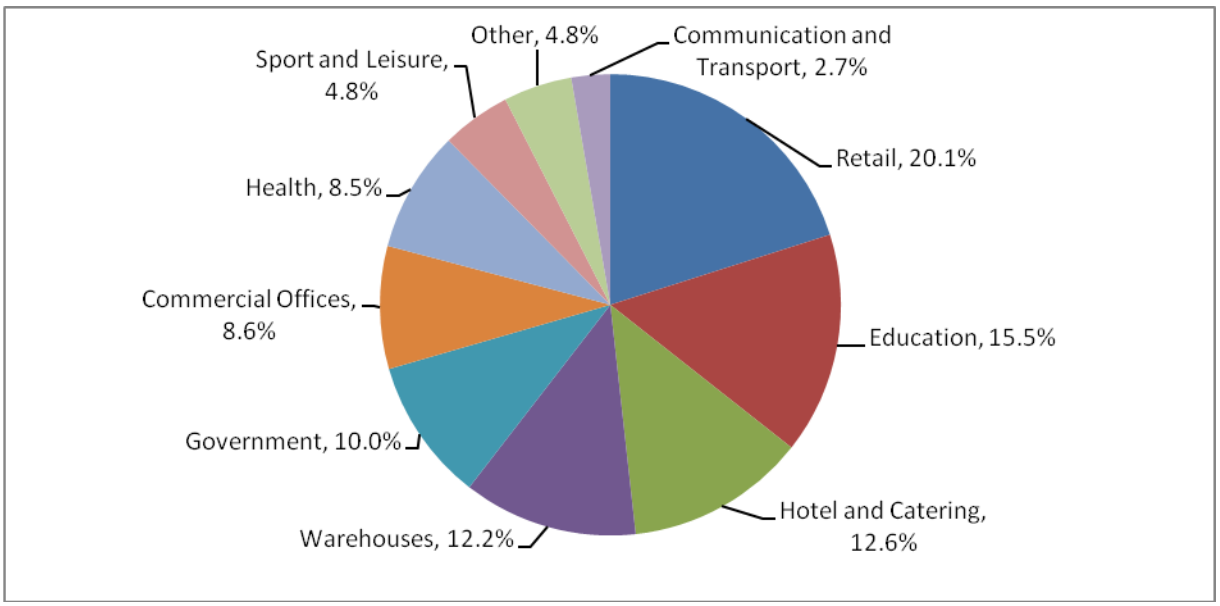
Table 16: Potential carbon dioxide equivalent savings for industrial sub-sectors from low cost energy savings opportunities 2009

Industrial sub-sector	Range of low-cost savings opportunities, 2009 (Ktoe)		Conversion factor by Energy type (tCO_2e/toe)					Sector conversion factor (tCO_2/toe)	Range of low-cost savings opportunities, 2009 ($KtCO_2e$)	
	min	max	Coal	Gas oil	Fuel oil	Natural Gas	Electricity		min	max
Coke, refined petroleum products & nuclear fuel	0.0	0.0	3.8	2.9	2.9	2.2	5.0	3.5	0	0
Chemicals, chemical products & man-made fibres	194.5	194.5	3.8	2.9	2.9	2.2	5.0	3.3	638	638
Food products & beverages	23.7	123.3	3.8	2.9	2.9	2.2	5.0	3.1	74	384
Non-metallic mineral products	15.5	84.8	3.8	2.9	2.9	2.2	5.0	3.2	50	272
Basic metals	58.0	83.3	3.8	2.9	2.9	2.2	5.0	3.8	222	319
Pulp, paper & paper products	19.9	70.3	3.8	2.9	2.9	2.2	5.0	3.2	64	227
Other	0.0	692.7	3.8	2.9	2.9	2.2	5.0	3.6	0	2,518
Total Industrial									**1,049**	**4,359**

4.1.2 Service sector

The share of service sector energy consumption by sub-sector in 2008 is shown in Figure 11.

Figure 11: Services sub-sector energy consumption (2008)



Source: DECC (2010), *Energy Consumption in the UK, Industrial (Service; Transport) Data Tables: 2010 update*

The sub-sectors used by DECC in their annual Energy Consumption Service Sector Data Tables[13] are also those used in the Defra *Business Benefits* study for 2006. The low cost energy savings opportunities for Services sub-sectors according to this study are shown in Table 17.

Table 17: Low cost energy savings for Services sub-sectors for 2006

Service sub-sector	Estimated savings opportunity in 2006 (%)
Retail	11.3
Hotels	13.0
Warehouses	10.0
Commercial offices	17.4
Education	10.0
Government	15.0
Sports & leisure	7.4
Health	6.7
Other	11.0

Source: Oakdene Hollins & Grant Thornton for Defra (2007), *Quantification of the business benefits of resource efficiency*

As outlined above, the change in the DECC methodology for calculating energy consumption means that year-on-year comparisons of energy intensity are potentially misleading. However unlike the situation with the Industrial sector, the Carbon Trust (2010)[16] provides Service sub-sector realisation rates for efficiency measures with a payback of less than one year for the high-level Private, Services and Public sub-sector categories. In addition they provide a realisation rate for the Retail sector which represents 20% of all Service sector consumption (see Figure 11).

The Carbon Trust's estimated realisation rate to 2009 of measures with a payback of less than one year that existed in 2006/07 was:

- 45% for the Public sector
- 41% for Services and
- 58% for Retail.

The remaining opportunity in 2009 can then be calculated by adjusting the data in Table 17 to take into account any changes in real sub-sector output (Annex B), and applying the relevant remaining opportunity according to the Carbon Trust. For Service sub-sectors, DECC only provides data to 2008 (see Figure 11); these were converted to an estimate for 2009 energy consumption by adjusting for the change in real sector GVA[14].

To convert the remaining low cost opportunity for each sub-sector to a financial value, the unit energy savings opportunity was multiplied by the weighted average unit cost of energy (Annex B). The results are shown in Table 18.

The CO_2e savings for each Service sub-sector, derived using the conversion factors from the previous Defra study for 2006[18], are shown in Table 19.

Table 18: Estimated low-cost energy savings opportunities by Service sub-sector available in 2009

Service sub-sector	Estimated savings opportunity in 2006 (%)	Carbon Trust realisation rate	Remaining opportunity (%)	2009 savings opportunity (Ktoe)	Weighted average energy price (p/kWh)	2009 savings opportunity (£M)
Retail	11.3	58%	4.7%	164	7.36	**140**
Hotels	13.0	41%	7.7%	167	5.13	**99**
Warehouses	10.0	41%	5.9%	124	5.50	**79**
Commercial offices	17.4	41%	10.3%	152	5.74	**101**
Education	10.0	48%	5.2%	139	4.42	**71**
Government	15.0	48%	7.8%	135	4.60	**72**
Sports & leisure	7.4	41%	4.4%	36	5.65	**24**
Health	6.7	48%	3.5%	51	4.06	**24**
Communication	11.0	41%	6.5%	30	8.10	**29**
Other	11.0	41%	6.5%	54	5.36	**33**
Total Services			6.3%			**673**

Table 19: Potential carbon dioxide equivalent savings for Service sub-sectors from low cost energy savings opportunities 2009

Service sub-sector	Savings opportunity, 2009 (Ktoe)	Conversion factor by energy type (tCO_2e/toe)			Sector conversion factor (tCO_2/toe)	Savings opportunity, 2009 ($KtCO_2e$)
		Electricity	Natural Gas	Oil		
Retail	164	5.0	2.2	2.9	4.3	704
Hotels	167	5.0	2.2	2.9	3.4	559
Warehouses	124	5.0	2.2	2.9	3.5	437
Commercial offices	152	5.0	2.2	2.9	3.6	549
Education	139	5.0	2.2	2.9	3.1	426
Government	135	5.0	2.2	2.9	3.1	422
Sports & leisure	36	5.0	2.2	2.9	3.6	130
Health	51	5.0	2.2	2.9	2.9	148
Communication	30	5.0	2.2	2.9	4.6	140
Other	54	5.0	2.2	2.9	3.5	185
Total Services						**3,701**

4.1.3 Road freight

Annex D provides a detailed assessment of the UK Road freight sector, and this section summarises the findings. Table 20 shows the estimated energy consumption, fuel consumption and emissions within the UK Road freight sector in 2009. *Please note: the previous Defra study for 2006 focused solely on the activities reported in government statistics, namely, the 'mainly public haulage' of HGV and LGV, i.e. the first two activities*

shown in Table 20, with the 'mainly own account[26]' being covered within the individual sectors.

Table 20: A summary of UK road freight energy consumption split by activity in 2009

Activity	Energy consumption (Mtoe)	Fuel consumption (Ml)	Emissions ($MtCO_2$)
HGV – mainly public haulage	8.16	9,840	23.41
LGV – mainly public haulage	5.44	6,560	15.61
Mainly own account – HGV and LGV	8.34	10,052	23.92
Total	**21.94**	**26,452**	**62.94**

Please note: the 'mainly public haulage' data were split between HGV and LGV using the 2008 ratio from data provided by DECC.

The Chartered Institute of Logistics and Transport (CILT) reports that only a small number of companies operating in the sector have fully engaged in energy (emissions) reduction, although the tendency is for these to be the large companies. This observation appears to be confirmed by DECC energy intensity figures which show that, whilst fluctuations in energy intensity have taken place between 1990 and 2008, no change in the underlying energy intensity occurred. It is therefore assumed that the estimated 11% no cost / low cost savings opportunity determined within the previous Defra study for 2006 remains.

Table 21 shows the estimated savings opportunities assuming an 11% saving can be achieved through no cost / low cost interventions. The savings opportunity is much higher than the 2006 Defra study estimates for 2006 due to the inclusion of the 'mainly own account' operations. On a like-for-like basis the savings opportunity would be £1.9 billion, i.e. the forecourt price for the two 'mainly public haulage' components, instead of the £2.0 billion estimated in the previous study for 2006. For this study it is considered appropriate to consider the economic savings using the bulk diesel price as the minimum savings opportunity and using the forecourt price as the maximum savings opportunity.

Table 21: a summary of UK road freight savings opportunity split by activity, 2009

Activity	Energy consumption (Mtoe)	Fuel consumption (Ml)	Emissions ($MtCO_2$)	Economic savings (£M)	
				Using bulk diesel price	Using forecourt price
HGV – mainly public haulage	0.90	1,082	2.58	924	1,130
LGV – mainly public haulage	0.60	722	1.72	617	754
Mainly own account – HGV and LGV	0.92	1,106	2.63	945	1,155
Total	**2.42**	**2,910**	**6.93**	**2,486**	**3,039**

4.1.4 Energy summary

Savings by sub-sector from low-cost energy efficiency measures are shown in Table 22.

26 'Own Account' is defined as Goods vehicle operators who only carry goods in the course of their own trade or business

Table 22: summary of financial and CO_2 equivalent savings from low-cost energy efficiency measures 2009

Sub-sector	Savings opportunity (Ktoe)	Savings opportunity (£M)	Savings opportunity ($KtCO_2e$)
Chemicals, chemical products & man-made fibres	195	90	638
Food products & beverages	73	32	229
Non-metallic mineral products	50	15	161
Basic metals	71	40	270
Pulp, paper & paper products	45	20	146
Other Industrial	346	188	1,259
Total Industrial	**780**	**384**	**2,704**
Retail	164	140	704
Hotels	167	99	559
Warehouses	124	79	437
Commercial offices	152	101	549
Education	139	71	426
Government	135	72	422
Sports & leisure	36	24	130
Health	51	24	148
Communication	30	29	140
Other Service	54	33	185
Total Service	**1,053**	**673**	**3,701**
HGV – mainly public haulage	900	1,027	2,580
LGV – mainly public haulage	600	686	1,720
Mainly own account – HGV & LGV	920	1,050	2,630
Total Road freight	**2,420**	**2,763**	**6,930**
TOTAL	**4,253**	**3,820**	**13,335**

The CO_2e savings opportunity in the Industrial sector had declined by 52% from 2006[18] and 49% for the Service sector. Since the energy savings opportunity is estimated to have declined on average by 54% and 49% respectively (i.e. by a similar magnitude to the changes in CO_2e savings opportunity), it is clear that there has been minimal impact from a change in energy mix on potential CO_2e savings. Meanwhile the savings opportunity in the Transport (road freight) sector has increased by 41%.

Among industrial sub-sectors, it is for heavy consumers that the savings opportunity has declined by more than the average. For example within Basic metals the CO_2e opportunity has declined by 62%, the same is true for Food and beverages and Pulp and paper, while the opportunity in Coke and refined petroleum products has disappeared altogether.

Among Service sub-sectors, the Retail sector's CO_2e savings opportunity has declined by 65%, while Education has declined by only 23%, Government by 21% and Health by 20%.

4.2 Waste

This section is split into four main parts, namely, the evaluation of:

- Construction, demolition and excavation waste (CDEW)
- Mining and quarrying waste
- waste from commercial and industrial sources.

4.2.1 Construction, demolition and excavation waste (CDEW)

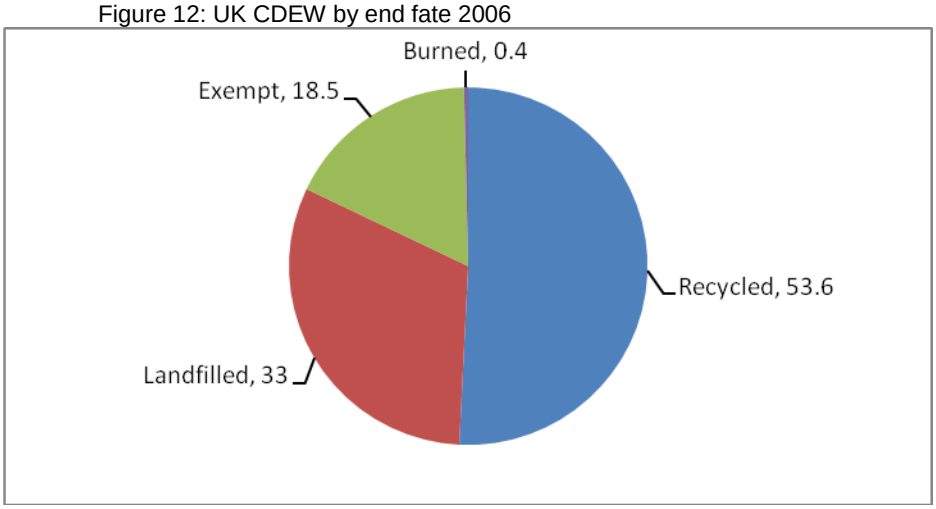
4.2.1.1 Background

The Defra *Business Benefits* study for 2006 broke the 105.5 Mt of inert arisings of UK CDEW down by end fate using data contained in WRAP's *Quick Wins* report[27] (Figure 12). This showed that over 50% was recycled but 31% was still being sent to landfill. The 2006 study estimated that 19.66 Mt of hard CDEW could be diverted from landfill to recycling. In addition, using the BRE smartwaste tool it was estimated that a waste reduction opportunity of 0.71 Mt existed for other materials, such as plasterboard, timber, steel, non ferrous metals and packaging.

This section of the report reviews the two waste savings opportunities:

- diversion of waste from landfill
- waste reduction.

Figure 12: UK CDEW by end fate 2006



Source: WRAP (2007), WAS7-*001 Final Report* on Waste Management Quick Wins

4.2.1.2 Diversion of waste from landfill by country

England

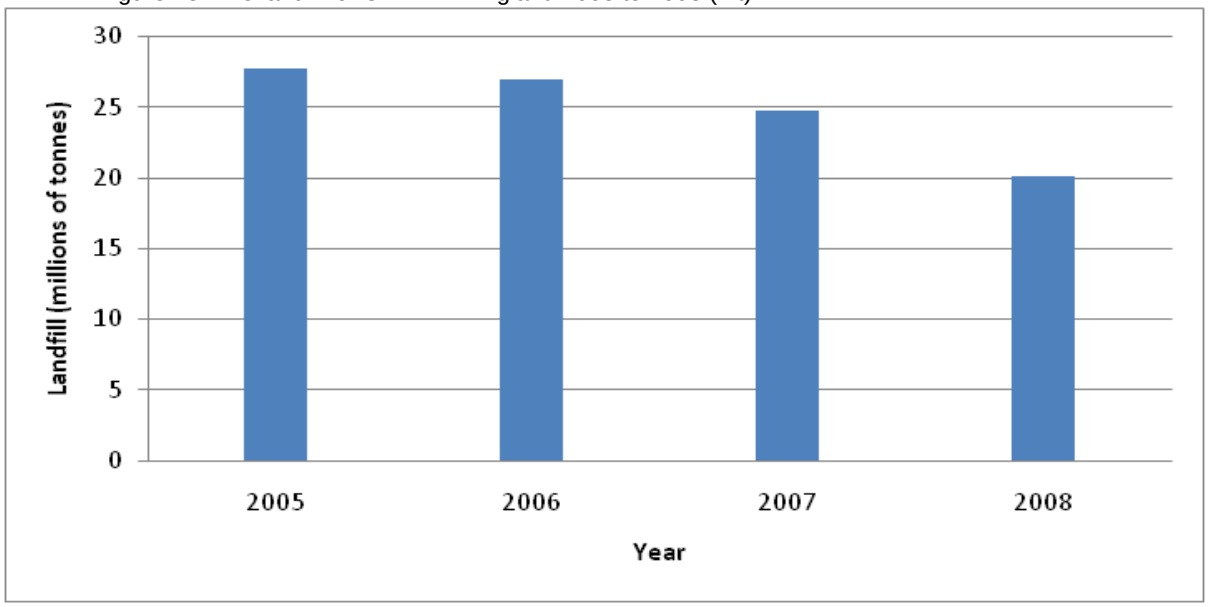
The 2005 Communities and Local Government report[28] estimated that 89.6 Mt of CDEW were generated in England in 2005 of which 27.7 Mt (30.9%) were sent to landfill. In addition, the report shows that 18.1 Mt or 69% of the 27.7 Mt assigned to landfill was clean excavation waste (Annex E).

[27] WRAP (2007), *WAS7-001 Final Report on Waste Management Quick Wins*

[28] Communities and Local Government (2005), *Survey of arisings and use of alternatives to primary aggregates in England*

The National Audit Office reports[29] that the landfilling of CDEW in England fell by 28% or 7.6 Mt between 2005 and 2008. Figure 13 shows that between the base year for this project (2006) and 2008, landfilling of CDEW fell by ca.6.9 Mt.

Figure 13: The landfill of CDEW in England 2005 to 2008 (Mt).



Source: National Audit Office (2010), *Reducing the impact of business waste through the business resource efficiency and waste programme*

Wales

The Environment Agency Wales report[30] states that 12.2 Mt of CDEW were generated in Wales in 2005 of which 10% (1.2 Mt) was sent to landfill. WRAP reports[31] that: *"In 2007 around 2.5 million tonnes of construction and demolition waste was handled by waste facilities in Wales, and it is estimated that about half of this was sent to landfill".* This suggests that little change in the volume of waste sent to landfill in Wales occurred between 2005 and 2007.

Scotland

No specific data could be identified that quantified the level of CDEW sent to landfill in Scotland between 2006 and 2009 although SEPA report that CDEW fell from 11.8 in 2006 to 8.6 in 2008.

Northern Ireland

The Environment & Heritage Service in Northern Ireland reports[32] that 1.8 Mt of CDEW were generated in Northern Ireland in 2004/05 and 1.7 Mt in 2005/06. In 2005/06 0.65 Mt tonnes were sent to landfill. The report shows that 0.30 Mt of the 0.65 Mt was disposed of as waste but, unlike in England, clean 'mixed' CDEW represented the most significant opportunity at 0.15 Mt or 49% of the total.

[29] National Audit Office (2010), *Reducing the impact of business waste through the business resource efficiency and waste programme*

[30] Environment Agency Wales, *Building the future: a survey on the arising and management of construction and demolition waste in Wales* 2005-06

[31] WRAP Website available at URL http://www.wrap.org.uk/construction/wales.html

[32] Capita Symonds for Environment & Heritage Service (2006), *Survey of arisings and use of construction, demolition and excavation waste as aggregate in Northern Ireland in 2004/05 & 2005/06*

The Northern Ireland Environment Agency reports[33] that in 2008 1.2 Mt of CDEW were landfilled in Northern Ireland. The report states that the significant increase in landfill between the 2005/06 and 2008 surveys is probably due to a number of landfills not accepting CDEW as capping or engineering material in 2005.

Summary and analysis

Based on this analysis it is estimated that CDEW sent to landfill in the UK fell by ca.9.75 Mt between 2006 and 2009 with the estimated waste sent to landfill in 2009 being 23.25 Mt. However, this represents total waste sent to landfill, some of which will be sent for beneficial re-use, such as landfill engineering and capping and some for disposal. From a resource efficiency perspective, it is the waste sent for disposal that represents the most significant opportunity.

The Strategic Forum for Construction, which had responsibility for delivering the voluntary *Halving Construction, Demolition and Excavation Waste to Landfill by 2012 compared to 2008* initiative, reports a 2008 baseline of 12.55 Mt; showing a reduction of 5.55 Mt sent for landfill disposal in England between 2005 and 2008[34].

Based on this analysis it is suggested that:

- The 19.66 Mt diversion from landfill opportunity for 2006 shown in the Defra *Business Benefits* report represented an overestimate, since there is no evidence provided in subsequent reports that *"one half of the material sent for re-use in exempt activities is actually landfilled by another name"*; an assertion made in the WRAP *Quick Wins* report. Taking landfill engineering and capping into consideration it is estimated that in 2006 the UK landfill diversion opportunity stood at 13.06 Mt.
- The estimate of savings opportunity in 2009 stood at 6.5 Mt.

4.2.1.3 Waste reduction

There may be opportunities to reduce waste in the sector through initiatives such as in-situ site remediation and increased refurbishment; however there is little data to show the potential of such activities. Therefore this section focuses on construction waste and more specifically the output and intensity changes within the Construction sector between 2006 and 2009.

Output

Table 23 shows the output from the Construction sector in Great Britain between 2006 and 2009. This shows that output fell by £11.2 billion or 10.3% between 2006 and 2009.

Table 23: Construction output (constant (2005) prices, seasonally adjusted) in £M

Year	Housing new work	Non-housing new work	Housing repair and maintenance	Non-housing repair and maintenance	Total output
2006	21,995	40,150	23,210	23,009	108,364
2007	22,188	42,357	23,041	23,366	110,952
2008	18,336	44,156	23,677	23,546	109,716
2009	14,192	40,457	21,501	21,002	97,152

Source: ONS (March 2010), *Statistical bulletin: output in the construction industry*

[33] NI Environment Agency available at URL: http://www.ni-environment.gov.uk/niea_2008_cdew_report-2.pdf

[34] http://www.strategicforum.org.uk/pdf/Waste_Draft_Part%202_22-3-10V4.pdf

Intensity
The change in intensity can be calculated by firstly determining the change in waste arisings between 2006 and 2009 and then subtracting the change due to output, i.e. the 10.3% derived above.

It is estimated that the waste arisings in the Construction sector in 2006 were 15.0 Mt. This estimate is derived using the data contained in Annex E and NFDC data which states that 32.8 Mt of demolition waste were generated in GB in 2006. An estimate of the total construction waste arisings in 2009 can be produced using the benchmarks developed by the Construction Resource and Waste Platform[35] (Table 24). This shows the estimated waste arisings to be 12.6 Mt. This shows that waste arisings from the GB Construction sector fell by 2.4 Mt or 16% between 2006 and 2009. Therefore it is estimated that of the 16% reduction in waste arisings 10.3% is due to changes in output and 5.7% due to intensity changes or resource efficiency improvements. Since the Defra *Business Benefits* study for 2006 reported resource efficiency savings of 15% in 2006, it is estimated that the savings opportunity in 2009 stood at 9.3% or 1.17 Mt.

Table 24: Estimate of waste arisings in the GB construction sector in 2009

	Housing new work	Non-housing new work	Housing repair and maintenance	Non-housing repair and maintenance	Total output
Output (£M)	14,192	40,457	21,501	21,002	97,152
Benchmark waste arisings (tonnes/£100k)	16.3	16.2	9.4	8.1	
Total estimated waste arisings (Mt)	2.3	6.6	2.0	1.7	12.6

4.2.1.4 Waste savings opportunity

From a tonnage perspective the above analysis shows that in 2009 the diversion from landfill opportunity stood at 6.5 Mt and the waste reduction opportunity at 1.17 Mt.

From an economic perspective the WRAP report *Assessing the costs and benefits of reducing waste in construction* estimates that the average net benefit from resource efficiency is 0.4% of the building project value (total savings 0.77% minus total cost 0.37%). The types of intervention included are:

- Develop quality SWMP: Additional time beyond minimum legal compliance (England only) to develop plan with quality forecasts (including using the Net Waste Tool) and robust management actions.
- Develop site logistics strategy: Planning time required to establish how materials are to be delivered, stored and moved around the site.
- Site training: Time to provide training, and site operatives' time to receive training (five ½hr briefings for 10 operatives per session).
- Materials storage: Nominal allowance for construction of hard standing and temporary shelter for materials (or cabin hire).
- Management time: Additional time required to ensure SWMP is adhered to, including materials handling, re-use of materials on site, efficient installation and waste segregation (2.5hrs per week for ¾ of the programme).

[35] Construction Resources and Waste Platform (2009), *Benchmarks and baselines*

- Updating SWMP: The SWMP needs to be reviewed and updated throughout the project. This cost allows for a 4 hour review every 3 months.
- Site segregation: To ensure good segregation, this cost allows for a single individual to sort and move wastes and monitor the re-use of materials on site. (Included part-time for 50% of the programme as reduced demand during early packages.)

The types of intervention not included within the report are changes in design specification.

Therefore, since the UK Construction sector is valued at £110 billion[36], the savings opportunity is estimated to be £440 million.

Using the conversion factors used in the original Defra study[37] it is estimated that the 6.5 Mt of landfill diversion potential equates to a CO_2 saving of 6,500 to 65,000 tonnes and the waste prevention opportunity 1.1 Mt.

4.2.2 Mineral waste

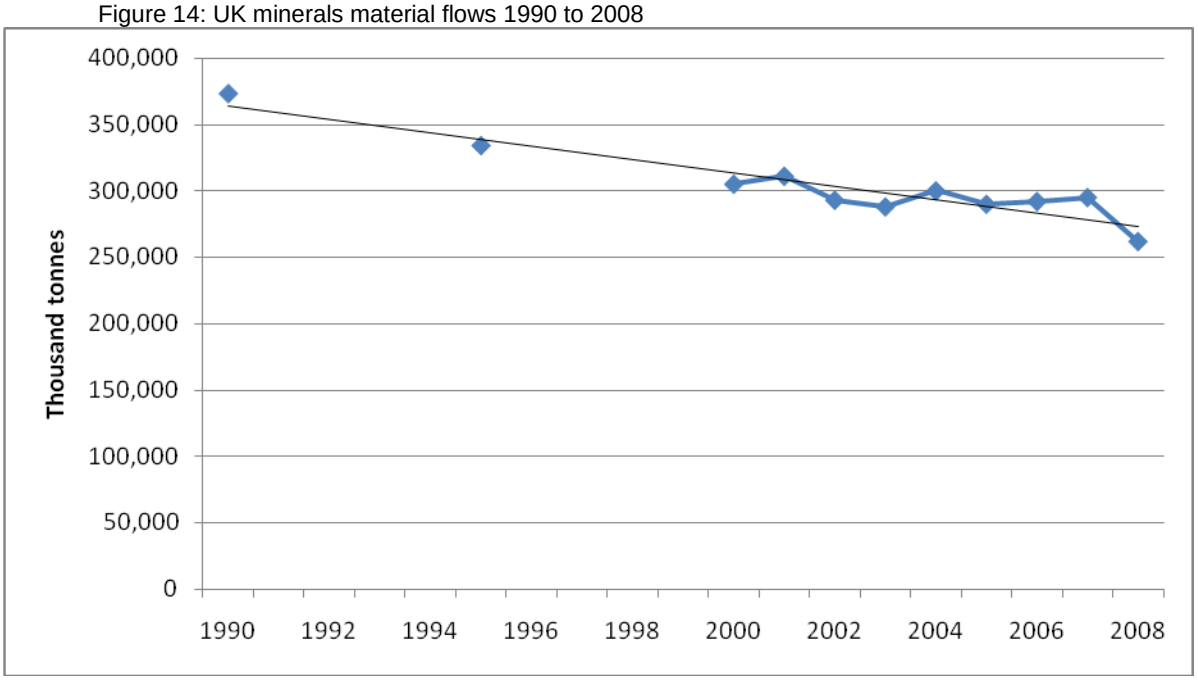
Figure 14 shows the material flows and waste arisings within the UK minerals sector. The analysis shows the steady decline in material flows, including a reduction of 30 Mt or 10% between 2006 and 2008; in line with the 10.3% decline between 2006 and 2009 seen in the Construction sector, discussed above.

Figure 15 shows waste arisings from the UK Minerals sector between 1990 and 2006. This shows that over the period waste dropped from 143,000 tonnes to 89,000 tonnes. Although the fall in output (Figure 14) clearly had a significant impact on waste arisings, dividing material flow by waste arisings shows that steady resource efficiency (intensity) improvements have been made over the period (Figure 16). The analysis shows that waste equated to 38% of material flow in 1990 and this had reduced to 30% in 2006.

[36] Strategy for sustainable construction (2009), *Progress report Sept 2009*

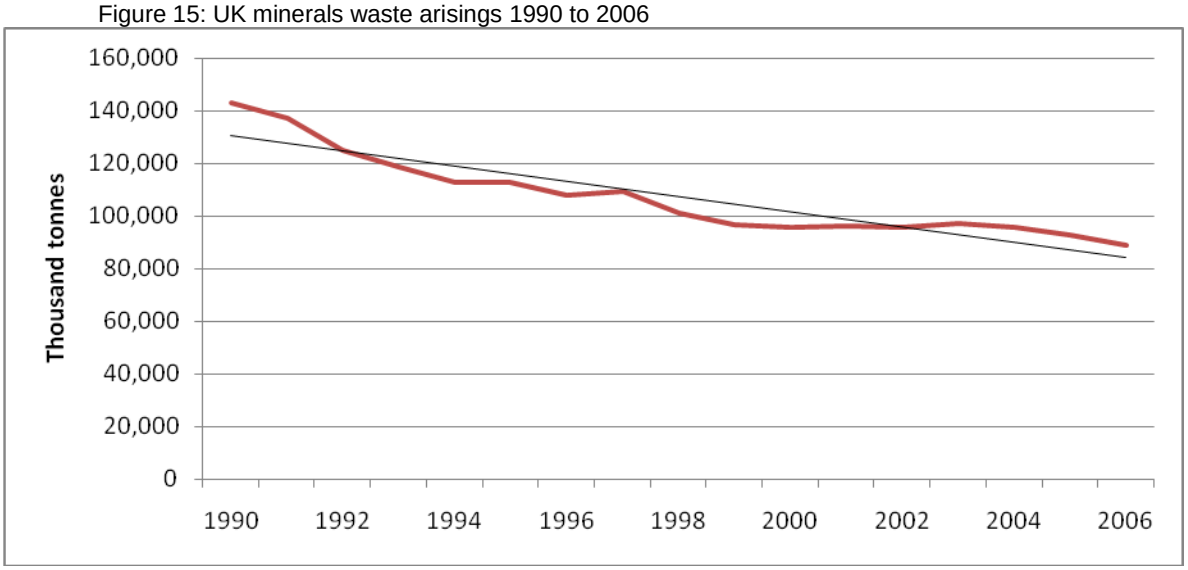
[37] Oakdene Hollins for Defra (2009), *Quantification of the potential CO_2 savings from resource efficiency in the UK*

Figure 14: UK minerals material flows 1990 to 2008



Source: ONS (2010): *Environmental Accounts 2010*

Figure 15: UK minerals waste arisings 1990 to 2006



Source: From the Defra and the UK Minerals Year Book, published by British Geological Survey

Figure 16: Intensity (waste arisings / material flow) within the UK minerals sector 1990 to 2006

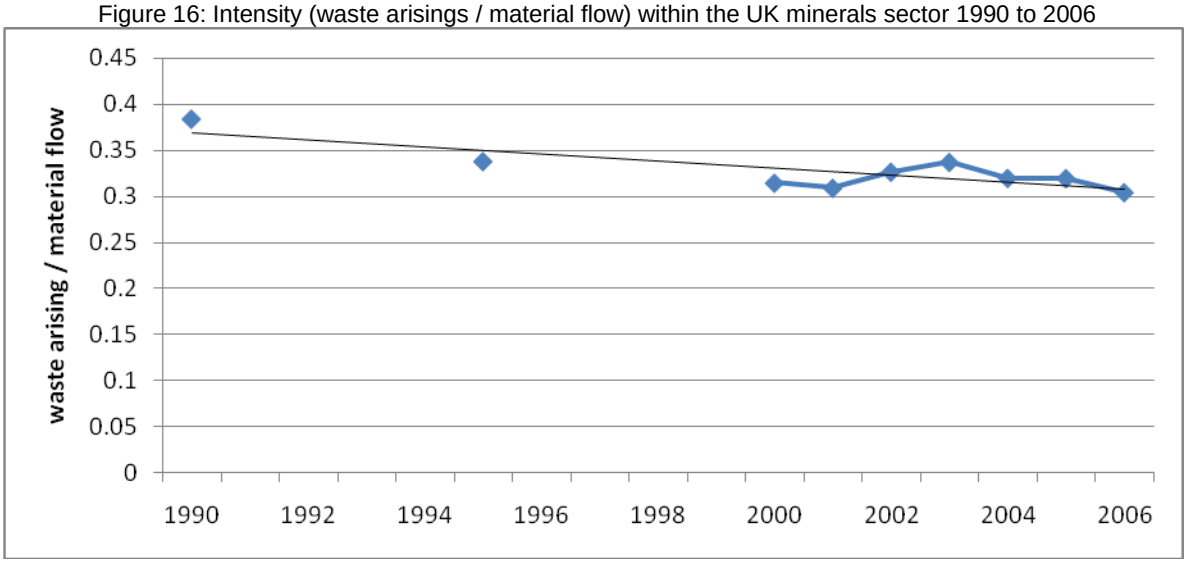


Table 25 shows the extrapolation of the data contained within Figure 14, Figure 15 and Figure 16. It is estimated that with the output and intensity changes that the 4.85 Mt diversion from landfill opportunity in 2006 will have reduced to 4.15 Mt with an economic saving of £35.3 million.

Table 25: summary of output and intensity changes 2006 to 2009

Waste arisings		Reason for change 2006 to 2009			
2006	2009	Output		Intensity	
Mt	Mt	Mt	%	Mt	%
88.8	75.5	7.3	8.2	6.1	6.9

Taking the carbon conversion factor from the previous Defra study for 2006, namely 6 kgCO_2/t, it is estimated that the savings opportunity in 2009 was 24,900 tonnes.

4.2.1 Commercial and industrial waste

4.2.1.1 Waste reduction

For the Commercial and Industrial sectors, the final results of the Defra *Survey of Commercial and Industrial Waste Arisings 2009* for England have been used as the primary data source to analyse waste reduction achievements. These data can be extrapolated to the whole of the UK based upon the national breakdowns of waste arising from the 2006 submission to Eurostat[38]. Full details on the methodology used to calculate UK C&I waste arisings can be found in Annex F. As noted in Section 3.1.2, the 2006 baseline waste data is based upon projections from the 2002/03 C&I Waste Survey. This does affect the reliability of the 2006 C&I Waste estimates and the analysis preformed from them. However because no alternative estimates for the 2006 base year are available, this data has been used as the baseline for the waste estimates within this study.

[38] An alternative approach that can be used is to add up the results of the national surveys, with the caveat that the years differ (see Annex F for these results). However there is not a significant difference in the results obtained.

UK C&I waste arisings estimates for the sectors included in the survey (i.e. excluding Agriculture, Mining, Construction and Waste Management) can be found in Table 26 alongside the 2006 estimates. Overall there is a 24% fall in C&I waste arisings between 2006 and 2009, with waste in the Industrial sector has falling by 17% and waste in the Commercial sector has falling by 30%. The Metal manufacturing sector is notable as being the only sector where waste rose over the period (rising 41%).

Table 26: UK C&I waste 2006-2009 (Mt)

Sector	2006	2009	% change 2006-09
Food, drink & tobacco	7.9	5.8	-27%
Textiles / wood / paper / publishing	6.0	4.0	-33%
Power & utilities	7.0	6.9	-2%
Chemicals / non-metallic minerals	6.5	4.4	-32%
Metal manufacturing	3.8	5.3	41%
Machinery & equipment (other)	3.9	2.7	-32%
Subtotal – Industrial	***35.0***	***29.0***	***-17%***
Retail & wholesale	16.6	11.2	-33%
Hotels & catering	4.7	3.3	-29%
Public sector	7.2	5.3	-26%
Transport & storage	3.4	2.7	-19%
Other services	9.2	6.4	-31%
Subtotal – Commercial	***41.1***	***28.9***	***-30%***
Total	**76.1**	**58.0**	**-24%**

Sources: calculated from Defra & EA C&I Waste Datasets

To determine the progress in waste reduction over the period, the changes in waste arising need to be compared to the changes in GVA. Overall, GVA for the other C&I sectors fell by only 1.5% between 2006 and 2009, but this modest decline - caused largely by strength in the large Service sector - masks steep declines in GVA in many Industrial sectors. Using the GVA data, BAU scenarios can be generated to which actual waste arising can be compared (Table 27). From this the achievements by sector can be calculated and compared to the opportunities identified in the previous Defra report for 2006. One important point to note when interpreting these results is to appreciate the impact that the recent financial crisis may have had on industry activity during this period of turbulence.

Overall the results show substantial progress in waste reduction between 2006 and 2009, equivalent to 14.1 Mt after accounting for changes in economic activity. By applying the 95% confidence intervals from the C&I Waste Statistics it is possible to develop error bands for this waste reduction estimates. This gives a range of 9.1 to 19.1 Mt for the waste reduction achieved.

The notable standout from the results is the Metal manufacturing sector, which has moved backwards in terms of its waste generation, which represents a new opportunity. It is not known exactly what the large increase in waste arisings within the sector represents. It is noted however that waste within the sector has fallen significantly since 2002 (where waste arisings were 7.5 Mt), which may be a more reliable gauge of resource efficiency progress in the sector than a comparison versus 2006. Nonetheless, this additional waste reduction opportunity can be calculated in terms of their financial and carbon savings (Table 28). A small opportunity is available for waste reduction in Power and utilities by virtue of the waste arisings not falling by as much as GVA for the sector. The financial savings have been calculated by applying 2009 export prices for the Metals sector or by inflating the prices used

for 2006 for the Power and utilities sector (see Annex G). The carbon savings have been calculated using the carbon conversion factors used in the previous Defra study for 2006. This gives a financial value of the waste reduction opportunity estimated at £1.00 billion, and a carbon savings are estimated at 3.86 $MtCO_2$. The ranges for these estimates are £749 million to £1,274 million for the financial savings and 2.91 to 4.84 $MtCO_2$.

There is some variation in waste reduction performance elsewhere, with the greatest reductions having been achieved with the commercial sectors relative to economic activity. All of the sectors have met and exceeded the opportunities identified in the Defra study for 2006.

Table 27: Waste reduction in other C&I sectors, 2006-2009 (Mt)

Sector	2006	GVA % change	2009		Waste Reduction Savings	
	Actual		BAU	Actual	Achieved	Opportunity
Food, drink & tobacco	7.9	-3.6%	7.6	5.8	1.8	0.9
Textiles / wood / paper / publishing	6.0	-11.2%	5.3	4.0	1.3	0.3
Power & utilities	7.0	-7.3%	6.5	6.9	-0.4	0.0
Chemicals / non-metallic minerals	6.5	-11.0%	5.8	4.4	1.4	0.5
Metal manufacturing	3.8	-21.8%	2.9	5.3	-2.4	0.0
Machinery & equipment (other)	3.9	-16.0%	3.3	2.7	0.6	0.0
Retail & wholesale	16.6	-3.9%	15.9	11.2	4.7	0.8
Hotels & catering	4.7	-1.5%	4.6	3.3	1.3	0.3
Public sector	7.2	3.3%	7.4	5.3	2.1	0.0
Transport & storage	3.4	-2.2%	3.3	2.7	0.6	0.0
Other services	9.2	1.3%	9.3	6.4	3.0	0.4
TOTAL	**76.1**	**-1.5%**	**72.1**	**58.0**	**14.1**	**3.3**

Sources: calculated from Defra C&I Waste Datasets, ONS Blue Book

Table 28: Valuation of waste reduction opportunity for other C&I sectors 2009

Sector	Mt	£/tonne	Saving (£M)	kg CO_2 / kg waste	Saving ($MtCO_2e$)
Power & utilities	0.41	£22	£9	0.02	0.01
Metal manufacturing	2.36	£420	£992	1.63	3.85
Total	**2.77**		**£1,001**		**3.86**

Sources: calculated from Defra C&I Waste Datasets, ONS Blue Book

4.2.1.2 Waste diversion

For landfill volumes, the C&I waste data for 2006 is not sufficient to make an accurate assessment as it does not break down waste management routes by sector. Instead the waste management routes are listed on an aggregate level for all the sectors contained in the survey, and because the sectors included are different from those in the 2009 data, an effective comparison cannot be made over time (Household, Construction, Mining and Agricultural waste are included in the 2006 data in addition to the C&I sectors in the 2009 survey). However alternative data for C&I landfill volumes for England can be calculated from landfill returns data, at an aggregate C&I level. These can be extrapolated up to the

UK level and allow a comparison between 2006 and 2009. (Annex F provides more details on the data sources and extrapolation).

These data shows that between 2006 and 2009 the C&I landfill tonnage for the UK fell by 6.1 Mt or 25.3%, slightly outpacing the decline in C&I Waste arising which fell by 23.9% (Table 29). As a result the percentage of C&I waste sent to landfill fell from 31.5% in 2006 to 30.9% in 2009. In comparison the Defra C&I 2009 waste survey calculated the percentage of C&I waste sent to landfill at 23.5%[39]. Due to the significant difference between these estimates, both have been used to model waste diversion achieved. This gives a range for waste diversion achieved, with the average providing the middle estimate.

Table 29: UK C&I landfill volumes (Kt)

Year	2006	2009	Change (%)
C&I Landfill Volumes	24,006	17,928	-25.3%
C&I Waste Arising	76,122	57,965	-23.9%
% Landfill	31.5%	30.9%	

Sources: calculated from Defra & EA C&I Waste Datasets

The BAU scenario for waste diversion models the landfill volumes that would have occurred if the percentage of C&I waste sent to landfill was held constant at 2006 levels, i.e. if 31.5% of the 58.0Mt of waste arising was sent to landfill (18.3Mt). This is then compared to actual percentages sent to landfill in 2009, for the two cases (30.9% and 23.5%). The results are shown in Table 30, which shows that 2,508 tonnes of waste diversion have been achieved, leaving an opportunity of 6,362 tonnes, implying a realisation rate of 28%.

Table 30: Waste diversion for C&I sectors, 2006-2009 (Kt)

Scenario	2006	2009		Waste Diversion Savings		
	UK	BAU	Actual	Achieved	Opportunity	Remaining
High landfill (30.9%)	24,006	18,280	17,928	352	8,870	8,518
Low landfill (23.5%)			13,616	4,664		4,206
Average			**15,772**	**2,508**		**6,362**

The waste diversion opportunities can be valued in financial terms by applying a cost per tonne of £70 for the opportunity[40]. This values the opportunity at £445 million. The carbon savings entailed can be calculated using the weighted average of the carbon conversion factors from the previous Defra study for 2006. The carbon conversion factor comes to 0.85 kg CO_2 per tonne of waste, which puts the carbon savings resulting from the waste diversion opportunities at 5.40 $MtCO_2$. The range provided for these estimates are £294 million to £596 million and 3.57 to 7.23 $MtCO_2$.

[39] Jacobs for Defra (2010), *Commercial and Industrial Waste Survey 2009, Final Report*

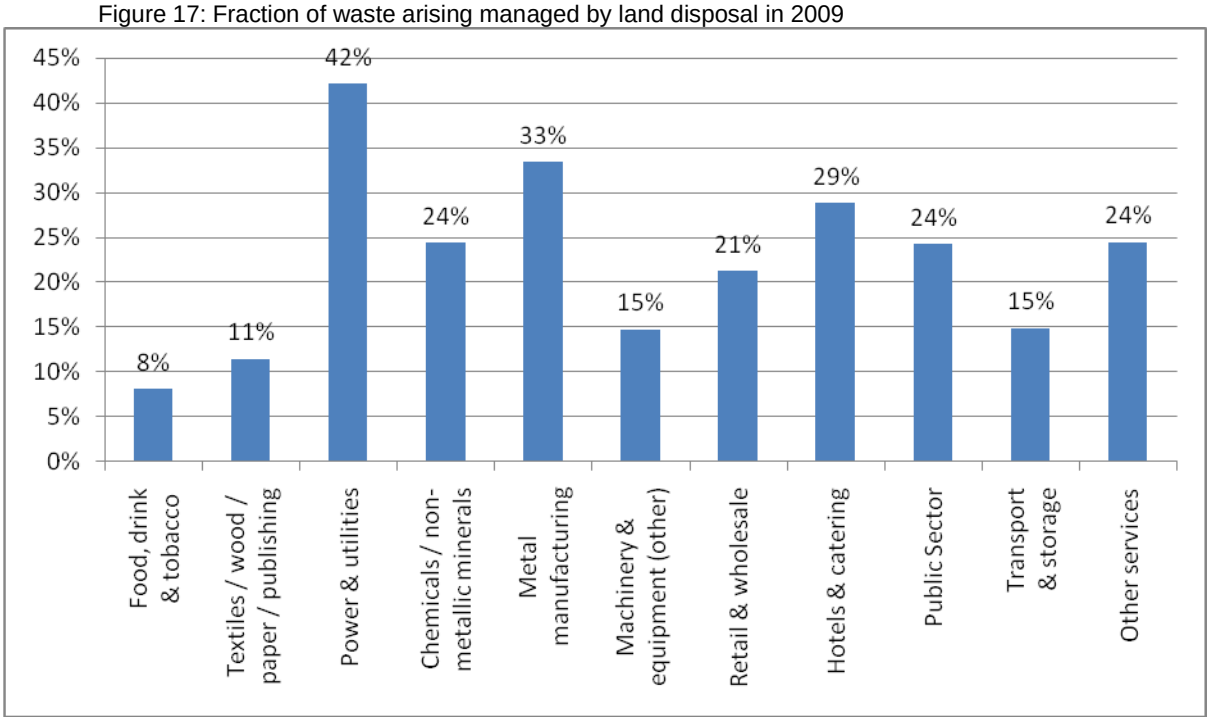
[40] Based on the median landfill gate fee for the UK from WRAP (2010), *Gate Fees* Report

Table 31: Valuation of 2009 waste diversion opportunity for other C&I sectors

Scenario	Tonnes	£/t	Saving (£M)	$kgCO_2$/ kg waste	CO_2 Mt
High landfill (30.9%)	8,518	70	£596.23	0.85	7.23
Low landfill (23.5%)	4,206		£294.45		3.57
Average (27.2%)	**6,362**		**£445.34**		**5.40**

In terms of the sectors, Figure 17 gives an impression of the sectors where the greatest waste diversion opportunities lie. Power and utilities (42%), Metal manufacturing (33%) and Hotels and catering (29%) have the highest fraction of their waste managed by land disposal. By comparison Food, drink and tobacco (8%) and Textiles / wood / paper / publishing (11%) have relatively low quantities of waste sent to landfill. In terms of materials the Defra 2009 C&I waste estimates reveal that mixed wastes (predominantly non-metallic waste i.e. packaging) account for 58% of the material managed by land disposal, followed by mineral waste (36%).

Figure 17: Fraction of waste arising managed by land disposal in 2009



Source: calculated from Jacobs for Defra (2010), *Commercial and Industrial Waste Survey 2009, Final Report*

4.2.2 Waste – progress in existing opportunity

The remaining waste opportunities for 2009 are summarised in Table 32, and in Figure 18, which shows the relative split between waste reduction and diversion. A total of 22.2 Mt of waste opportunities remain, most of which lie in waste diversion. The financial value of the opportunities is £1.9 billion, most of which lies in waste reduction. The potential carbon savings amount to 10.4 $MtCO_2e$, which is fairly evenly split between waste reduction and waste diversion. In terms of sectors the largest opportunities lie in the Metal manufacturing

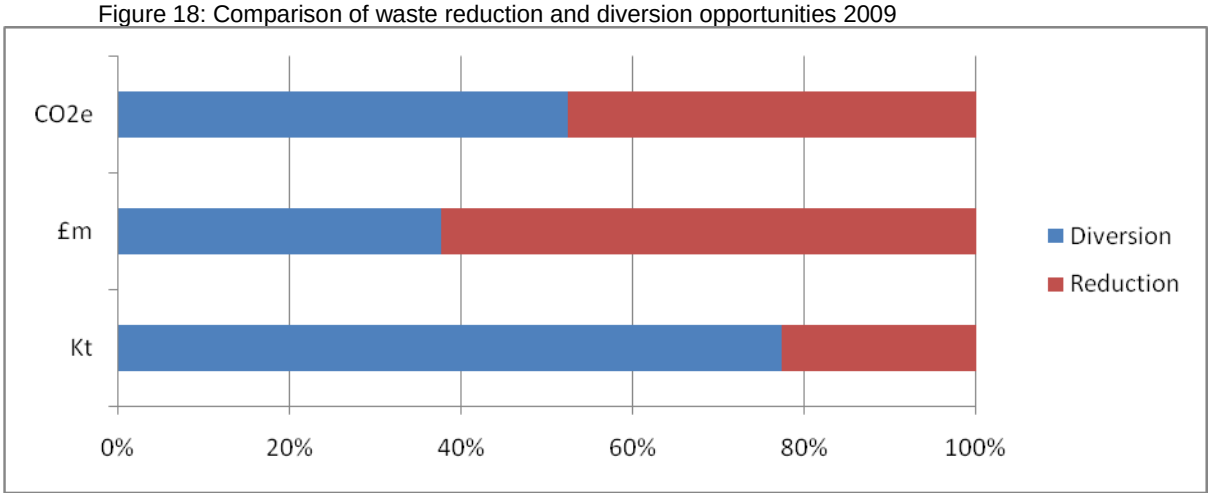
and Construction sectors. For Metal Manufacturing it is not known exactly what the large increase in waste arisings within the metals sector represents.

By comparison the no cost / low cost waste savings estimates for 2006 were £2.7 billion and 14.7 $MtCO_2e$. The opportunity has thus decreased by 28% in terms of the financial value, and by 29% in terms of carbon impact, which indicates a significant improvement between 2006 and 2009.

Table 32: Summary of the waste opportunities remaining in 2009

Sector	Type	Opportunity		
		Kt	£M	Kt CO_2e
Construction, demolition & excavation[41]	Reduction	2,240	197	1,092
	Diversion	6,500	243	36
Mining & quarrying	Diversion	4,150	35	25
Power & utilities	Reduction	407	9	10
Metal manufacturing	Reduction	2,364	992	3,853
C&I Landfill	Diversion	6,513	445	5,402
TOTAL		**22,173**	**1,922**	**10,418**

Figure 18: Comparison of waste reduction and diversion opportunities 2009



4.2.3 Waste – new opportunities

As a number of sectors have met the waste reduction opportunities estimated for 2006, it is necessary to set new targets for the future. This is because it is not true that no further opportunities exist within waste reduction, only that those identified by the relatively few available case studies for 2006 have been realised.

In 2009 WRAP published a study that quantified potential resource efficiency savings from a number of different interventions. It took a top-down approach to identify potential CO_2e savings from material efficiencies, and allocated these between supply intervention strategies that are aimed at influencing production, and demand strategies that are aimed at

[41] The split between reduction and diversion for construction is based on the relative prices from the previous report

influencing consumption. For each of the strategies identified the potential resource efficiency savings are quantified in terms of the impact they could have in reducing GHG emissions compared to a reference scenario. The financial savings were measured by the reduced expenditure of the material inputs saved and the associated increase of the profits of the sector. (More details on the study and the definitions of the scenarios are provided in Section 5.2 and Annex I). Some of these savings were identified as being 'Quick Wins'; that is savings that can be achieved in the short term (2010 to 2020) and that are being relatively easy to implement as they do not require additional costs or major technology and or cultural shifts. Nevertheless some degree of these savings may be forward looking in their nature and it is possible that unintended consequences of material resource efficiency may exist.

The carbon and financial savings of the Quick Wins scenario are listed in Table 33, broken down by sector. The opportunities total 5.5 $MtCO_2$ or £16.3 billion. It is notable that Lean production (that is, reducing the material inputs into production processes through the design of lighter and leaner products) accounted for the majority of the carbon savings (54% of the total) and the financial savings (76% of the total) – see Annex J for the breakdown between the types of interventions.

Table 33: Quick Win waste opportunities to 2020 by sector[42]

Sector	Carbon (Kt CO_2)	Financial (£M)
Agriculture, forestry & fishing[43]	161	362
Mining & quarrying	91	325
Food, drink & tobacco	100	219
Textiles / wood / paper / publishing	404	1,388
Power & utilities	1,237	3,489
Chemicals / non-metallic minerals	1,570	4,396
Metal manufacturing	1,043	2,683
Machinery & equipment (other)	25	98
Construction	510	2,161
Retail & wholesale	29	111
Hotels & catering	1	5
Public sector	6	24
Transport & storage	246	912
Other Services	41	164
Total	**5,464**	**16,339**

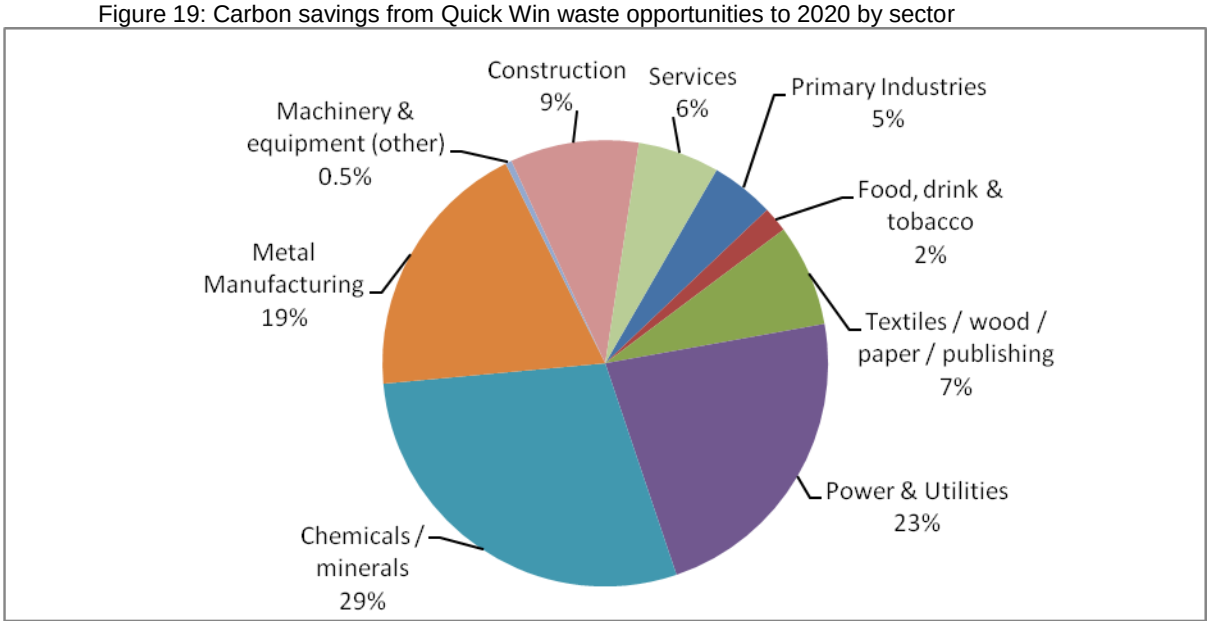
Source: Produced from the data in Stockholm Environment Institute and the University of Durham for WRAP (2009), *Meeting the UK climate change challenge: The contribution of resource efficiency*

A graphical breakdown of the carbon savings by each sector is given in Figure 19. Three sectors account for 70% of the opportunity: Chemicals / minerals (29%), Power and utilities (23%) and Metal manufacturing (19%).

[42] The WRAP data did not attribute the financial savings between sectors, so this has been performed here on the basis of the relative weights of the carbon savings for each of the interventions.

[43] The WRAP savings for agriculture relate to material inputs. For a broad review of greenhouse gas emissions abatement potential e.g. application of fertiliser and changing land use, the reader is referred to SAC (2008), *UK Marginal Abatement Cost Curves for the Agricultural and Land Use, Land-Use Change and Forestry Sectors out to 2022, with Qualitative Analysis of Options to 2050*

Figure 19: Carbon savings from Quick Win waste opportunities to 2020 by sector



Source: Produced from the data in Stockholm Environment Institute and the University of Durham for WRAP (2009), *Meeting the UK climate change challenge: The contribution of resource efficiency*

4.2.4 Waste summary

To summarise, the waste opportunity in 2009 comprises two parts: opportunity remaining from 2006 (Section 4.2.2) and new opportunities available (Section 4.2.3). It is not completely clear as to whether the two parts overlap, but because a considerable proportion of the existing opportunity arose from sectors moving backwards, it has been assumed that this has not been built into the WRAP figures. Additionally the degree of duplication in the sectors and intervention types listed is low. Nevertheless it is noted however that the £3,675m of savings opportunity estimated for the metal manufacturing sector represents around 24% of sector GVA for 2009, largely due to the increase in waste arisings reported for the sector in the recent C&I waste survey.

Table 34 presents the total waste opportunity for 2009, which are 15.9 $MtCO_2$ and £18.3 billion. A striking observation is that the majority of the carbon savings are associated with the existing opportunities (much originating from landfill diversion) whereas the majority of the financial savings come from the new opportunities identified by WRAP.

Table 34: Summary of waste opportunities for 2009

	Carbon (Kt CO_2)	**Financial (£M)**
Existing Opportunity	10,418	1,922
New Opportunity	5,464	16,339
Total	**15,881**	**18,260**

4.3 Water

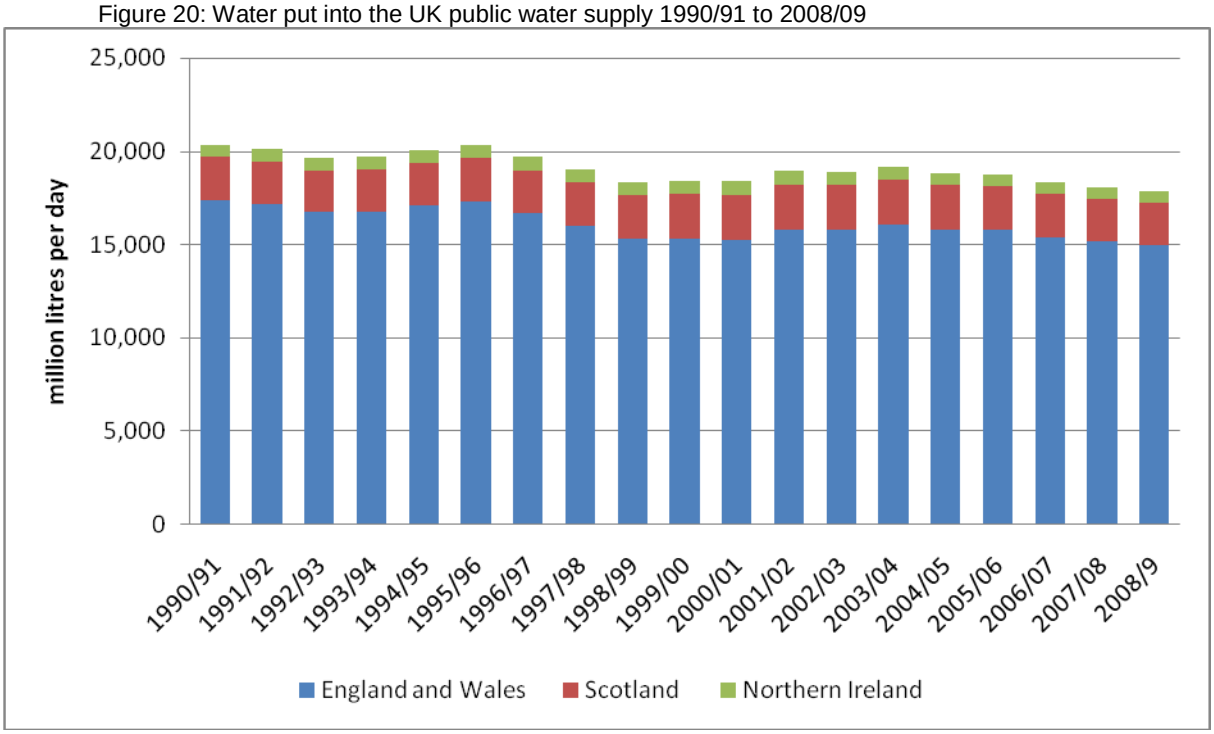
This section is split between the two freshwater users:

- Public water supply: Water abstracted by water companies and distributed to end users.
- Non-public supply: Water abstracted directly by end users.

4.3.1 Public water supply

For public water supply, the Defra Environmental Statistics service provides annual UK updates (1990/91 to 2008/09) broken down by nation (England and Wales, Scotland and Northern Ireland). Figure 20 shows that the total volume of water put into the UK public water supply has reduced year on year since 2003/04 with a 2.4% reduction between 2006/07 and 2008/09.

Figure 20: Water put into the UK public water supply 1990/91 to 2008/09



Source: Defra (2009), *e-digest of environmental statistics* 2009; http://defraweb/evidence/statistics/environment/inlwater/alltables.htm

The Defra/ONS Environmental Accounts[44] reports that in 2006/7 the UK household sector accounted for circa 3.5 billion cubic metres per year and of the 6.1 billion cubic metres per year consumed in England and Wales, 3.2 billion is in the household sector, 1.3 billion from non-households and the remainder was lost due to supply and distribution leakages.

This section provides an estimate of the savings made between 2006 and 2009 within:

- supply and distribution leakages
- household consumption
- non-household consumption.

This section provides an estimate of the savings made within these three areas. *Please note: household consumption is outside the scope of this project but is required in order to derive the savings made in non-household consumption. In addition, much of the analysis focuses on data from England and Wales only since the datasets for Scotland and Northern Ireland were considered incompatible.*

[44] ONS (2010), Environmental Accounts, Feb 2010 update

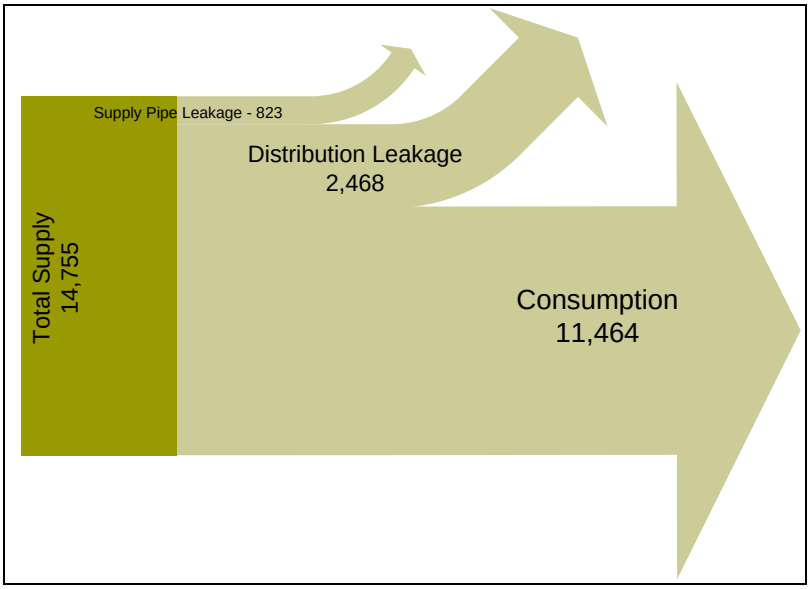
http://www.statistics.gov.uk/downloads/theme_environment/ea-feb10.pdf

4.3.1.1 Supply and distribution leakages

The opportunities in this area represent the savings for the water companies. Figure 21 shows that of the 14,755 million litres of water supplied each day in England and Wales in 2007-08, 3,291 million litres or 22% are lost through supply pipe or distribution leakage. However, OFWAT reports that:

"Most water companies are now operating at their economic level of leakage. This is the level of leakage at which it would cost more for a water company to further reduce its leakage than to produce water from an alternative source, and balances the needs of consumers and the environment".

Figure 21: Public water supply in England and Wales (million litres per day) in 2007-08



Source: Defra (2009) *Environment in Your Pocket,* (http://www.defra.gov.uk/evidence/statistics/environment/eiyp/pdf/eiyp2009.pdf)

This suggests that the no cost / low cost savings opportunities from leakage reduction are negligible. *Please note: Scottish Water reports that it will reach the economic level of leakage by 2014*[45]*.*

Table 35 shows that from 2005/06 to 2007/08 supply losses through leakage in England and Wales fell from 23.3% to 22.3%, a fall of 4.3%.

Table 35: Public water supply in England and Wales (million litres per day)

Year	Total public water supply	Distribution leakage	Supply pipe leakage	% of total supply lost through leakage
2005-6	15,357	2,611	966	23.3
2006-7	14,994	2,545	873	22.8
2007-8	14,755	2,468	823	22.3

Source: OFWAT Data; http://defraweb/evidence/statistics/environment/inlwater/alltables.htm

[45] Utility Week Website, available at URL http://www.utilityweek.co.uk/features/uk/four-ways-that-water-companies.php

4.3.1.2 Household consumption

Household customers account for the majority of the consumption of 'public water supply' with Defra/ONS *Environmental Accounts* (Feb 2010) reporting that household customers accounted for 71% in England and Wales in 2006/07.

One significant factor in household water use and the savings in water usage between 2006 and 2009 is whether the water is metered or unmetered. OFWAT reports that:[46]

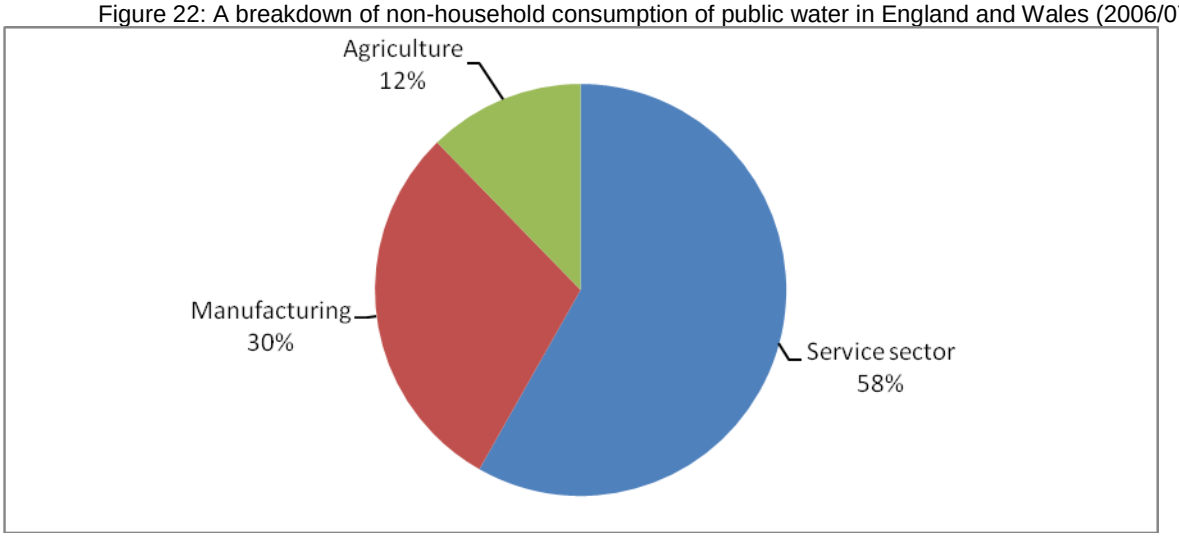
- Between 2000/01 and 2008/09, average household water consumption in unmetered households in England increased by 1 litre from 149 to 150 litres per person per day (an increase of less than 1%).
- Metered household water consumption decreased by 5 litres from 132 to 127 litres per person per day (a decrease of about 4%) over the same period.

Based on the OFWAT statement that one third of households had water meters in 2008/09, it is estimated that the change in household water consumption between 2005/06 and 2008/09 is a decrease per person per day of less than 0.5%. It is recognised that the figures on which this calculation is based may have changed during that time period and that therefore this figure represents a rough average.

4.3.1.3 Non-household consumption

The Environmental Accounts (Feb 2010) reports that non-household customers accounted for 29% of public water consumption in England and Wales in 2006/07. Figure 22 shows that the Service sector accounts for the majority (58%) followed by Manufacturing and then Agriculture.

Figure 22: A breakdown of non-household consumption of public water in England and Wales (2006/07)



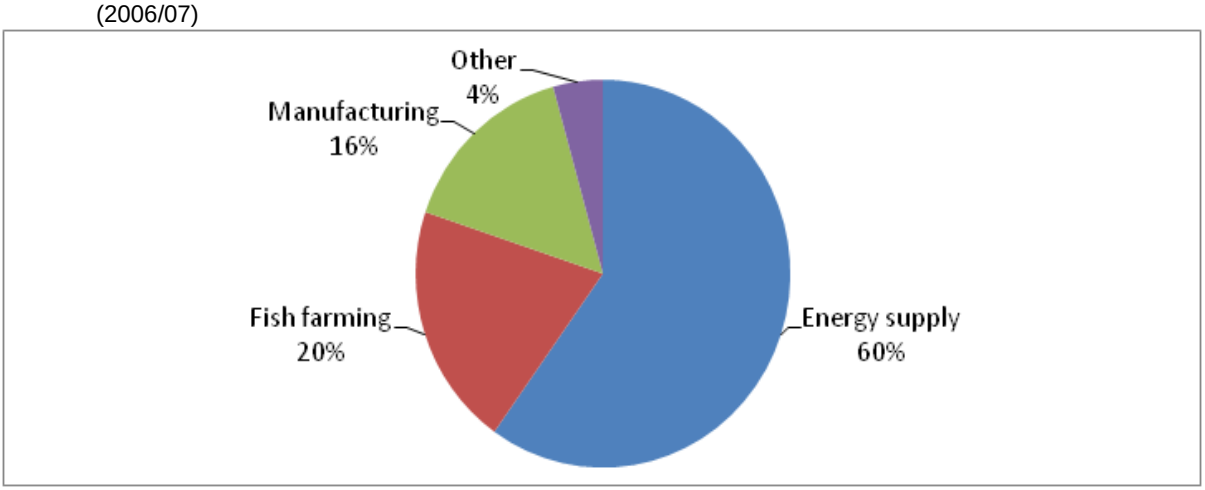
Based on the overall reduction in water consumption of 2.4% and the savings made in leakage reduction and household consumption, it is estimated that a 5.2% saving was made in non-household consumption between 2005/06 and 2008/09, i.e. an annual saving of 1.73%.

[46] Defra website available at URL: http://www.defra.gov.uk/sustainable/government/progress/regional/summaries/16.htm

4.3.2 Non-public supply abstraction

Non-public supply abstraction is dominated by non-household sources (Figure 23) and Defra/ONS *Environmental Accounts* show that, in England and Wales in 2006/07, non-households accounted for 99.5%, with the remainder being households. It is possible that energy supply comes out so highly in such figures due to the cooling requirements of hydropower plants in Wales, which return the water after it has been used. This type of use is important when considering priority water efficiencies as it may be considered less impactful. *Please note: leakages are included within the consumption figures and are much lower than in public supply due to the reduction in complexity of supply and distribution.*

Figure 23: A breakdown of non-household consumption of non-public water in England and Wales (2006/07)



Unlike for public water supply, annual government statistics are not available for non-public abstraction. The Environmental Accounts (Feb 10) stressed that a review was being undertaken of the water accounting framework with the aim of constructing a water account for England and Wales and ultimately for the UK. Consequently it was considered appropriate to use the Environmental Accounts data within this analysis. Table 36 shows the two available datasets for 1997/98 and 2006/07. This shows that non-public supply abstraction in the UK reduced by 1,523 M m^3 or 15.9%; an annual reduction of 1.8%, over the period. This can be seen to be in line with the annual reduction in public supply of 1.7% between 2005/06 and 2008/09, discussed in the previous section. Therefore, it was considered appropriate to assume that the trend in reduction of water use of 1.8% per year would have continued over the period under review in this study.

Table 36: Non-public supply abstraction[47] (M m^3)

1997/98		2006/07	
England and Wales	**UK**	**England and Wales**	**UK**
7,528	9,590	6,337	8,067

Please note: the non-public supply abstraction data are based upon the water use accounts for England and Wales only and is based upon abstraction licence data collected by the Environment Agency which licences all abstractions covered by the licensing regime over 20 m^3 per day[48].

4.3.3 Validation of estimated savings

Annex H shows the results of sector level studies or initiatives focused on water efficiency. In many of the examples the annual savings made are much higher than the 1.8% annual reduction in abstracted water use used in this study. However, in many of the cases, such as the FDF Federation House Commitment (FHC) or the Construction Excellence / BIS construction KPIs the companies in which the savings have been realised cannot be regarded as representative of the whole sector. It is suggested that the companies involved are likely to be the high performing companies who have fully embraced water efficiency.

4.3.4 Quantification of savings opportunities

In the Defra *Business Benefits* study for 2006, the data for 2004 expenditure on water[49] were extrapolated to 2006 and case studies from Envirowise and Enworks were used to determine the savings opportunity (Annex C). Table 37 shows the savings opportunities for 2009 assuming that water efficiency savings of 1.8% per year were realised between 2006 and 2009. The analysis shows that although the percentage savings opportunity has reduced the increased costs of water and waste water management has resulted in the overall savings opportunity increasing from £441.3 million to £524.2 million.

From a CO_2 perspective the savings opportunity will have reduced with respect to the previous 2006 estimate of 0.24 $MtCO_2$. Applying the 1.8% annual reduction in abstracted water use it is estimated that in 2009 it would be 0.23 $MtCO_2$. For both calculations it was necessary to make the assumption that the average emissions associated with public water supply are the same as emissions associated with direct abstraction.

[47] Defra (2009), *The Environment in Your Pocket* 2009 (http://www.defra.gov.uk/evidence/statistics/environment/eiyp/pdf/eiyp2009.pdf)

[48] ONS (2010), Environmental Accounts, Feb 2010 update

http://www.statistics.gov.uk/downloads/theme_environment/ea-feb10.pdf

[49] ONS (2008), *United Kingdom Input – Output Analyses 2005* (http://www.statistics.gov.uk/downloads/theme_economy/Input_Output_Analyses_2005_edition.pdf)

Table 37: Estimated water savings remaining in 2009 from previous *Business Benefits* study

Sector	Subsector	Water supply (input) savings		Estimated total savings including wastewater (£M)
		Estimated savings (%)	Estimated savings (£M)	
Industrial	Chemicals	3.6	6.5	10.8
	Food & drink	15.5	30.5	75.5
	Basic metals	2.5	2.4	5.0
	Transport equipment	<1	0.6	1.6
	Paper, publishing & printing	6.9	3.0	5.1
	Electricity, gas & water	<1	0.8	1.2
	Construction	7.5	1.2	2.4*
	Other	2.7	15.3	34.2
Commercial (Service)	Public administration	26.5	76.9	153.8*
	Health & social work	15.5	13.3	26.6*
	Education	23.5	18.4	36.8*
	Other community activities	16.5	8.4	16.8*
	Real estate, renting & business activities	26.5	10.9	21.8*
	Hotels & restaurants	28.5	3.3	6.6*
	Other	17.4	21.5	43.0*
Agriculture	All	27.5	41.8	83.6*
Total			**254.7**	**524.2**

*Note: No data were found on the expenditure on waste water management in these sectors and hence it was assumed that the cost of waste water management was equal to the cost of water supply.

4.3.5 Water savings interventions

The objective of this section is to highlight the types of intervention that could be undertaken to realise the savings.

The EA reports that for commercial businesses "*you can expect to save an average of 40% of your water use by making simple, low cost changes to toilets, showers, urinals, etc*", and in the Defra *Business Benefits* study for 2006 it was suggested that the type of water efficiency interventions implemented in each sector be tailored to whether the water was for domestic-type activities or process use. Table 38 can be used to indicate the type of water efficiency intervention that could be required by each industry. For example, Public Administration and Defence and Recreation, Culture and Sport have very high levels of domestic-type water consumption, at 70% and 78% of total water use respectively, and therefore it is suggested that these sectors be approached in a similar way to households with a focus on WCs, urinals, basin taps, etc.

Figure 24 shows the breakdown of domestic-type water use activities with WCs accounting for 61%. Water companies could be considered well positioned to provide the water efficiency advice service to such companies, since a very high percentage of the water they supply to non-householders through the public supply route will be used for domestic-type

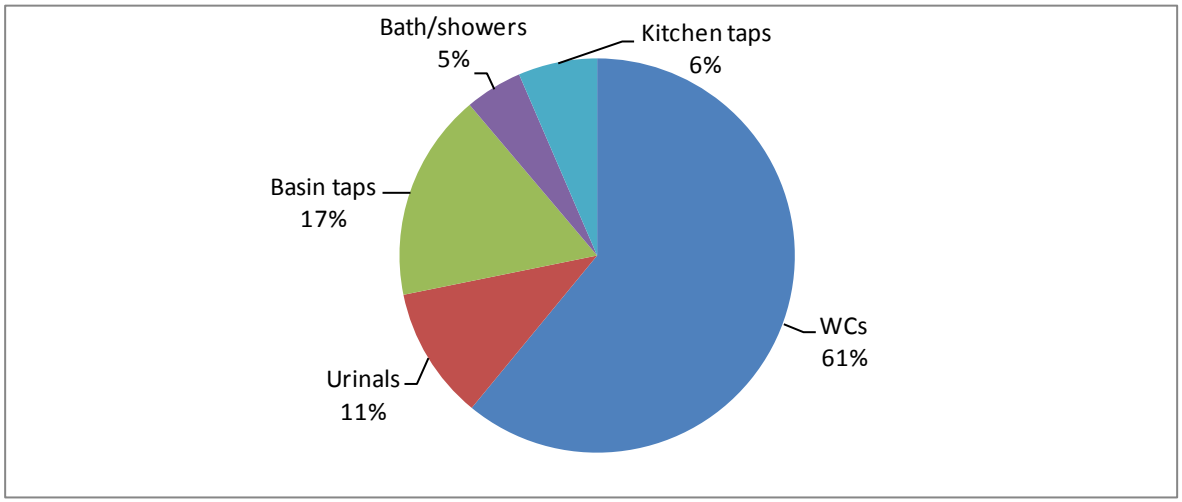
purposes. It is suggested that the service sector as a whole be targeted in this way, since it accounts for 55% of the non-household use of public water supply.

Table 38: Estimated domestic water consumption by industry type

SIC code	Industry	% of total water supply
15	Food & drink	13.20
52	Retail	16.72
55	Hotels	26.50
75	Public admin & defence	70.36
80	Education	35.73
85	Health & social work	55.88
92	Recreation, culture & sport	77.81
All others		5.79

Source: Market Transformation Programme (2008), *BILLIONWAT22: Domestic water consumption in domestic and non-domestic properties*

Figure 24: A breakdown of domestic water use in non-domestic properties.



Source: Market Transformation Programme (2008), *BILLIONWAT22: Domestic water consumption in non-domestic properties*

For sectors such as Food and drink (13%) and Retail (17%) with relatively low levels of domestic-type water use, emphasis should be placed on process water consumption. This requires a sector-level expertise. For Food and drink, for example, wash-downs during product changeovers and at the end of shifts are likely to be a significant water use. A significant percentage of the non-public supply abstraction water will fall into this category with Energy Supply, Fish Farming and Manufacturing being the key sectors. It is suggested that delivery bodies such as WRAP, Environment Agency and MAS are best placed to provide the water efficiency advice service to such sectors.

In addition, one area of leakage that may be considered an opportunity is the reduction in losses from raw water mains to treatment works. Although this is monitored by the Environment Agency, no data on the levels of leakage could be identified in this area and hence the savings opportunity could not be quantified.

4.4 Section summary

Table 39 shows that the no cost / low cost savings opportunity has been estimated at a total of **£22.6 billion,** with £18.3 billion savings opportunity in waste and £3.8 billion savings opportunity in energy.

Table 39: Summary of estimated low cost resource efficiency opportunities for 2009

Resource	Estimated Savings Opportunity	
	£M	$MtCO_2$
Energy	3,820	13.3
Waste	18,260	15.9
Water	524	0.2
Sub-Total	***22,604***	***29.4***

However when comparing the results on a like-for-like basis between 2006 and 2009, the results show that significant progress has been achieved in the realisation of the resource efficiency savings opportunities over the period (Table 40). Some improvement in resource efficiency should be expected naturally as a result of technological change, on average at around 1% per year[50], but clearly significant progress above that rate has been achieved. In financial terms the estimated savings opportunity has fallen by 19%. The largest fall was for the waste savings opportunity, which fell by 28%; conversely the water savings opportunity increased by 19%. In terms of the carbon savings opportunity, this fell by 37% due to a steep decline within the energy sector where the carbon impact fell by 43%. The divergence between the financial and carbon realisation is due to a re-evaluation of the road freight emissions and significant price rises within energy and water.

Table 40: Like-for-like comparison of 2009 and 2006 estimated savings opportunities

Resource	Estimated Savings Opportunity				% Change in Estimated Savings Opportunity	
	2006		2009			
	£M	$MtCO_2$	£M	$MtCO_2$	£M	$MtCO_2$
Energy	3,349	18.7	2,770	10.7	-17%	-43%
Waste	2,659	14.7	1,922	10.4	-28%	-29%
Water	441	0.2	524.2	0.2	19%	-4%
Total	**6,449**	**33.7**	**5,216**	**21.4**	**-19%**	**-37%**

[50] Stockholm Environment Institute and the University of Durham for Defra (2009), *Understanding Changes in UK CO_2 emissions 1992-2004: A structural decomposition approach*

5 Quantification of the resource efficiency savings opportunities with a payback of greater than one year

This section provides details on resource efficiency savings that have a payback period greater than one year. The estimates presented in this section come from a number of studies that have modelled long term resource efficiency savings for:

- Energy
- Waste
- Water.

It must be stressed that projecting or forecasting the resource efficiency savings opportunities using a 40-year time span is inevitably going to be less accurate than the estimate of savings from shorter term interventions, and hence these estimates should be treated with caution and regarded as only 'ballpark' estimates. Some of the studies provide an approximate timeframe for which the savings are achievable. This information has been included where available e.g. Quick Wins versus Best Practice versus Beyond Best Practice for the waste savings. A related consideration is the extent to which costly new technologies are involved in realising the savings. On this issue McKinsey note[51]:

"The role of technology in reducing emission is much debated. We found that some 70 percent of the possible abatements at a cost below or equal to 40 Euros per ton would not depend on any major technological developments. These measures either involve very little technology or rely primarily on mature technologies... The remaining 30 percent of abatements depend on new technologies or significantly lower costs for existing ones.

This is not to say that there are no costs and challenges involved in realising these long term resource efficiency savings issues regarding barriers to achieving the resource efficiency savings, only that it is thought much of them are achievable with existing technologies and with net financial benefits for the businesses undertaking them. More details regarding barriers and costs to implementing resource efficiency savings can be found in Section 8.

5.1 Energy

The Committee on Climate Change (CCC) produced the first of its reports *Building a low carbon economy – the UK's contribution to tackling climate change* in December 2008. This section analyses the energy abatement potential within the three focus areas of this report, namely: transport, non-domestic buildings and industry.

5.1.1 Transport

Work on the longer term resource efficiency savings opportunity has focussed predominantly on technology improvements and CILT reports that[52]:

[51] McKinsey Quarterly (2007 Number 1), *A cost curve for greenhouse gas reduction*, quoted in the Stern Review

[52] CILT (2009), *An Inconvenient Truck? CILT Guide to CO_2 emissions from freight*

"*While technology improvements depend largely on research, manufacturing and Government, the organisation and operation of transport is very much in our hands"*. This suggests that the sector feels the no cost / low cost interventions, discussed in this study can be delivered by the sector but these longer term interventions require external assistance if they are to be realised. Table 41 details the three scenarios used within the CCC study. The study took a technology based approach; quantifying the environmental and economic benefits from alternative technology based interventions.

Table 41: The three transport scenarios detailed in the CCC December 2008 report

Scenario	Description
Current ambition	The Current Ambition scenario includes identified measures which would cost less per tonne than the forecast carbon price, and/or which are covered by policies already in place; the scenario includes cautious estimates of emissions reductions from these measures. It includes significant progress towards low-carbon electricity generation, and some progress on improving fuel efficiency in new cars.
Extended ambition	The Extended Ambition scenario incorporates more ambitious but still reasonable assumptions on the penetration of energy efficiency improvements and a number of measures which would cost appreciably more per tonne of carbon abated than the predicted carbon price, but which are important stepping stones on the path to 2050. It is broadly in line with policies to which the government and/or EU are committed in principle, but where precise definition and implementation of policy is still required. It includes, for instance, a significant penetration of renewable heat, more radical energy efficiency improvement in cars and vans, and some lifestyle changes in homes and transport.
Stretch ambition	The Stretch Ambition scenario adds further feasible abatement opportunities for which at the moment no policy commitment is in place, including more radical new technology deployment and more significant lifestyle adjustments.

Source: CCC (2008), *Building a low carbon economy – the UK's contribution to tackling climate change*

5.1.1.1 Transport – Current Ambition Scenario

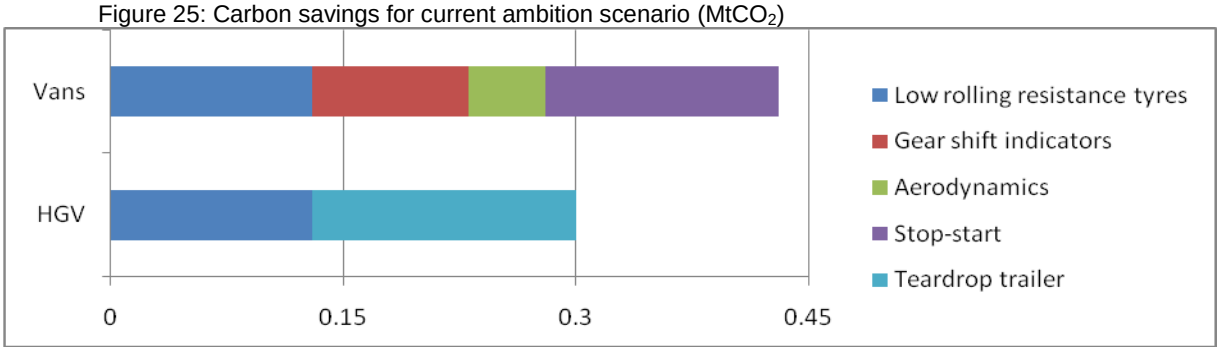
The result of the Current Ambition Scenario for vans and HGVs is shown in Table 42. This shows that the most significant opportunities from both environmental and economic perspectives are improvements in Stop-start technology for vans and Teardrop trailers for HGV (particularly for artic > 33 tonnes). The analysis shows that the overall savings opportunity is 0.73 $MtCO_2$ or £344 million. The estimated carbon savings are presented graphically in CCC (2008), *Building a low carbon economy – the UK's contribution to tackling climate change* and in Figure 25 by resource efficiency intervention.

Table 42: Costs savings for current ambition scenario

Type	Resource Efficiency Intervention	$MtCO_2$ saving	Social saving		Raw material (fuel) saving	
			Saving £/tCO_2	Total saving £M	Saving £/tCO_2	Total saving £M
Vans	Low rolling resistance tyres	0.13	67	8.7	410	53.3
	Gear shift indicators	0.10	58	5.8	410	41
	Aerodynamics	0.05	36	1.8	410	20.5
	Stop-start	0.15	26	3.9	410	61.5
HGV	Low rolling resistance tyres	0.13	102	13.2	410	53.4
	Teardrop trailer	0.17	67	11.4	410	69.7
Total		**0.73**		**44.8**		**299.4**

Source: CCC (2008), *Building a low carbon economy – the UK's contribution to tackling climate change*

Figure 25: Carbon savings for current ambition scenario ($MtCO_2$)



Source: CCC (2008), *Building a low carbon economy – the UK's contribution to tackling climate change*

5.1.1.2 Transport – Extended Ambition Scenario

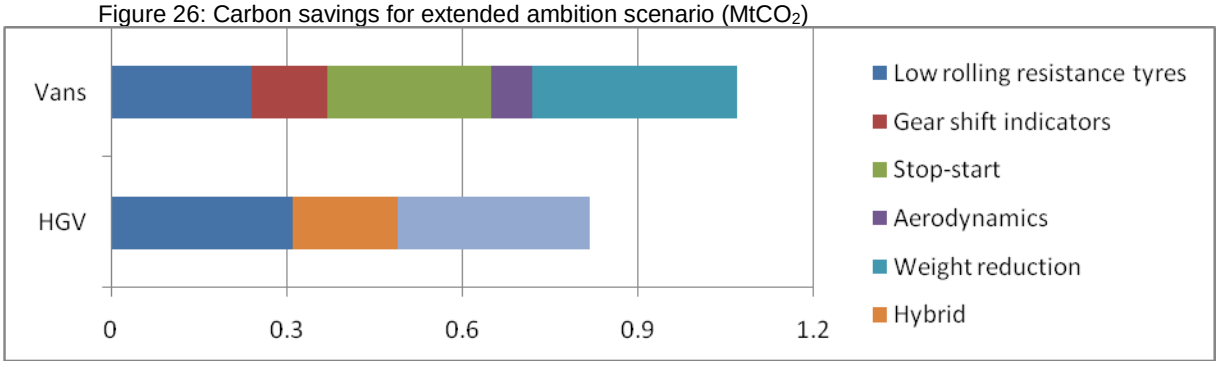
The result of the Extended Ambition Scenario for vans and HGVs is shown in Table 43. This shows that the most significant opportunities from both environmental and economic perspectives are improvements in Weight reduction for vans and Teardrop trailers are again the best option for HGV (particularly for artic > 33 tonnes). The analysis shows that the overall savings opportunity is 1.89 $MtCO_2$ or £898 million. The estimated carbon savings are presented graphically in Figure 26 by resource efficiency intervention.

Table 43: Costs savings for extended ambition scenario

Type	Resource Efficiency Intervention	$MtCO_2$ saving	Social saving		Raw material (fuel) saving	
			Saving £/tCO_2	Total saving £M	Saving £/tCO_2	Total saving £M
Vans	Low rolling resistance tyres	0.24	81	19.4	410	98.4
	Gear shift indicators	0.13	63	8.2	410	53.3
	Stop-start	0.28	60	16.8	410	114.8
	Aerodynamics	0.07	36	2.5	410	28.7
	Weight reduction	0.35	3	1.1	410	143.5
HGV	Low rolling resistance tyres	0.31	102	31.7	410	127.1
	Hybrid	0.18	112	20.1	410	73.8
	Teardrop trailer	0.33	71	23.3	410	135.3
Total		**1.89**		**123.1**		**774.9**

Source: CCC (2008), *Building a low carbon economy – the UK's contribution to tackling climate change*

Figure 26: Carbon savings for extended ambition scenario ($MtCO_2$)



Source: CCC (2008), *Building a low carbon economy – the UK's contribution to tackling climate change*

5.1.1.3 Transport – Stretch Ambition Scenario

The study reports the level of potential savings of 13 $MtCO_2$, namely:

- Unlocking the full potential of at least 3 $MtCO_2$ in vans through the potential intensification of energy efficiency improvement in internal combustion engines and application of a range of non-powertrain measures (e.g. improved aerodynamics) and the potential to deploy new technologies (e.g. plug-in hybrid and pure electric vans) .
- Significant potential for emissions reductions from HGVs exists through changed driver behaviour, modal shift and better journey planning. Indicative estimates suggest a potential to deliver cuts of up to 10 $MtCO_2$ in 2020, if a range of levers (e.g. better information, driver training) are deployed.

Although the social costs associated with this environmental saving cannot be quantified, applying the raw material saving of £410 per tonne CO_2 provides an estimate of the economic savings of £5.33 billion.

5.1.2 Non-domestic buildings

For non-domestic buildings the opportunities resulting in a financial saving taken from the MAC curve put the estimated savings at 11.16 $MtCO_2$ or £1.11 billion. This estimate is in line with the DECC *Zero Carbon Britain 2030* estimate that 13.5 $MtCO_2$ could be achieved within non domestic buildings at a cost of less than £40 per tonne CO_2. Much of the inefficiency in this area is associated with the heating of older commercial offices, education facilities, retail spaces, hotels and catering outlets.

5.1.3 Industry

For industry the opportunities taken from the MAC curve put the estimated savings at 5.86 $MtCO_2$ or £640 million. Four interventions account for two thirds of the financial savings opportunities identified.

5.2 Waste

The WRAP study quantified potential resource efficiency savings from a number of different interventions. It took a top-down approach to identify potential CO_2e savings from material efficiencies, and allocated these between supply intervention strategies that are aimed at influencing production, and demand strategies that are aimed at influencing consumption. The seven identified supply strategies are listed in Table 44 with their definitions.

For each of the strategies identified the potential resource efficiency savings are quantified in terms of the impact they could have in reducing GHG emissions compared to a reference scenario. The savings are broken down into ‘Quick Wins’, ‘Best Practice’ or ‘Beyond Best Practice’ to get three different resource efficiency scenarios:

- The Quick Wins scenario identifies what can be achieved in the short term (2010 to 2020). These strategies are viewed as being relatively easy to implement as they do not require additional costs or major technology and or cultural shifts presented in Section 4.2.3).
- The Best Practice scenario identifies the possible reductions that could be achieved if the best currently available technologies and consumption behaviours were adopted across all appropriate sectors and households by 2050.

- The Beyond Best Practice scenario considers the maximum potential of the resource efficiency strategies assuming that all major barriers could be removed so that the strategies could recognise their full potential.

Table 44: Definitions of supply strategies

Strategy	Definition
Lean production	Reduced material inputs into production processes through the design of lighter and leaner products
Material substitution	Substitution of highly carbon intensive materials for low carbon intensive materials
Waste reduction	A reduction in waste at the production stage that directly leads to a reduction in material requirements
Re-direction of landfill materials	Diversion of waste from landfill to recycling
Dematerialisation of the service sectors	Improving the efficiency of product use in the service sector through extending the lifetime of products, reducing edible food waste and eradicating junk mail
Strategies for sustainable building	Improving efficiency by introducing modern methods of construction such as modular design and off-site construction
Efficient use of existing infrastructure	Reduce material inputs into construction through replacing new build with retrofit

Source: Stockholm Environment Institute and the University of Durham for WRAP (2009), *Meeting the UK climate change challenge: The contribution of resource efficiency*

Annex I details the assumptions used for the three scenarios within each of the seven supply strategies shown in Table 44. *Please note: unlike the CCC report detailed within the energy section, which comprised of a technology review, the assumptions within this report are more speculative and hence further work is needed to determine their viability.*

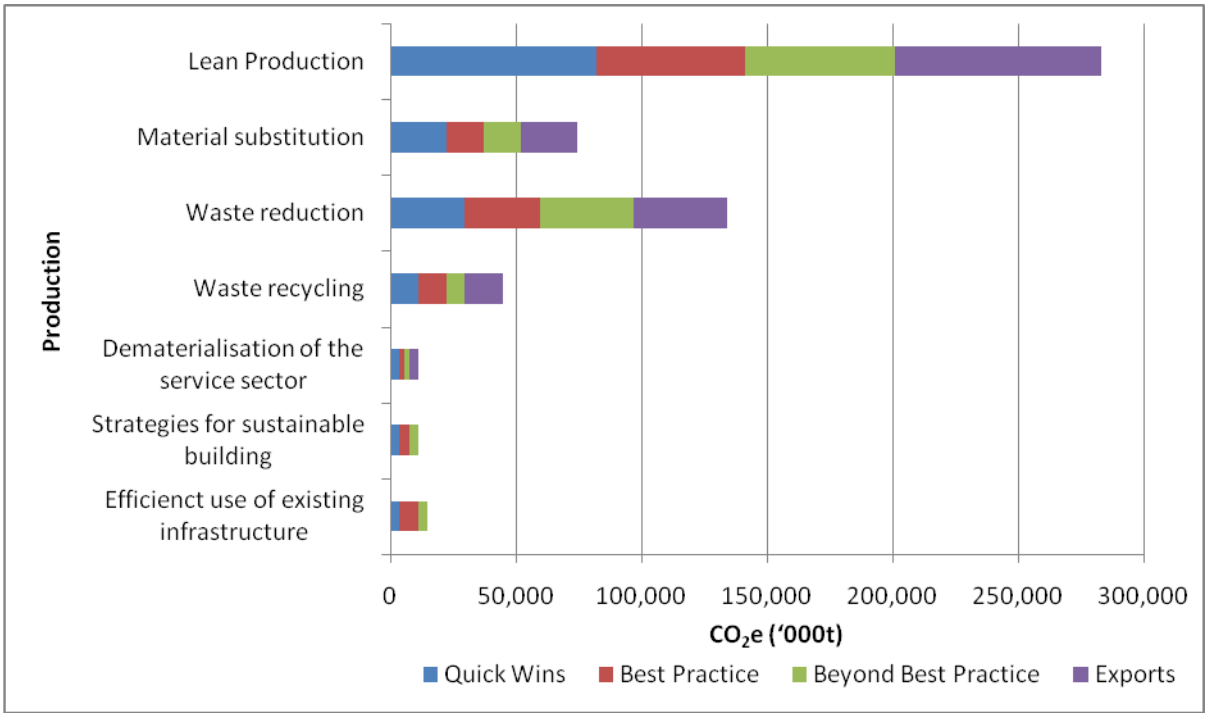
The study estimated savings opportunities within 123 different business sectors. From an economics perspective the study estimated the savings in percentage of UK GDP, in 2020 for the Quick Wins and in 2050 for the Best Practice and Beyond Best Practice scenarios. For the current study where the objective is to quantify the total annual resource efficiency savings opportunity using a 2009 baseline it was considered appropriate to apply the HM Treasury GDP 2009 valuation (£1,396,474 million) to the percentage savings.

Within the WRAP study *Meeting the UK climate change challenge: The contribution of resource efficiency* (2009), the supply strategies were estimated to have the collective potential to save an aggregated total of 572 $MtCO_2e$ by 2050. Lean production at ca.280 $MtCO_2e$ and waste reduction at 137 $MtCO_2e$ were the two most significant supply strategies identified, accounting for 73% of the total potential savings, as shown in Figure 27. The study concludes that the significance of these two strategies highlights the fact that it is not about dealing with waste in a more efficient manner, but about waste prevention throughout the supply chain.

Figure 28 shows the profile of the savings by scenario to 2050. This shows that in the short term, to 2020, all three scenarios can make a significant contribution in terms of resource efficiency savings. However, an assumption of the study is that the 'Quick Wins' will be exhausted by 2020 and hence in the longer term it is the 'Beyond Best Practice' scenario that makes the most significant contribution, accounting for 55% of the projected total annual savings in 2050, with the 'Best Practice' scenario accounting for 34% of the remaining opportunity and 'Quick Wins' 11%.

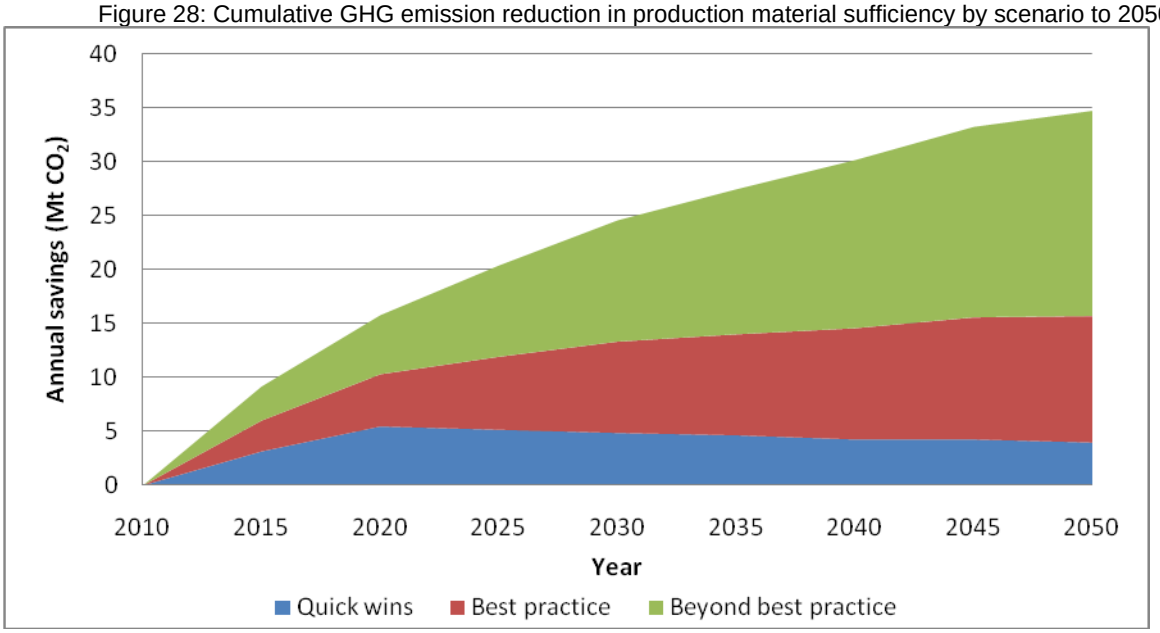
The study estimated savings opportunities within 123 different business sectors (see Annex J). Analysis shows that six of the 123 business sectors account for over 70% of the total projected savings opportunities (Table 45 and Annex J).

Figure 27: Cumulative GHG emission reduction in production material sufficiency to 2050 by supply strategy (Kt)



Source: Stockholm Environment Institute and the University of Durham for WRAP (2009), *Meeting the UK climate change challenge: The contribution of resource efficiency*

Figure 28: Cumulative GHG emission reduction in production material sufficiency by scenario to 2050 (Kt)



Source: Produced from the data in Stockholm Environment Institute and the University of Durham for WRAP (2009), *Meeting the UK climate change challenge: The contribution of resource efficiency*

Table 45: The projected savings opportunities from the six most significant business sectors

Sector	Savings opportunity ($MtCO_2$)							
	2015	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Wood products	0.49	0.81	1.08	1.39	1.64	1.82	2.15	2.42
Cement & plaster	2.05	2.99	3.38	3.81	3.99	4.09	4.60	4.76
Iron & steel	1.61	2.74	3.79	4.85	5.45	6.22	6.95	7.70
Electricity production & distribution	1.02	1.83	2.38	2.85	3.31	3.76	4.39	4.96
Construction	0.90	1.45	1.91	2.08	2.24	2.11	2.05	1.64
Sewage & refuse disposal	0.59	1.39	2.15	3.00	3.53	4.50	4.71	4.59
Sub total	6.66	11.21	14.69	17.98	20.17	22.49	24.84	26.06
Total	**9.17**	**15.77**	**20.38**	**24.56**	**27.44**	**30.14**	**33.21**	**34.71**

Source: Produced from the data in Stockholm Environment Institute and the University of Durham for WRAP (2009), *Meeting the UK climate change challenge: The contribution of resource efficiency*

From an economics perspective the study estimated the savings in percentage of UK GDP, in 2020 for the Quick Wins and in 2050 for the Best Practice and Beyond Best Practice scenarios. For the current study where the objective is to quantify the total annual resource efficiency savings opportunity using a 2009 baseline, the delivery timescale is less significant than the overall scale of the saving. Therefore, it was considered appropriate to apply the HM Treasury GDP 2009 valuation (£1,396,474 million) to the percentage savings to derive the current annual total resource efficiency savings potential. Table 46 shows that, based on these assumptions and based on 2009 UK GDP, the Quick Wins are valued at £16.3 billion, the Best Practice strategies £31.4 billion, and the Beyond Best Practice scenarios £38.4 billion.

Because the Quick Wins are equivalent no cost / low cost opportunities, they are listed in Section 4.2.3 as part of the existing opportunities. This means that **the longer term savings opportunities for waste are therefore £22.06 billion or 29.24 $MtCO_2$**.

Table 46: Estimated resource efficiency savings opportunity by strategy in 2009 (£ billions)

Strategy	Quick Win	Best Practice	Beyond Best Practice
Lean production	12.4	22.3	22.3
Material substitution	0	0	0
Waste reduction	1.3	3.5	6.0
Waste recycling	0.4	1.1	2.2
Dematerialisation of the service sector	0.6	0.8	0.8
Strategies for sustainable building	0.8	1.7	3.6
Efficient use of existing infrastructure	0.8	2.0	3.4
Total	**16.34**	**31.42**	**38.40**

5.3 Water efficiency

The Environment Agency reports that[53]: *"Businesses currently use around 9.8 billion cubic metres of water each year - but nearly a third of it could be saved bringing around £10 million savings each day - or over £3.5 billion each year"*. For the whole UK, the supply and treatment of water is reported to be responsible for around 4 $MtCO_2$ emissions[54]. Therefore a saving of one third equates to 1.33 $MtCO_2$.

5.4 Section summary

Table 47 summarises the long term resource efficiency savings opportunities identified in this section. The overall saving is estimated at 60.6 $MtCO_2$ or £32.6 billion.

Table 47: Summary of long term resource efficiency savings

Sector or intervention	**Savings opportunity**	
	$MtCO_2$ saving	**Total saving £M**
Material resource efficiency	29.2	22,061
Transport – energy	13	5,330
Non domestic buildings – energy	11.2	1,113
Industry - energy	5.9	640
Water efficiency	1.3	3,500
Total	**60.6**	**32,644**

[53] EA website available at URL http://www.environment-agency.gov.uk/news/109641.aspx [accessed 19 June 2010]

[54] Green bang website available at URL: http://www.greenbang.com/water-efficiency-could-boost-profits-by-35-billion_10873.html [accessed 19 June 2010]

6 Review of Government policies' contribution to resource efficiency

This section reviews the available evidence on the impact that Government policies, initiatives and voluntary agreements have had on achieving resource efficiency savings. The implication that underlies this policy intervention is that the long run efficiency savings resulting from technology, of around 1% per year on average[55] needs to be accelerated,

The aim was to select the most significant policies, initiatives and voluntary agreements where quantitative data are available on their contribution to resource efficiency, and ensuring coverage across all of the resources included within this study (energy, waste and water). The approach taken for this section was a literature review of evaluations resource efficiency policies, although some simple additional analysis has been performed. It is noted that different authors have use different methodologies to evaluate policies e.g. in the establishment of baselines of what would have happened in the absence of policy.

A wide range of policies, initiatives and voluntary agreements were selected on this basis. In all 5 policies, 3 initiatives and 4 voluntary agreements were reviewed. These are listed in Table 48 together with the resource and sectors covered by them. Some general comments on them are:

- Some are specific to a particular resource e.g. Landfill Tax for waste, whereas others cover all types of resources e.g. Business Resource Efficiency and Waste Programme (BREW)
- Others relate to particular sectors, typically where large opportunities have been identified in the past e.g. DfT Freight Best Practice (FBP) for energy use for Road freight
- None exclusively consider water; rather water is included within a larger programme e.g. The Federation House Commitment on water use by the FDF is part of their wider Five-fold Commitment agenda

Table 48: Policies, initiatives and voluntary agreements included in the review

Type	Name	Resource	Sectors
Policies	Landfill Tax	Waste	All
	Integrated Pollution Prevention and Control	Waste	Several
	Carbon Reduction Commitment	Energy	Non-Energy Intensive
	EU Emissions Trading System	Energy	Energy Intensive
	Climate Change Agreements	Energy	Energy Intensive
Initiatives	Business Resource Efficiency and Waste Programme	All	Several
	The Freight Best Practice programme	Energy	Transport
	Enhanced Capital Allowance Scheme	Energy	All
Voluntary Agreements	The Courtauld Commitment	Waste	Food, Retail
	Halving Waste to Landfill	Waste	Construction
	FDF Five-fold Commitment	All	Food
	BRC 'Better Retailing Climate'.	All	Retail

[55] Stockholm Environment Institute and the University of Durham for Defra (2009), *Understanding Changes in UK CO_2 emissions 1992-2004: A structural decomposition approach*

Some policies, initiatives and voluntary agreements that were considered for inclusion but were excluded for the following reasons:

- Defra Roadmaps: There was a lack of quantitative data on outcomes – the evaluations focussed on success factors and lessons learned.
- Home Improvement Commitment by WRAP: This only commenced in September 2009 and progress data are not available
- Direct Marketing Material Waste Prevention voluntary agreements (by the Direct Marketing Association): This targeted greater consumer recycling levels and not business waste
- Voluntary agreement by the Periodical Publisher Association (PPA): This targeted greater consumer recycling levels and not business waste
- Chemical Industries Association monitoring of emission levels, which is a long-standing where much of the impact is outside the study period

It should be noted that the effectiveness of these are currently being reviewed as part of a wider study commissioned by WRAP evaluating resource efficiency agreements.

6.1 Policies

Policies reviewed in this section are:

- Landfill Tax
- Integrated Pollution Prevention and Control (IPPC)
- Carbon Reduction Commitment (CRC)
- EU Emissions Trading System (EU ETS) & Climate Change Agreements (CCAs).

6.1.1 Landfill Tax

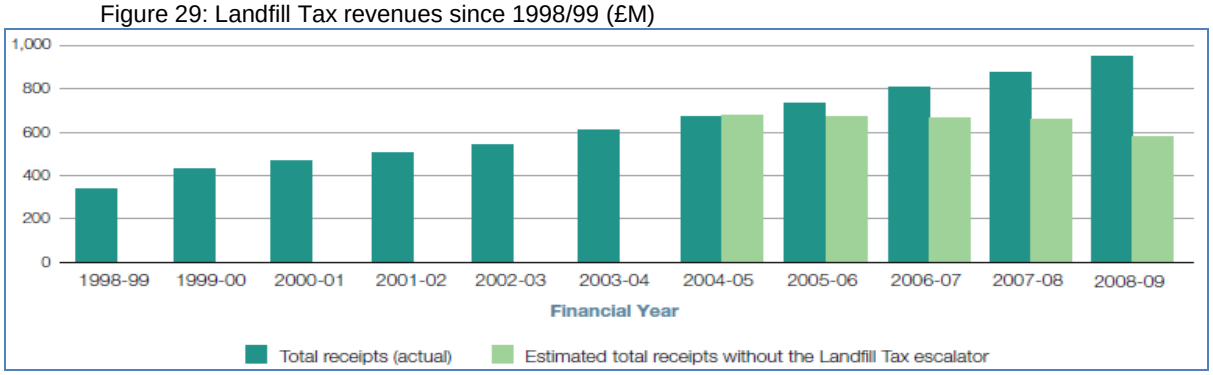
Landfill Tax is a tax on the disposal of waste, aimed at encouraging waste producers to produce less waste, recover more value from waste, for example through recycling or composting and to use more environmentally friendly methods of waste disposal. The tax applies to all waste disposed of by way of landfill or at a licensed landfill site, on or after 1 October 1996. The tax is charged by weight and there are two rates: a standard rate and a lower rate for inert or inactive waste, although some material is exempt from the tax (dredgings from water, mining and quarrying waste, from reclamation of contaminated land etc.). In 2009 43 Mt of material were disposed of to landfill; (63% waste charged at the standard rate, 13% at the lower rate and 24% was exempt)[56].

In the 2007 Budget the Chancellor announced that the Landfill Tax would increase more quickly and to a higher level than previously planned, with increases of £8 per tonne per year for active waste announced from 2008/09 to at least 2013. This was a significant increase on the existing Landfill Tax escalator under which the standard rate of tax was increased by £3 per tonne each year for three years[57]. Figure 29 presents National Audit Office (NAO) analysis of the effect of the landfill escalator since 2004/05.

[56] HMRC website available at URL: http://customs.hmrc.gov.uk/channelsPortalWebApp/channelsPortalWebApp.portal?_nfpb=true&_pageLabel=pageExcise_ShowContent&propertyType=document&id=HMCE_CL_000509, [accessed 15th July 2010]

[57] Defra website available at URL: http://www.defra.gov.uk/environment/waste/strategy/factsheets/landfilltax.htm [accessed 15 July 2010]

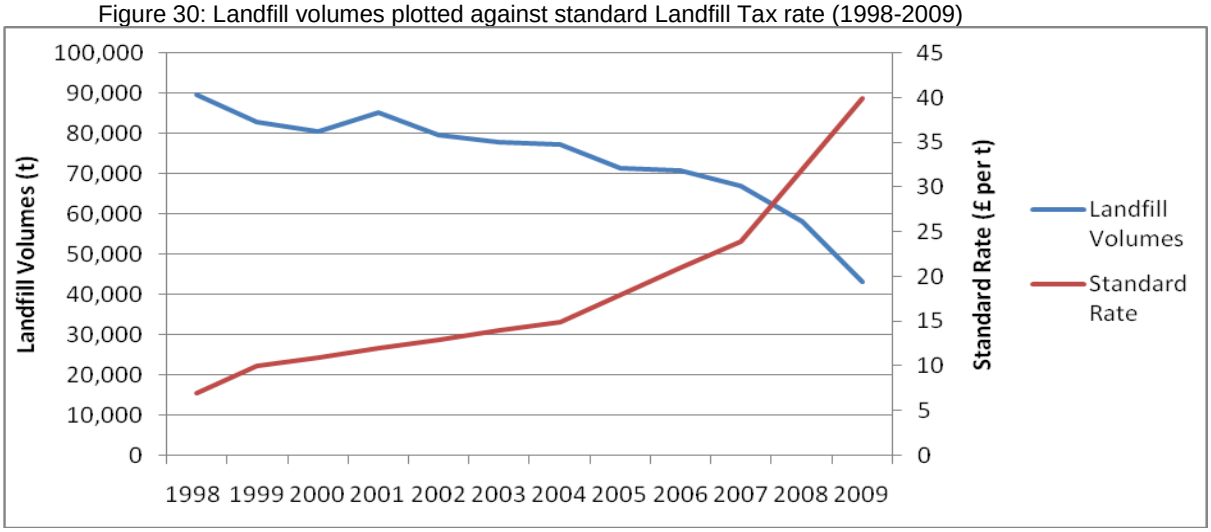
Figure 29: Landfill Tax revenues since 1998/99 (£M)



Source: NAO (2010), *Reducing the impact of business waste through the Business Resource Efficiency and Waste Programme*

Trends for the Landfill Tax and for landfill volumes can be seen in Figure 30, which plots landfill volumes against the standard rate of tax between 1998 and 2009. Over the period shown, landfill volumes have halved from 89.7 Mt in 1998 to 43 Mt in 2009. The correlation between the standard rate of Landfill Tax and the landfill volumes is very high at -0.99, i.e. almost perfect negative correlation. The impact of the Landfill Tax on landfill volumes appears therefore to have been very strong. However some of this effect can likely be attributed to other policies, and to the many other drivers that exist for volumes of waste. On the impact of Landfill Tax, the 2009 Budget reported that the tax would generate a 0.7 $MtCO_2e$ saving in 2012[58].

Figure 30: Landfill volumes plotted against standard Landfill Tax rate (1998-2009)



Source: HMRC (2010), *Landfill tax bulletin*

6.1.2 Integrated Pollution Prevention and Control (IPPC)

Integrated Pollution Prevention and Control (IPPC) is a regulatory system to control the environmental impact to air, land and water of emissions arising from industrial activities. It involves determining the appropriate controls for industry to protect the environment through a single permitting process. In order to gain an IPPC permit, operators of industrial sites must show that they have systematically developed proposals to apply the Best Available

[58] HM Treasury (2009), *2009 Budget*

Techniques to pollution prevention and control, and that they address other requirements, relevant to local factors. IPPC has been implemented to meet the following environmental objectives[59]:

- Protection of the environment as a whole by preventing or minimising emissions to all media (air, land and water)
- Encouragement of reductions in raw materials and energy use and increased recycling and reuse
- Promotion of the use of clean technology to reduce pollution at source
- Encouragement of innovation, by leaving significant responsibility for developing satisfactory solutions to environmental issues with industrial operators
- Provision of a 'one-stop shop' for administering applications for permits to operated
- Simplification and strengthening of the role of the Competent Authorities (regulators).

Data are captured as part of the regulation for waste arising and landfill volumes, which can be used to assess the progress that can be attributed to companies and sectors captured by the IPPC. The methodology used for this is to remove the sites that were not captured by the IPPC in both 2006 and 2009 so as to look at trends on a like-for-like basis and hence remove compositional changes in the companies captured by the IPPC. GVA data provided by the *Blue Book* are then used to develop BAU scenarios for waste and landfill volumes against which progress in waste reduction and waste diversion can be measured[60]. The trends that are shown for the IPPC-captured companies can then be compared to the waste statistics for sectors as a whole, to assess the effect of the Directive on the companies covered by it. The industries covered by the Directive in both 2006 and 2009 were:

- Food and drink manufacturing
- Energy and fuel production
- Chemical, rubber and plastics production
- Production and processing of metals
- Paper manufacture and printing
- Manufacture of non-metallic mineral products
- Other industry (textile and leather activities, and timber activities).

Table 49: Like-for-like waste and landfill volumes for IPPC captured sectors

Sector	Total waste				Landfill Volumes		
	% IPPC Captured	2006 (Mt)	2009 (Mt)	% Change	2006 (Mt)	2009 (Mt)	% Change
Chemicals, rubber & plastics	25%	1.00	0.75	-25%	0.46	0.35	-24%
Energy & fuel production	97%	6.80	5.86	-14%	3.01	1.92	-36%
Food & drink manufacturing	37%	2.93	2.21	-24%	0.49	0.18	-64%
Metals	54%	2.04	1.59	-22%	0.99	0.46	-54%
Minerals	18%	0.43	0.42	-2%	0.12	0.08	-32%
Paper	26%	0.96	0.92	-4%	0.22	0.13	-42%
Other industry	14%	0.32	0.33	2%	0.01	0.05	536%
Total	**47%**	14.48	12.07	**-17%**	5.30	3.16	**-40%**

Source: Own calculations from EA Pollution Inventory Database, Eurostat

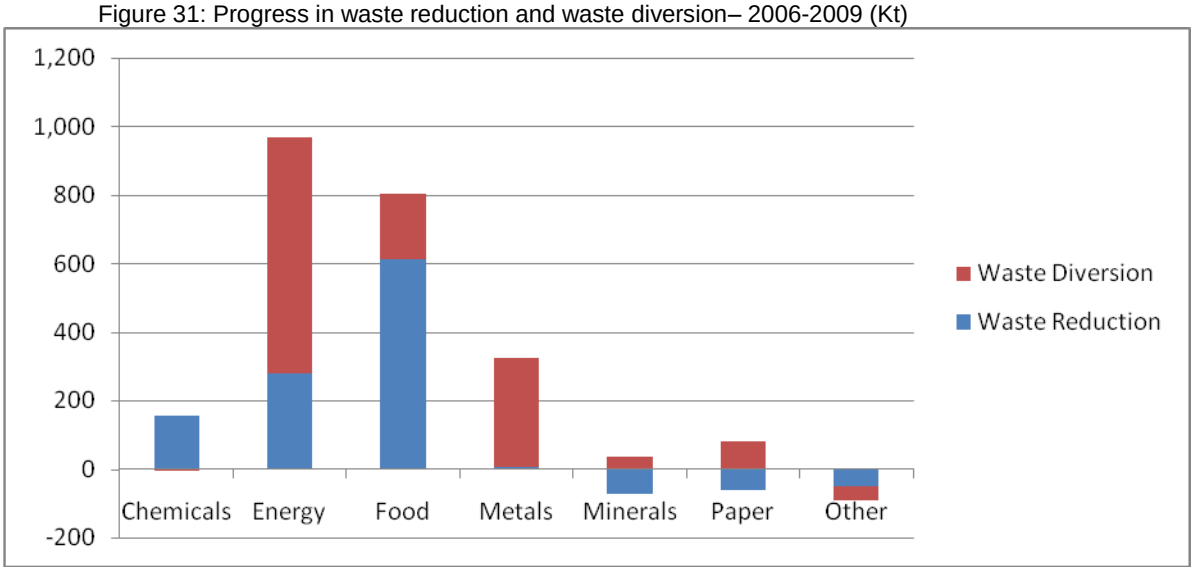
[59] Envirowise/WRAP website available at URL: http://envirowise.wrap.org.uk/uk/Integrated-Pollution-Prevention-And-Control-IPPC.html [accessed 14 Jul 2010]

[60] The waste diversion figures take account of progress in waste reduction to avoid double counting of the progress

The results of the like-for-like waste IPPC data are shown in Table 49. Collectively 47% of the waste generated by these sectors was captured by the IPPC data, although there was wide variation in the capture rates for each of the sectors, with Energy and fuel production having 97% of waste captured by the IPPC, whereas Other industry and Minerals had less than 20% of the sector captured by the IPPC. For the sectors as a whole a 17% fall in waste volumes and a 40% fall in landfill volumes were observed. Sector variation was evident in waste volumes, with some sectors' waste arising increasing; although almost all sectors exhibited falling landfill volumes.

The changes in GVA are accounted for in Table 50 to waste reduction and waste diversion achieved between 2006 and 2009. Total progress in waste reduction and waste diversion are estimated at 0.87 Mt and 1.3 Mt respectively; giving a total progress in waste of 2.1 Mt. The sectoral breakdown of the progress made is presented graphically in Figure 31.

Figure 31: Progress in waste reduction and waste diversion– 2006-2009 (Kt)



Source: Own calculations from EA Pollution Inventory Database, ONS Blue Book

Nearly half of the progress was made within the energy and fuel production sector (although this large share is probably partly due to the high IPPC coverage in the sector). The UK Quality Ash Association (UKQAA) was in broad agreement on the magnitude of these estimates. On its explanation the UKQAA noted the following reasons[61]:

- In 2007 there was a change in the way of reporting land reclamation and restoration as no longer being a landfill activity, in line with the rest of Europe.
- A change in the UK energy mix towards gas has led to waste falling (most of the waste arises in coal-fired stations).
- There is a difference in the quality of ash depending on whether coal is used for base-load or peak-load. Base-load ash is less saleable for cement as the quality is lower.

Significant progress was also made in Food and drink manufacturing, particularly in waste reduction, although some of this progress is likely to be the result of the reclassification of animal feed as a by-product rather than a waste. Other sectors with significant progress made were Chemicals, rubber and plastic (waste reduction) and Metals (waste diversion).

The final step in the analysis of the IPPC is to compare the progress made for those companies captured by the IPPC to the overall sectoral trends displayed in the C&I waste

[61] UKQAA, personal communication

arisings data analysed in the previous section. This analysis gives an indication of the effectiveness of the IPPC, although the selection of companies within and outside of the IPPC is another explanation of the results. This analysis has been conducted for three sectors where there were a sufficient proportion of companies both within and outside the IPPC regulation:

- Food, drink and tobacco
- Chemicals / non-metallic minerals
- Metal manufacturing.

Table 50: Progress in waste reduction and waste diversion – 2006-2009 (Kt)

Sector	% Change in GVA	Waste Reduction	Waste Diversion	Total
Chemicals, rubber & plastics	-9%	156	-4	152
Energy & fuel production	-7%	279	688	967
Food & drink manufacturing	-4%	611	194	804
Metals	-22%	6	318	325
Minerals	-19%	-72	35	-37
Paper	-10%	-62	82	21
Other industry	-13%	-50	-40	-90
Total	**-10%**	**869**	**1,274**	**2,142**

Source: Own calculations from EA Pollution Inventory Database, ONS Blue Book

The results of this analysis are shown in Table 51. For the Metal manufacturing sector a clear picture emerges of the effectiveness of IPPC in driving change relative to companies not captured by the IPPC, with IPPC captured companies' waste falling by 22% versus a 116% increase for non-IPPC captured companies. For the Chemicals / non-metallic minerals sector waste fell less quickly for the IPPC captured companies, most likely due to the modest decline in waste volumes for the minerals sector (2% fall) where there is a greater proportion of waste that is unavoidable and is likely to have already been largely reduced by IPPC captured companies. For the Food, drink and tobacco sector, there is little difference in the achievements of IPPC and non-IPPC captured companies.

Table 51: Comparison of waste arisings for IPPC and non-IPPC captured companies (Kt)

Sector	2006			2009			% change 2006-2009		
	IPPC	Non-IPPC	Total	IPPC	Non-IPPC	Total	IPPC	Non-IPPC	Total
Food, drink & tobacco	2,926	4,932	7,859	2,210	3,562	5,772	-24%	-28%	-27%
Chemicals / non-metallic minerals	1,432	5,081	6,514	1,173	3,243	4,416	-18%	-36%	-32%
Metal manufacturing	2,035	1,724	3,758	1,585	3,718	5,303	-22%	116%	41%

Source: Own calculations from EA Pollution Inventory Database, Defra C&I Data

6.1.3 The Carbon Reduction Commitment (CRC)

The Carbon Trust reports[62] that the Carbon Reduction Commitment Energy Efficiency Scheme (CRC) is a mandatory carbon emissions reporting and pricing scheme to cover all

[62] http://www.carbontrust.co.uk/policy-legislation/business-public-sector/pages/carbon-reduction-commitment.aspx

organisations using more than 6,000 MWh per year of electricity (equivalent to an annual electricity bill of about £500,000).

The CRC came into force in April 2010 and aims to significantly reduce UK carbon emissions not covered by other pieces of legislation. The primary focus is to reduce emissions in non-energy intensive sectors in the UK. This complements the roles of Climate Change Agreements and the EU ETS, which are directed primarily at energy-intensive organisations. The CRC is further discussed in Section 6.1.4 below where its coverage is assessed.

6.1.4 EU Emissions Trading System (EU ETS) & Climate Change Agreements (CCAs)

The European Union Emissions Trading System (EU ETS) commenced on 1 January 2005 with the aim of reducing emissions of greenhouse gases from industrial sources across the European Union. The EU ETS is a cap and trade scheme – under which a total cap is determined for the amount of CO_2 emissions permitted and is made available to participants in the form of 'allowances'. At the end of each year participants must submit verified emissions data and enough allowances to cover their emissions. Participants may trade the allowances to buy more or to sell surplus allowances to reduce CO_2 emissions in the most cost-effective and economically efficient manner. The EU ETS is the largest emissions trading scheme in the world covering an unprecedented number of countries and industrial activities. It covers some 11,000 industrial sites in 30 countries (the 27 EU Member States plus Iceland, Liechtenstein and Norway) and covers close to half of the EU CO_2 emissions. At present around 1,000 sites in the UK are participating in the scheme, representing 48% of UK CO_2 emissions in 2009; and the scheme is a cornerstone of the UK Government's response to tackling climate change[63]. However, several areas of concern were identified by the NAO for the future of the scheme and its ability to deliver real reductions in CO_2 emissions from UK businesses:

- The national caps across the EU were too unambitious.
- In the UK the method of allocating allowances was unsatisfactory.
- The 10% limit on auctioning of allowances in Phase II was too restrictive and in the UK the Government should have chosen to auction more allowances.
- The UK limit on the use of project credits generated by emissions reduction projects outside the EU was too high.

Many of these issues will be addressed in Phase III of the EU ETS which will start in 2013 and will include:

- A significant increase in auctioning of allowances with at least 50% of all allowances being auctioned (including 100% auctioning in the power sector). This compares to around 3% in Phase II.
- An EU wide cap that will decline annually by 1.74%
- Access to international project credits from outside the EU will be limited to 50% of the reductions required in the EU ETS.

Climate Change Agreements (CCAs) were introduced by DECC to recognise a need to give special consideration to energy-intensive industries with regards to climate change, given their energy use and their need to compete internationally. Consequently, energy-intensive industries can obtain an 80% discount from the Climate Change Levy, provided they meet

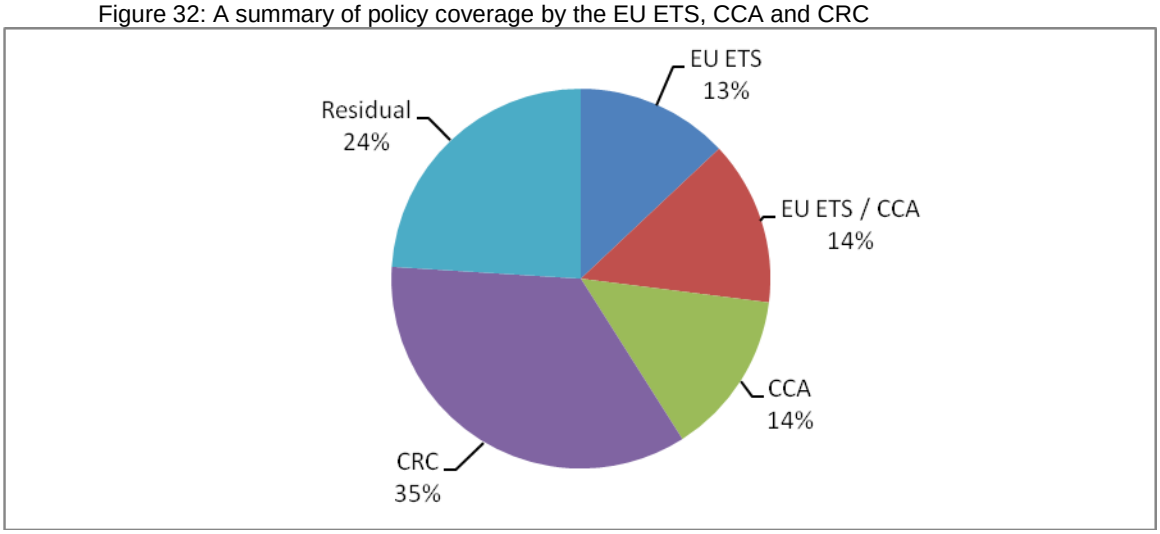
[63] NAO (2009), *European Union Emissions Trading Scheme*

challenging targets for improving their energy efficiency or reducing their carbon emissions[64]. CCAs set the terms under which eligible companies may claim the levy reduction. CCAs have a two-tier structure:

- sector-level agreements between DECC and the sector or trade association (known as umbrella agreements). These set out sector targets, the sector and DECC's obligations, and the procedures for administering the agreements.
- individual agreements between DECC and the facility operator (known as underlying agreements). These set out the targets the facility needs to meet, the operator and DECC's obligations, and the procedures for administering the agreements.

Annex K shows the results of a DECC study[65] and this is summarised in Figure 32. This shows that the EU ETS covers 13% of commercial and industrial energy consumption not covered by either the CCA or CRC with an additional overlapping influence on 14% of the sector; overlapping with the CCA. The CRC can be seen to have the greatest 'unique' coverage at 35% which appears to show that it is satisfying one of its major objectives of targeting UK carbon emissions not covered by other pieces of legislation. 24% of UK carbon emissions fell outside the coverage of these three policies.

Figure 32: A summary of policy coverage by the EU ETS, CCA and CRC



Source: AEA Technology and Databuild for DECC (October 2010), *Assessing the carbon dioxide emissions and cost effective carbon savings potential for organisations not covered by EU ETS, CCAs or CRC*

6.2 Initiatives

Initiatives reviewed in this section are:

- Business Resource Efficiency and Waste Programme (BREW)
- The Freight Best Practice programme, run by the DfT
- Enhanced Capital Allowance Scheme (ECA).

[64] DECC Website, What are Climate Change Agreements, accessed 20/01/2011, available http://www.decc.gov.uk/en/content/cms/what_we_do/lc_uk/ccas/what_are_ccas/what_are_ccas.aspx

[65] DECC (October 2010): *Assessing the carbon dioxide emissions and cost effective carbon savings potential for organisations not covered by EU ETS, CCAs or CRC* (CESA 0903). AEA Technology and Databuild.

6.2.1 Business Resource Efficiency and Waste Programme (BREW)

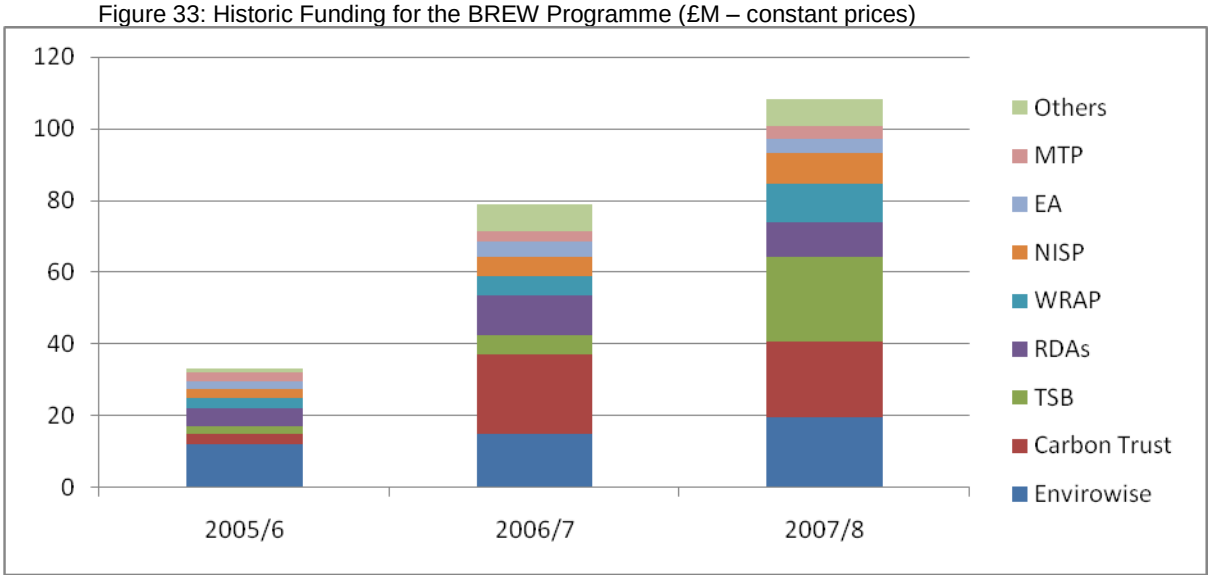
The aim of the BREW Programme was to keep Landfill Tax increases broadly revenue-neutral by returning a part of the additional funds to the business community through initiatives to help businesses make more efficient use of resources, although the ring-fence around the additional tax receipts was removed in April 2008. Between 2005/06 and 2007/08, a total of £220.1 million in real terms was spent through a number of delivery bodies co-ordinated through Defra. The historic funding of the BREW Programme is shown in Figure 33. The most significant, in terms of the amount of funding received over the three years were:

- Envirowise, 21%
- Carbon Trust, 21%
- Technology Strategy Board (TSB), 14%
- Regional Development Agencies (RDAs), 12%
- Waste & Resources Action Programme (WRAP), 8%
- National Industrial Symbiosis Programme (NISP), 8%.

The Programme was a key part of Defra's initiatives to reduce business waste, with around two-thirds directly targeted at business waste; with the remainder was targeted at reducing water and energy consumption. Initiatives of the programme included:

- Market development for waste materials
- Advice and support
- Local and regional initiatives
- Longer term development initiatives.

Figure 33: Historic Funding for the BREW Programme (£M – constant prices)



Source: Defra website available at URL http://www.defra.gov.uk/environment/business/support/historic.htm [accessed 16th July 2010]

Data are available on the seven key performance indicators to assess the performance of the BREW programme (Table 52). It should be noted however that these data were captured and reported by the different delivery bodies, and uncertainty is noted in them due to differences in the assumptions and methodologies used to calculate them[66]. Additionally it is not clear the extent to which the BREW Programme was responsible for the effects rather than other factors such as Landfill Tax because of the absence of sufficient data. In a

[66] NAO (2010), *Reducing the impact of business waste through the Business Resource Efficiency and Waste Programme*

survey carried out by the NAO 63% of respondents reported that they had taken some action to reduce waste sent to landfill, however only 7% stated that they were aware of the Programme, and only 5% stated that they had accessed its services (although other surveys reported an 18% take-up)[67].

With these caveats in mind the overall reported outcomes were:

- Increased sales of £134.4 million from selling on materials that might otherwise have become waste
- Cost savings to business of £495 million
- Waste diverted from landfill of 5.7 Mt
- Hazardous waste savings of 0.294 Mt
- Virgin raw material savings of 6.92 Mt
- Water savings of 25.8 M m^3
- Greenhouse gas savings of 7.05 MtCO_2e.

Table 52: BREW performance indicators and reported outcomes

Indicator	Reported Outcomes			
	2005-06	2006-07	2007-08[a]	Total
Increased sales (£M)[b]	14.7	79.5	40.8	134.9
Cost savings to business (£M)[b]	87.9	188.1	219.0	495.0
Waste diverted from landfill (Mt)	0.68	1.58	3.44	5.70
Hazardous waste savings (Mt)	0.12	0.15	0.024	0.294
Virgin raw material savings (Mt)	0.68	3.58	2.66	6.92
Water savings (M m^3)	5.6	14.6	5.6	25.8
Greenhouse gas savings (MtCO_2e)	0.32	2.52	4.21	7.05

Source: NAO (2010), *Reducing the impact of business waste through the Business Resource Efficiency and Waste Programme*
a – provisional
b – reported in constant prices

6.2.2 DfT Freight Best Practice Programme

The Department for Transport (DfT) operates Freight Best Practice (FBP), a programme aimed at improving the operational efficiency and reducing the environmental impact of the freight industry in England. The objectives of the programme are to reduce carbon emissions and contribute to reducing congestion and improving local air quality and safety. The programme targets both own account operators and the hire/reward sector, and produces a range of guides, case studies, software and newsletters covering saving fuel, developing skills, equipment and systems, operational efficiency and performance management.

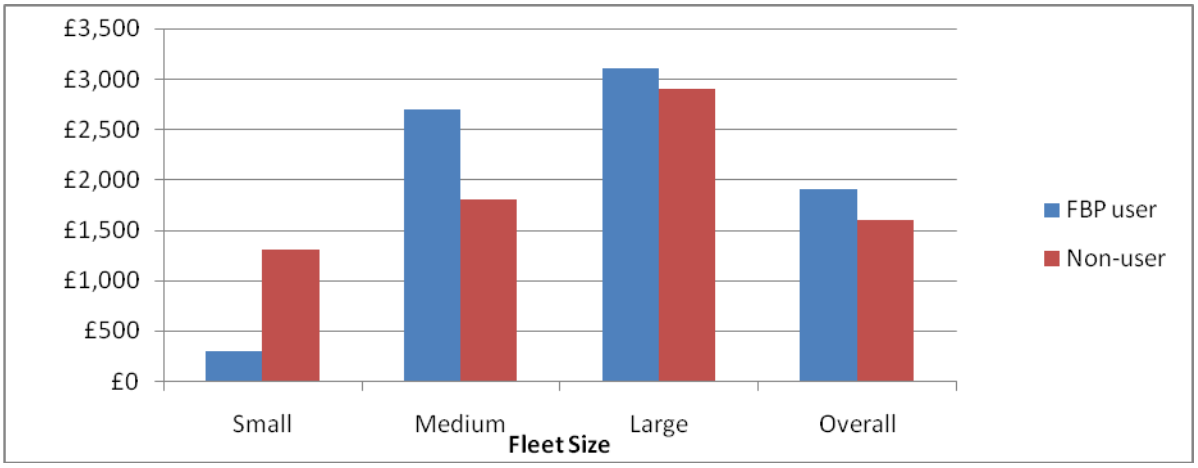
To evaluate the effectiveness of the programme, the DfT commissioned an independent impact assessment of the programme in 2007. This took the form of a telephone survey with 1,558 respondents. 24% of fleets reported that they were aware of the programme; with 9% of fleets using at least one aspect of the programme[68]. FBP users reported having achieved

[67] NAO (2010), *Reducing the impact of business waste through the Business Resource Efficiency and Waste Programme*

[68] Databuild for DfT (2007), *Freight Best Practice Impact Assessment*

financial savings of £190 million or £1,900 through implementing measures to improve their fuel efficiency. This compares to £1,600 of savings accrued by non-users (Figure 34). Of the savings accrued by users of the FBP, 44% were attributed to the programme. Total savings attributed to the FBP were £83.3 million or 241,000t CO_2 (Table 53).

Figure 34: Average fuel efficiency savings for FBP users and non users (£)



Source: Databuild for DfT (2007), *Freight Best Practice Impact Assessment*,

Table 53: Financial and carbon savings attributed to FBP

Measure type	Attributed Financial Savings (£M)	Attributed Carbon Savings (tonnes CO_2)	% Attributed
Saving fuel	6.2	18,000	21%
Driver skills	28.0	81,000	51%
Equipment	39.7	115,000	46%
Operational efficiency	5.0	14,000	51%
Performance management	4.4	13,000	59%
Total	**83.3**	**241,000**	**44%**

Source: Databuild for DfT (2007), *Freight Best Practice Impact Assessment*,

6.2.3 Enhanced Capital Allowance Scheme (ECA)

The Enhanced Capital Allowance scheme (ECA) was introduced in 2001 to encourage businesses to invest in energy-saving equipment, water-efficient equipment and low carbon dioxide emission cars. The scheme provides a tax incentive to businesses that invest in equipment that meets published energy-saving criteria by providing 100% first-year capital allowances on investments in energy-saving equipment against taxable profits of the period of investment as well as accruing long term savings from greater energy and water efficiency[69]. Table 54 gives a list of the types of technologies that are covered by the ECA for energy and water.

[69] ECA Website available at URL: http://www.eca.gov.uk/etl/ [accessed 10/08/10]

Table 54: Technologies covered by ECA

Energy	Water
Air-to-air energy recovery	Cleaning-in-place equipment
Automatic monitoring and targeting (AMT)	Efficient showers
Boiler equipment	Efficient taps
Combined heat and power (CHP)	Efficient toilets
Compact heat exchangers	Efficient washing machines
Compressed air equipment	Flow controllers
Heat pumps for space heating	Leakage detection equipment
Heating ventilation & air conditioning equipment	Meters and monitoring equipment
Lighting	Rainwater harvesting equipment
Motors and drives	Small-scale slurry and sludge dewatering equipment
Pipework insulation	Vehicle-wash water reclaim units
Radiant and warm air heaters	Water efficient industrial cleaning equipment
Refrigeration equipment	Water management equipment for mechanical seals
Solar thermal systems	Water reuse systems
Uninterruptible power supplies (UPS)	

Source: ECA Website available at URL: http://www.eca.gov.uk [accessed 10/08/10]

An evaluation of the effectiveness of the ECA for energy saving technologies has been conducted using a survey and here the main results are presented[70]. Around half of the 1,733 respondents were aware of the ECA, with slightly higher levels of awareness noted for large and high energy using companies. Of the respondents who purchased equipment, 37% of those aware of the ECA bought energy saving equipment compared to 25% for those unaware. The proportion spent on energy saving for those aware of the ECA was found to be statistically different to those that were unaware. The CO_2 savings as a result of the purchases of the energy equipment was estimated at 1,700Kt in the first year and 9,450Kt for the lifetime of the assets, although at least 25% of this was estimated to be 'deadweight' i.e. purchases of the qualifying equipment would have occurred anyway without the ECA. Of the remaining savings a direct link could not be established to the ECA scheme, with another possible cause identified as being part of an energy saving or trading scheme (e.g. CCA or EU ETS). Being a member of such an association was found to have a greater influence on purchasing decisions than being aware of the ECA.

6.3 Voluntary agreements

The voluntary agreements reviewed in this section are:

- The Courtauld Commitment
- Halving Waste to Landfill (in construction)
- The FDF Five-fold Commitment including the Federation House Commitment
- British Retail Consortium's 'Better Retailing Climate'.

[70] Experian for HMRC (2008), *Evaluation of Enhanced Capital Allowance (ECA) for Energy Saving Technologies*

6.3.1 The Courtauld Commitment

The Courtauld Commitment (CC) is a voluntary agreement between WRAP and over 40 major grocery retailers, brand owners, manufacturers and suppliers, which was launched in 2005. The retailers represent 92% of the UK's grocery supermarkets. The signatories agreed to work with WRAP to achieve the following objectives[71]:

- To design out packaging waste growth by 2008 (this was achieved);
- To deliver absolute reductions in packaging waste by 2010; and
- To help reduce the amount of food UK householders throw away, by 155,000 tonnes by 2010, against a 2008 baseline.

The Commitment is a powerful vehicle for change, and has already resulted in real reductions in packaging and food waste, and realised significant commercial savings. The signatories are working closely with WRAP to develop solutions across the whole supply chain, including:

- Innovative packaging formats
- Reducing the weight of packaging (for example, bottles, cans and boxes)
- Increasing the amount of recycled content in packaging
- Designing for recyclability
- Increasing the use of concentrates
- Encourage the use of refill and self-dispensing systems
- Collaborating on packaging design guidance
- Providing in-store guidance
- Supporting the Love Food Hate Waste campaign.

In September 2010 WRAP reported the achievements of the Courtauld Commitment over its first five years[72]:

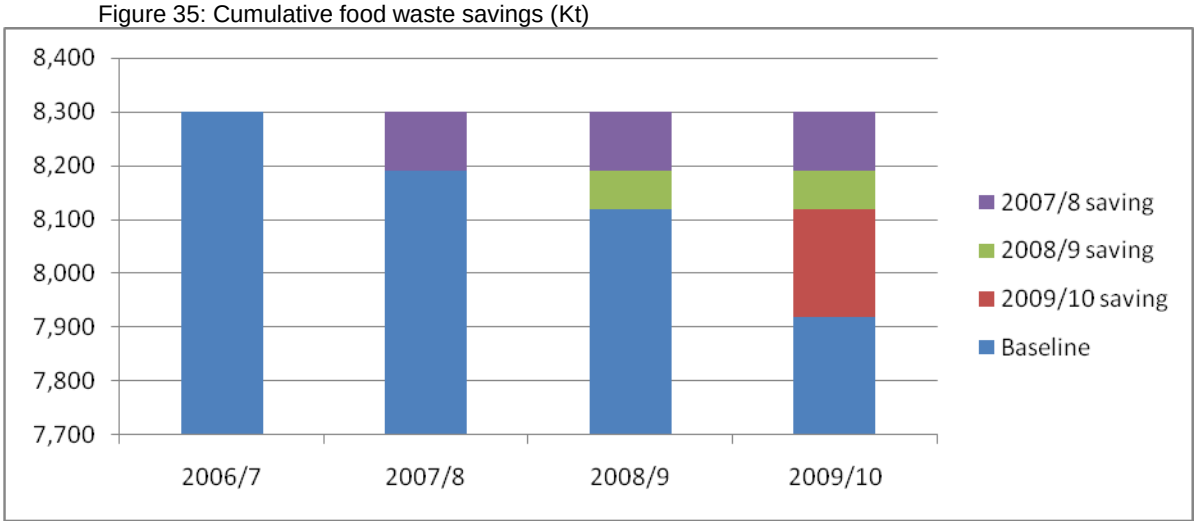
- 1.2 Mt of food and packaging waste were prevented. Cumulative food waste savings represented 0.67 Mt (Figure 35 gives the annual progress) and primary packaging savings (in grocery and hospitality) were 0.52 Mt
- The value of the food and packaging waste saved was approximately £1.8 billion
- The carbon savings resulting were around 3.3 $MtCO_2e$.

Two of the original three objectives were achieved. A zero growth rate of packaging waste was achieved in 2008. The food waste target was exceeded by a factor of 1.75, with 0.27 Mt less food waste arising in 2009/10 compared to 2007/08. The third target of reducing packaging waste was missed, with total packaging remaining constant at 2.9 Mt between 2006 and 2009. The reasons given for this were a 6.4% increase in grocery sales over the period and a shift towards products packaged in heavier materials. However on average a 4% reduction in total primary packaging was achieved.

[71] WRAP website available at URL http://www.wrap.org.uk/retail_supply_chain/voluntary_agreements/courtauld_commitment/index.html [accessed 6th October 2010]

[72] WRAP website available at URL http://www.wrap.org.uk/retail_supply_chain/voluntary_agreements/courtauld_commitment/index.html [accessed 6th October 2010]

Figure 35: Cumulative food waste savings (Kt)



Source: WRAP presentation (2010) *The Courtauld Commitment – Target Evaluation*

The Courtauld Commitment has entered a second phase with a new set of new targets. The second phase of the Commitment will continue to focus on reducing the environmental impact of packaging and food waste, and expand to include waste in the supply chain (in manufacture, distribution and back-of-store)[73]. The new targets are:

- Packaging – to reduce the weight, increase recycling rates and increase the recycled content of all grocery packaging, as appropriate. Through these measures the aim is to reduce the carbon impact of this grocery packaging by 10%.
- Household food and drink – to reduce UK household food and drink waste by 4%.
- Supply chain product and packaging waste – to reduce traditional grocery product and packaging waste in the grocery supply chain by 5% - including both solid and liquid wastes.

Linking in with the Courtauld Commitment, a number of the retailers and brands have also announced measures to minimise packaging. These efforts will have the effect of reducing waste arisings in the household. Examples include[74]:

- The Co-operative Food has reduced the weight of its own-brand ale bottles, saving 106 tonnes of glass per year.
- Asda reported that it reduced the weight of its instant coffee glass jar by 25%, and lightweighted glass wine bottles saving 300 tonnes of glass each year.
- WRAP's GlassRite initiatives have been instrumental in driving down the weight of glass containers in the UK, saving about 150,000 tonnes of glass from the waste stream each year.
- Sainsbury's has reduced packaging weight by 13% since 2004-05, and is looking to reduce its own-brand packaging by 33%, by 2015, from a 2009 baseline.
- Tesco reports that it is collaborating with over 250 suppliers, on over 3,600 packaging reduction initiatives, for both own-brand and branded products. Of the own-brand initiatives, 2,000 have been completed, saving 80,000 tonnes per year.
- For Easter eggs, the confectionery sector reduced packaging by at least 25%, with some eliminating over 50% of materials – saving 1,000 tonnes per year of packaging. Efforts were also made to improve the recyclability of the packaging, and increase the recycled content of the materials.

[73] WRAP website available at URL http://www.wrap.org.uk/retail_supply_chain/voluntary_agreements/courtauld_commitment/index.html [accessed 6th October 2010]

[74] Oakdene Hollins & WRAP (2010) *Waste arisings in the supply of food and drink to households in the UK*

In addition, WRAP is funding an 'in-store dispensing system' trial at Asda to determine the commercial viability of dispensing fabric conditioner into refillable pouches. Early estimates are that this could reduce the weight of packaging, when compared to the conventional one-trip bottle system, by 97%.

6.3.2 WRAP's Halving Waste to Landfill Commitment in the construction sector

The construction industry's commitment to halve the amount of construction, demolition and excavation waste sent to landfill by 2012 was launched in October 2008 with the agreement of 16 signatories. The baseline for the agreement has been set for 2008 by the Strategic Forum for Construction at 12.55 Mt (England only)[75]. This figure excludes inert waste used in landfill engineering and quarry restoration. Progress against the baseline at an overall CD&E waste stream will be monitored using Environment Agency landfill operator returns at a 'top-down', and also by a 'bottom-up' approach where signatories set their own baseline and report annually against it on the WRAP Reporting Portal (clearly the 'bottom-up' approach will not capture the whole industry).

The current situation of the agreement is that almost 400 organisations representing all parts of the supply chain (from clients to developers, manufacturers, contractors and designers) have signed up to the agreement, with a value of over £25 billion or more than a quarter of the entire industry. Signatories cite the large financial benefits of the scheme such as utilising the value of surplus materials and avoiding skip costs as reasons for signing up[76]. Contractors, who have set a baseline so far, reported a total of some 11.5 Mt of waste arising from their projects of which 2.85 Mt was being sent to landfill. The small number of contractors who have set a baseline and then had a full year to report against it have shown a decrease of over 40% in waste being sent to landfill per £1 million spend[77].

6.3.3 Food and Drink Federation's 'Five Fold Ambition'

In October 2007 the Food and Drink Federation (FDF) launched its Five-fold Environmental Ambition to make real environmental improvements across all the areas where a significant difference could be made. Specific commitments by members were[78]:

- To play a full part in tackling climate change by reducing their CO_2 emissions by 20% by 2010 against a 1990 baseline. Furthermore, to send a clear message about the urgency of the problem, to strive towards a 30% reduction by 2020 compared to 1990.
- To send zero food and packaging waste to landfill from 2015.
- To make significant reductions in the levels of packaging reaching households through support for WRAP's Courtauld Commitment, this aims to achieve an absolute reduction in 2010 compared with 2006.
- To embed environmental standards in members' food transport practices to achieve 'fewer and friendlier' food transport miles – and to contribute to an absolute target for

[75] Strategic Forum for Construction (2010) *CD&E Waste: Halving Construction, Demolition and Excavation Waste to Landfill by 2012 compared to 2008*

[76] WRAP (2009), *Time for A new age: Halving waste to landfill: seize the opportunity*

[77] WRAP, personal communication (2010)

[78] FDF website available at URL http://www.fdf.org.uk/environment_progress_report.aspx [accessed 6th October 2010]

the food chain to reduce its environmental and social impacts by 20% by 2012 compared with 2002.
- To use the Federation House Commitment to help members achieve significant reductions in water use – and to contribute to an industry-wide target to reduce water use, outside of that embedded in products themselves, by 20% by 2020 against a 2007 baseline.

In the two years following the commitments real progress has been made across all five pillars[79]:

- FDF members reduced their CO_2 emissions by 19% in 2008, the latest data available under our Climate Change Agreement with Government, compared to a 1990 baseline.
- FDF has worked with WRAP to conduct 13 detailed waste prevention reviews in food and drink manufacturing sites – promoting best practice across the sector to support efforts to send zero waste from factories to landfill by 2015.
- 23 FDF members have now signed the Courtauld Commitment to reduce the amount of packaging reaching households and 15 member companies have joined a labelling scheme to provide consumers with standardised on-pack information in relation to packaging recyclability.
- 45 companies, with a combined turnover of £17 billion, are promoting greener food transport through the use of FDF's best-practice checklist that is designed to promote 'fewer and friendlier' food miles.
- The first 36 signatories to the Federation House Commitment on water efficiency reported savings of almost 500,000 m3 of water in the first year of operation.

A review of the commitment is scheduled in 2010 to ensure the Ambition remains true to its objectives; engaging members, Government, best practice bodies, supply chain partners and key opinion formers to help us to build on the successes of the past two years and collectively evolve the Ambition towards even greater effectiveness.

6.3.4 British Retail Consortium's 'Better Retailing Climate'

The *Better Retailing Climate* initiative was launched by the British Retail Consortium (BRC) in April 2008 setting out goals and established the industry's collective environmental ambitions. A range of leading retailers signed up to this voluntary initiative (accounting for 42% of the UK retail market, by value). The goals of the initiative were to[80]:

- Reduce the direct environmental impact of the retail businesses
- Manage climate risks
- Help customers, staff and suppliers to reduce their environmental impacts and vulnerabilities
- Engage in the public policy debate and support the Government in meeting its climate change goals
- Report achievements transparently and consistently.

[79] FDF (2010), *Our Five-fold Environmental Ambition: Progress Report 2009*

[80] BRC website available at URL: http://www.brc.org.uk/brc_policy_master.asp?id=612&spolicy=A+BETTER+RETAILING+CLIMATE [accessed 6th October 2010]

Four indicators were established under the first goal, which were to reduce the environmental impact of the internal operations and physical assets, on a like-for-like basis. The four targets together with the progress achieved are[81]:

- Cutting energy-related emissions from buildings by 15% on 2005 levels by 2013 – this was revised to 25% due to the progress being made (in 2009 an 18% reduction had been achieved).
- Aim for a reduction of 15% in energy-related transport CO_2 emissions from store deliveries by 2013 compared with 2005 levels (in 2009 a 18% reduction had been realised).
- Ensuring measurement of water-use in sites collectively anticipated as accounting for at least 75% of usage, and setting targets for reductions by 2012 (in 2009 a 75% measurement had been realised).
- Diverting waste from landfill so that less than 50% of waste is landfilled by 2013 (this was revised in 2008 to 25%), by minimising waste from operations and managing sustainably any unavoidable waste (in 2009 23% of waste was sent to landfill).

In addition, leading UK retailers, and the BRC, are working with UK Governments to reduce the environmental impact of carrier bags. There have been two voluntary carrier bag agreements in the UK[82]:

- 25% agreement (2008), based on a 2006 baseline, to reduce the environmental impact of all carrier bags by 25% by the end of 2008. This included single-use bags, 'bags for life' and other reusable bags. The results, reported in February 2009, showed that participants had achieved a 26% reduction in the total number of carrier bags used, and a 40% reduction in the environmental impact measured by the reduction in the use of virgin materials.
- 50% agreement (2009), based on a 2006 baseline, to reduce the number of single-use carrier bags given out by 50% by end of May 2009. Results announced in July 2009 showed a 48% reduction against a target of 50%. The Governments have asked WRAP to continue to monitor progress for a review in summer 2010.

6.4 Discussion

In terms of the coverage of the policies, initiatives and voluntary agreements reviewed, the following conclusions can be drawn.

Several policies look specifically on energy use across a number of sectors. However it is observed from considering the combined coverage of the EU ETS, CCA and CRC that:

- 24% of energy consumption is not covered by any of the three policies (39% of the Commercial sector and 13% of the Industrial sector)
- CRC is meeting its objective of focusing on energy consumers not covered by other policies (57% of the Service sector and 18% of the Industrial sector)
- There is a high level of duplication between the EU ETS and the CCA (14%).

Consumers not covered by any of the three policies are the low energy consumers such as commercial outlets where the energy savings opportunities are very similar to those in the domestic sector.

Waste is covered by a number of policies and voluntary agreements, notably Landfill Tax and Integrated Pollution Prevention and Control, which cover multiple sectors. Coverage is further enhanced through the Courtauld Commitment and Halving Waste to Landfill, which

[81] BRC (2010), *A Better Retailing Climate Progress Report 2010*

[82] WRAP website available at URL: http://www.wrap.org.uk/retail_supply_chain/voluntary_agreements/carrier_bags/ [accessed 6th October 2010]

include the Retail and Construction sectors, both not covered by the IPPC, and only duplicated the Food sector.

None of the policies, initiatives and voluntary agreements exclusively considers water. Rather water is included within a larger programme e.g. The Federation House Commitment on water use by the FDF is part of their wider Five-fold Commitment agenda.
Finally other policies, initiatives and voluntary agreements focus on particular 'high-impact' sectors in order to accelerate progress in these sectors. These include:

- The Freight Best Practice programme for energy use in transport
- FDF Five-fold Commitment for the Food and drink sector
- BRC Better Retailing Climate for the Retail sector.

Highlights of the effectiveness of the policies, initiatives and voluntary agreements include:

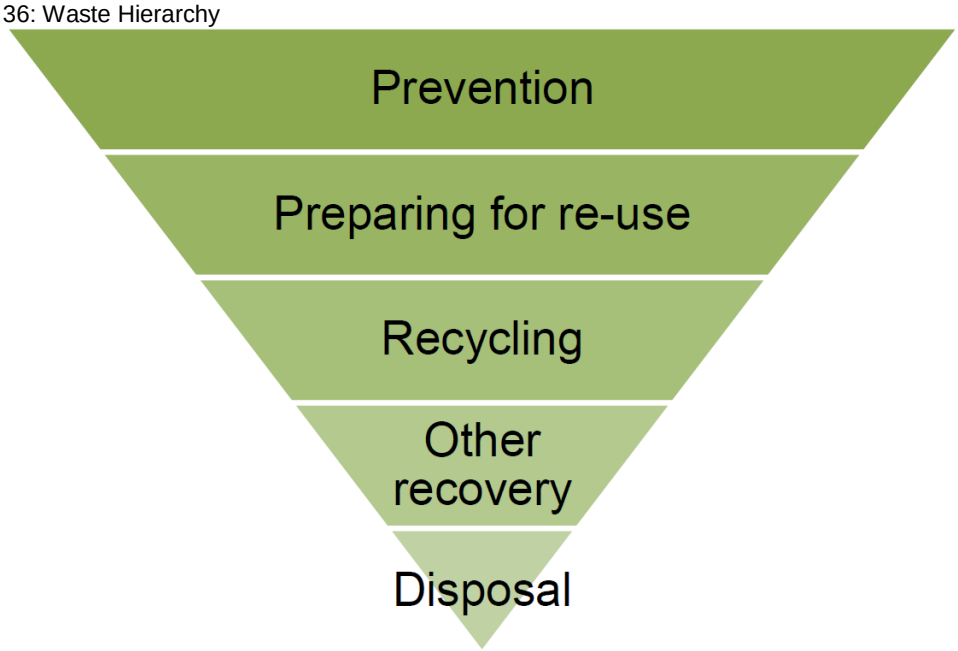
- Landfill Tax analysis showed that the impact on landfill volumes has therefore been very strong, even if some of this effect can likely be attributed to other policies.
- IPPC analysis showed that companies covered under the IPPC in the Metal manufacturing sector reduced waste arising by over 20% between 2006 and 2009, whereas those not covered generated savings increased their waste substantially, although the trends are less clear for the Food, drink and tobacco and the Chemicals / non-metallic minerals sectors.
- The BREW programme reported outcomes included £495 million of cost savings and carbon savings of 7.05 $MtCO_2$ between 2005/06-2007/08
- DfT Freight Best Practice is estimated to have saved £83.3 million and 0.24 $MtCO_2$ in 2007
- The ECA has saved 9.45 $MtCO_2$ over the lifetime of the assets
- WRAP's Courtauld Commitment Phase 1 prevented 1.2 Mt of food and packaging waste, saving £1.8 billion and 3.3 $MtCO_2$ over the five years to 2010
- WRAP's Halving Waste to Landfill agreement shows early indications that the companies involved achieved a decrease of over 40% of waste to landfill
- The FDF through their Five-fold Commitment (including the Federation House Commitment) have reduced CO_2 emissions by 19% and saved almost 500,000 m3 of water
- BRC through their Better Retailing Climate agreement have reduced energy use by 18%, increased measurement of water to 75% and reduced the proportion of waste sent to landfill to 23%

7 Review of the significance of the waste hierarchy

The concept of the hierarchy was first emphasised in the Waste Framework Directive (1975) and subsequent policy and legislation have followed its principles[83]. The goal of the waste hierarchy is to minimise the environmental effects of waste disposal. In general, the waste hierarchy states that waste prevention is better than waste disposal, and the principles are based on the premise that the disposal option which is generally least environmentally harmful is ranked highest. Figure 36 presents the five steps of the hierarchy[84] and Table 55 gives definitions and examples for each step.

It is noted that this is a stylised representation of the waste hierarchy, with the exact ranking being material specific and depending upon the criterion adopted e.g. greenhouse gas emissions, private benefits/costs etc. Additionally the steps of the hierarchy are not necessarily independent or exclusive of each other. For example measures to prevent waste such as lightweighting can adversely affect the ease of remanufacturing[85] or recycling[86] downstream. Similarly a product can be reused or remanufactured, possibly several times, before then being recycled, recovered or disposed of.

Figure 36: Waste Hierarchy



Source: Defra (2010) *Consultation draft - Guidance on applying the waste hierarchy*

The resource efficiency savings from waste in the previous Defra 2006 study were estimated at around 37 Mt, of which ca.33 Mt involved improved waste management techniques, i.e. end of pipe approaches. Only around 4 Mt of the identified waste savings involved waste reduction. It was concluded that this reflects the main focus of previous delivery body

[83] Waste Framework Directive (75/442/EEC)

[84] Directive 2008/98/EC on waste (Waste Framework Directive)

[85] CRR (2010) *Market Failures in Remanufacturing*

[86] OECD (2006) *Improving Recycling Markets*

activity, case studies and surveys on which the estimates in this study are dependent. (Such approaches are not considered to be a missed opportunity instead they are viewed as a significant first step in moving organisations away from landfill.)

Table 55: Definitions and examples of steps in the waste hierarchy

Step	Definition
Prevention	Measures taken before a substance, material or product has become waste, that reduce (a) the quantity of waste, including through the re-use of products or the extension of the life span of products; (b) the adverse impacts of the generated waste on the environment and human health; or (c) the content of harmful substances in materials and products. Prevention includes *avoidance* (buying fewer items, reducing process waste or using less material per unit), *reduction* (keeping products for longer, designing them so they last longer), and *re-use* (selling and buying used items).
Preparing for re-use	Checking, cleaning or repairing recovery operations, by which products or components of such products that have become waste are prepared so that they can be re-used without any other pre-processing
Recycling	Any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. Includes the reprocessing of organic material, i.e. composting, but not energy recovery or the reprocessing into materials that are to be used as fuels or backfilling operations
Other recovery	Energy recovery e.g. combustion with energy recovery, anaerobic digestion, processes including gasification and pyrolysis which can produce energy (fuels, heat and power) and materials from waste, etc. This category also includes backfilling operations.
Disposal	Any operation which is not recovery even where the operation has as a secondary consequence the reclamation of substances or energy e.g. landfill, incineration. The revised Waste Framework Directive sets a threshold above which energy efficient municipal waste incinerators can be classified as recovery facilities, and below which they continue to be classified as disposal facilities.

Source: Defra (2010) *Consultation draft - Guidance on applying the waste hierarchy*

The structure of this section is as follows. The next section presents evidence on the carbon benefits that can be achieved by moving up the waste hierarchy. It starts by summarising the extensive evidence available on whether it is beneficial for particular material streams to be recycled, energy recovered or landfilled. The available evidence comparing waste reduction and waste diversion is then assessed, including the additional carbon benefits of reuse and remanufacture. The final section assesses the economic benefits of moving up the waste hierarchy.

7.1 Carbon benefits

7.1.1 Waste diversion

There is an extensive body of research of LCAs comparing recycling, energy recovery and disposal. Here that work is summarised for the main materials. The key reports include:

- WRAP (2010), *Environmental benefits of recycling – 2010 update*
- ERM (2006), *Carbon balances and energy impacts of the management of UK wastes*
- EEA (2006), *Paper and cardboard — recovery or disposal? Review of life cycle assessment and cost-benefit analysis on the recovery and disposal of paper and cardboard*
- Enviros (2003), *Glass Recycling – Life Cycle Carbon Dioxide Emissions*

Much of this research is summarised by Defra (2010) *Consultation draft - Guidance on applying the waste hierarchy*.

Paper/Card
The evidence is relatively finely balanced between recycling and energy recovery and depends upon the assumptions made on issues such as the energy mix and the efficiency of recovery. Landfill is the least environmentally beneficial. WRAP (2010) and EEA (2006) both conclude that the recycling should be preferred to energy recovery, whereas ERM (2006) favours energy recovery, although on other environmental metrics recycling is preferred to energy recovery.

Plastics
The evidence shows that recycling should be preferred to energy recovery or landfill. In carbon terms, energy recovery performs worse than landfill, but on other environmental metrics energy recovery is preferred to landfill.

Food and Garden Waste
The evidence puts anaerobic digestion ahead of composting due to the gas and digestate produced; with landfill being the least preferred. This departs from the waste hierarchy.

Textiles
The evidence puts recycling ahead of energy recovery, which is ahead of landfill, although substantial savings are possible through reuse i.e. second hand clothing.

Metals
The evidence shows that there are substantial carbon savings available from recycling metals. For aluminium 95% of the energy can be saved compared to virgin and 62-74% can be saved for steel[87].

Wood
The limited evidence is inconclusive.

Glass
The environmental benefits of recycling are dependent on the type of recycling (see Enviros (2003). Recycling the glass back into containers (i.e. closed loop recycling) in the UK, saves 314 kg CO_2 for every one tonne of waste recycled. Open loop recycling measures are less beneficial with some waste technology options even having a negative environmental impact compared to landfill (Figure 39).

7.1.2 Waste reduction

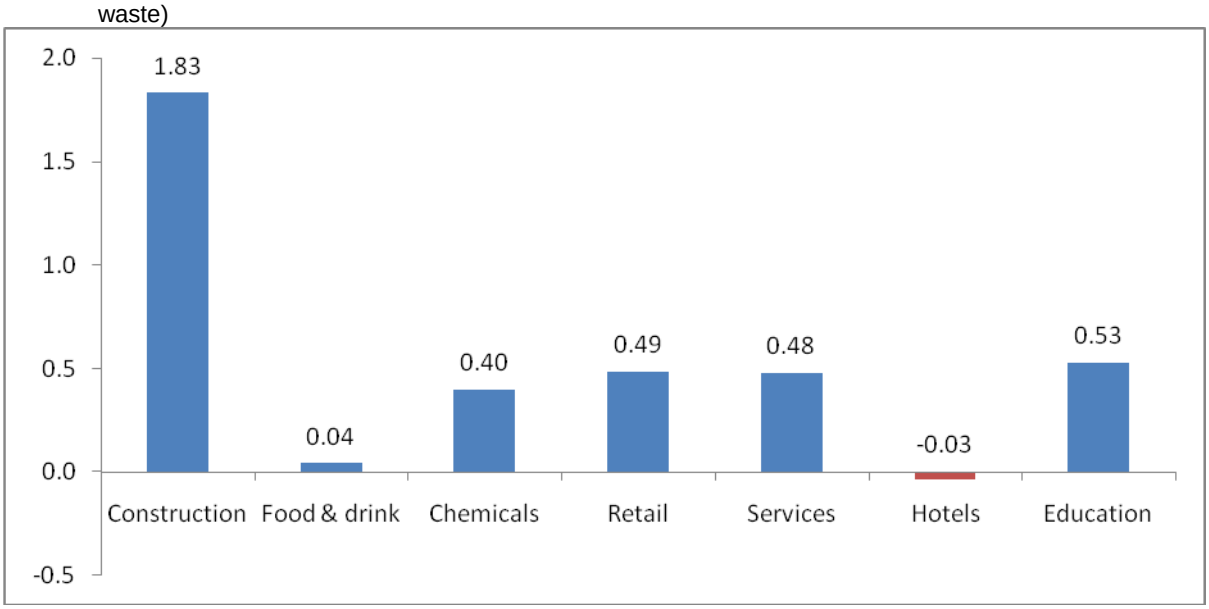
Whilst it may be intuitive that waste reduction should deliver substantial carbon savings over waste diversion because of the embodied energy saved, there are actually relatively few quantitative estimates of the scale.

The previous study *Quantification of the potential CO_2 savings from resource efficiency in the UK* distinguished between waste reduction and waste diversion. In waste tonnage terms only 11% of the savings estimated were from waste reduction, but this represented 40% of the carbon impact. This meant that in terms of tonne of carbon per tonne of waste, the waste reduction savings prevent 5.5 times the amount of carbon as the waste diversion savings. For the sectors where both waste reduction and waste diversion opportunities were identified it is possible to compare the two (Figure 37). It should be noted that these savings are based upon case study evidence, so the scale of the differences will depend on the

[87] BMRA Website available at URL http://www.recyclemetals.org/about_metal_recycling [accessed 6th October 2010

precise measures identified. For six of the sectors the carbon benefits per tonne of waste for waste reduction exceeded those of waste diversion. For the Construction sector these savings of waste reduction over waste diversion were substantial at 1.83 $kgCO_2$/kg waste; with significant savings also available for the Education, Services, Retail and Chemicals sectors. For the Food and drink and Hotels sectors the savings for waste reduction and waste diversion per tonne of waste were essentially the same, mostly because the waste diversion opportunities were for higher energy embodied materials such as plastic and paper whereas the waste reduction opportunity was for card.

Figure 37: Carbon benefits of waste reduction over waste diversion in 2006 study, by sector ($kgCO_2$/kg waste)



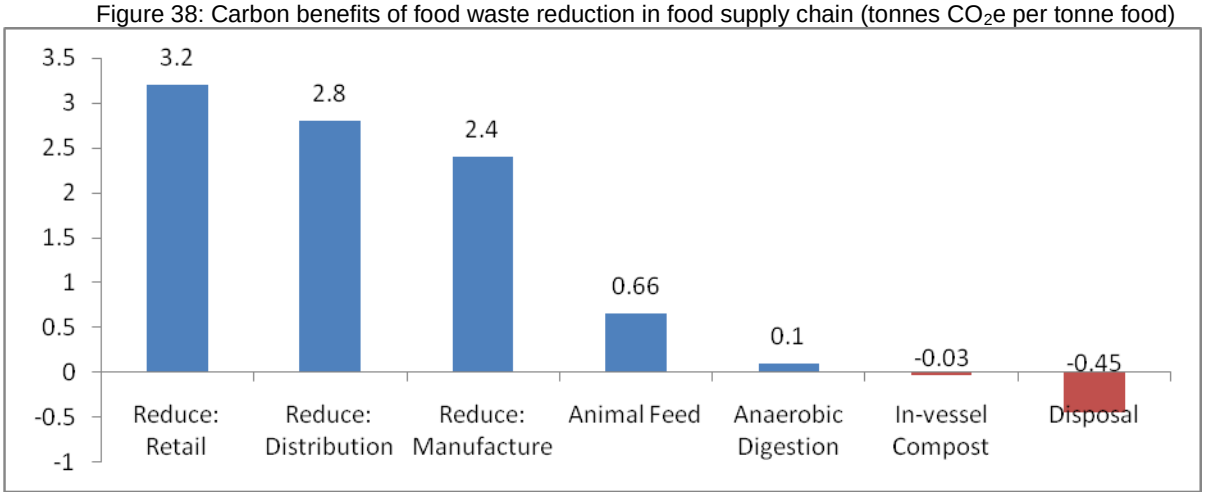
Source: Oakdene Hollins for Defra (2009), *Quantification of the potential CO_2 savings from resource efficiency in the UK*

For two material streams data are available that compare the benefits of waste reduction and waste diversion. For Food the best waste management route in terms of carbon saved is animal feed, which avoids 0.66 tonnes CO_2e per tonne of food (Figure 38). However the savings available from waste reduction are of a different order of magnitude at 2.4, 2.8 and 3.2 tonnes CO_2e per tonne of food, depending upon the point along the supply chain where the reduction occurs. So whilst the emphasis on diverting food waste to animal feed within Food and drink manufacturing has led to significant carbon benefits of 0.66 tonnes CO_2e per tonne of food, the opportunity available from reduction is 1.74 tonnes CO_2e per tonne of food (2.4 - 0.66).

For glass the switch away from the landfilling of waste container glass to recycling and waste minimisation is extremely beneficial in environmental terms. Figure 39 shows that on average 843 kg CO_2 are saved for every one tonne of waste prevented at source through 'reduction' and, when recycling the glass back into containers (i.e. closed loop recycling) in the UK, 314 kg CO_2 is saved for every one tonne of waste recycled. This illustrates that the specific details of moving up the waste hierarchy are important to evaluating carbon impacts. It is estimated that a better direction of glass for recycling away from aggregates and filtration could save 0.1 $MtCO_2$ per year[88].

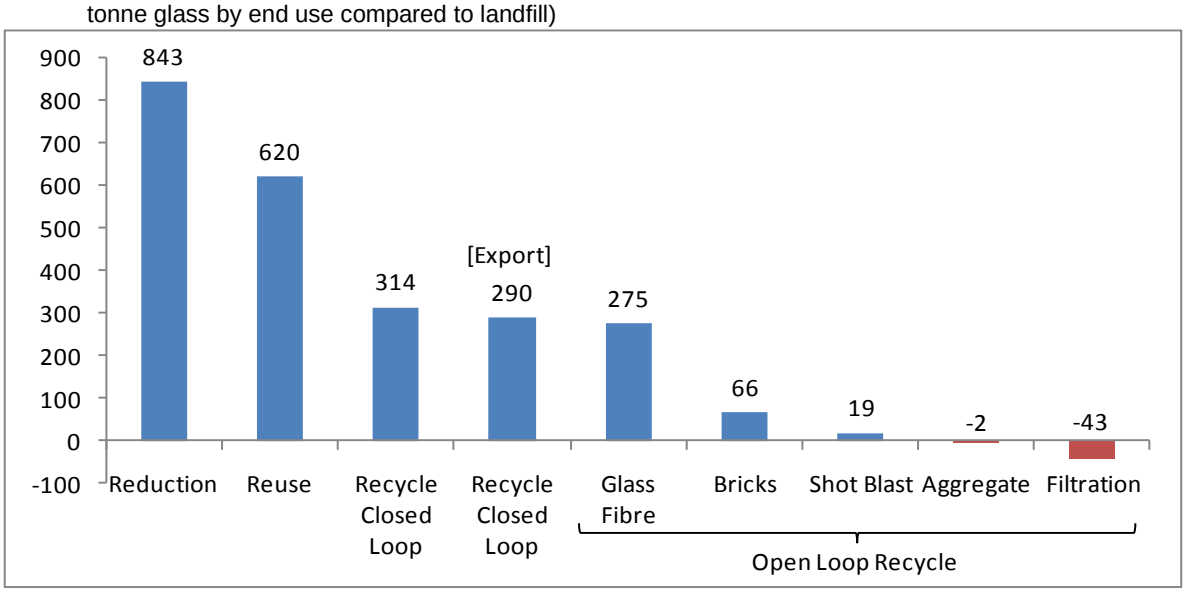
[88] Grant Thornton (2006), *The impact of the carbon agenda on the waste management business*

Figure 38: Carbon benefits of food waste reduction in food supply chain (tonnes CO_2e per tonne food)



Source: Oakdene Hollins & WRAP (2010), Waste *arisings in the supply of food and drink to households in the UK*

Figure 39: LCA analysis of waste technology options for container glass in the UK (kg CO_2 savings per tonne glass by end use compared to landfill)



Source: All data with the exception of the re-use figure are taken from Enviros Consulting (2003), *Glass Recycling: Life Cycle Carbon Dioxide Emission*. Re-use data are taken from Danish Environmental Protection Agency (1998), *Life Cycle Analysis Assessment of Packaging Systems for Beer & Soft Drinks*. Note: Transportation impacts have been included in the data and 'reduction' refers to the full embedded CO_2 value of the glass.

7.1.3 Reuse and remanufacture

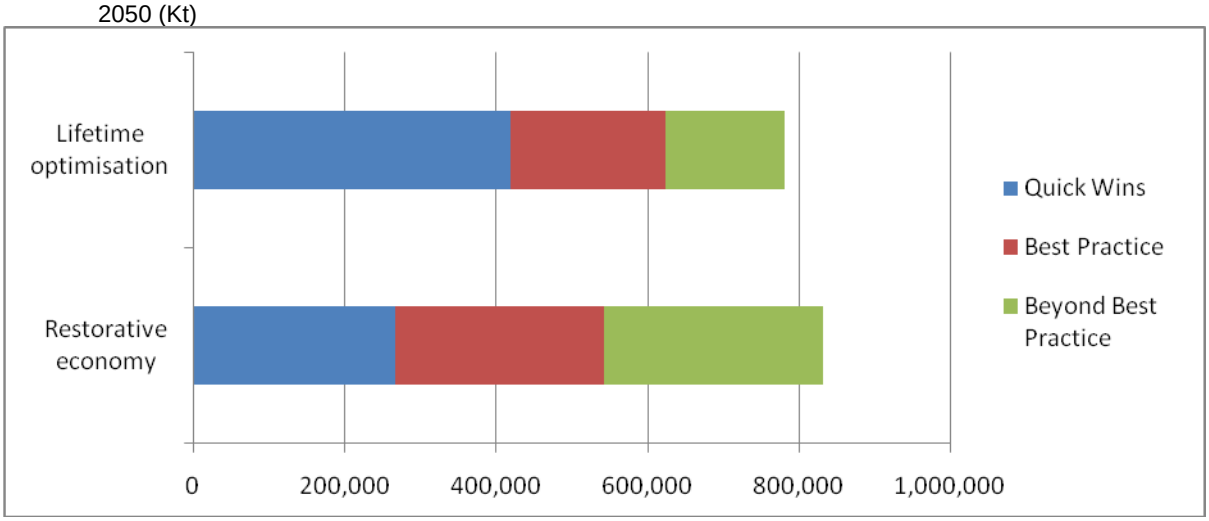
Included within waste prevention and preparing for reuse at the top of the hierarchy are:

- Avoidance, reduction and re-use
- Checking, cleaning or repairing recovery operations.

The cumulative long-term benefits of these measures have been estimated by WRAP under the terms 'Lifetime Optimisation' (ensuring that products are used for their full useful life) and 'Restorative Economy' (extending the life of products by improving product durability). Both of these measures were estimated to have potential carbon benefits of around 800 $MtCO_2e$

cumulative to 2050 and were amongst the largest opportunities identified[89] (some overlap between the two measures was noted). The current situation for the remanufacturing sector has been estimated as avoiding 10 $MtCO_2e$ in 2009, with Textiles and Construction being the two most significant sectors[90]. Product specific carbon savings for remanufacturing have been estimated (Table 56). This shows that the carbon footprints of remanufactured products are typically at least 25% below those of new products, but can be as high as 80%. These carbon benefits are *in addition* to those that can be achieved through waste diversion measures such as recycling at end-of-life.

Figure 40: Cumulative GHG emission reductions from lifetime optimisation and restorative economy to 2050 (Kt)



Source: Stockholm Environment Institute and the University of Durham for WRAP (2009), *Meeting the UK climate change challenge: The contribution of resource efficiency*

Table 56: Carbon footprints of new and remanufactured products (kg CO_2)

Product	End Mill Cutting Tools	6-Speed Automatic Gearbox	Photovoltaic Panels	Refrigerated Display Cabinets	Toner Cartridges	Retreaded Tyres
New	6.4	432.5	417	8,370	35	86.9
Remanufactured	1.3	284.5	152	6,267	22.8	60.5
Saving (%)	80%	34%	64%	25%	35%	30%

Source: CRR website available at URL: http://www.remanufacturing.org.uk/reducing-carbon-footprint.lasso [accessed 20th October 2010]

7.2 Economic benefits

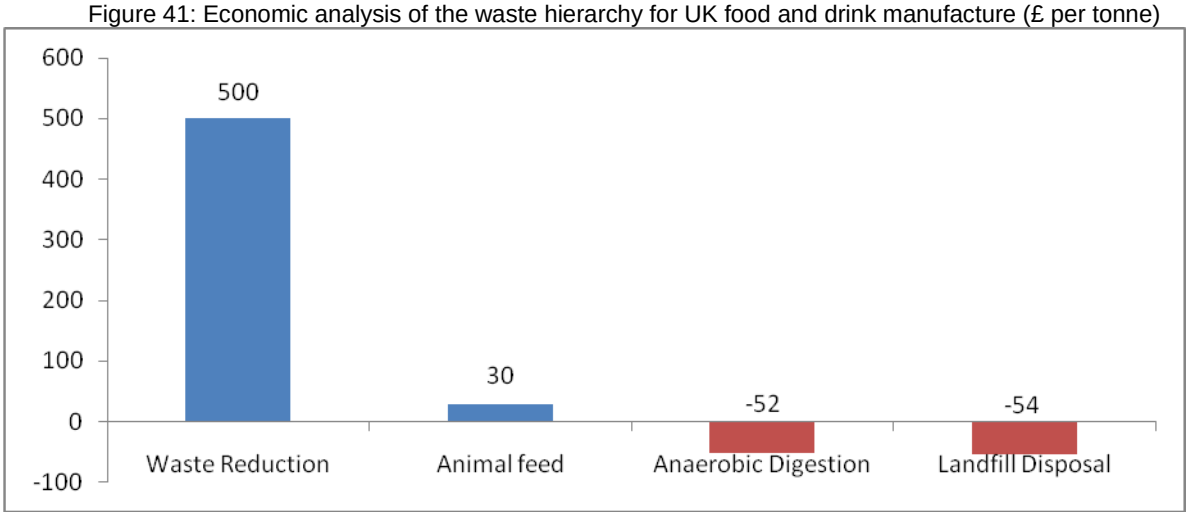
The previous Defra 2006 report pointed to the savings associated with waste reduction compared to waste disposal. It found that in some circumstances, these savings can be an order of twenty times greater than the associated waste disposal savings, although relatively few savings on this magnitude were identified in the case studies or surveys. An assessment of the economic benefits of moving up the waste hierarchy in food and drink manufacture is shown in Figure 41. The economic benefits of waste reduction are very large at £500 per tonne (the estimated cost of ingredients) compared to the waste management

[89] WRAP (2010) *Meeting the UK climate change challenge: The contribution of resource efficiency*

[90] CRR (2009) *Remanufacturing in the UK*

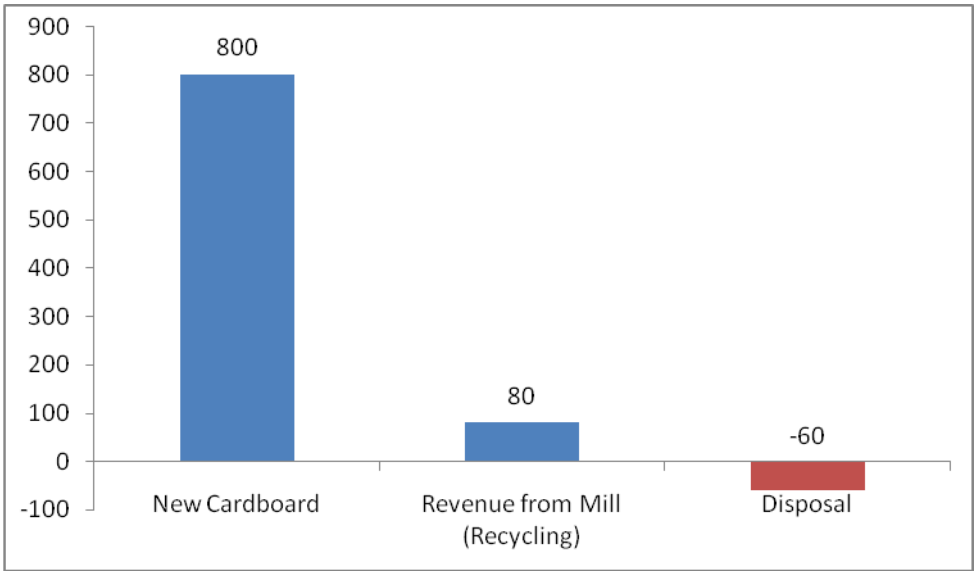
options. Reuse of food waste as animal feed at generates revenue for the company £30 per tonne, whereas anaerobic digestion and landfill disposal incur costs to the company. A similar analysis is available for cardboard (Figure 42). Revenue can be generated by diverting cardboard from disposal to recycling at the mill (£140 per tonne). However the cost of new cardboard is £800, which is available for waste reduction. With this in mind it might seem surprising that the emphasis remains on waste management rather than waste reduction. The barriers to achieving resource efficiency savings are discussed in the next Section.

Figure 41: Economic analysis of the waste hierarchy for UK food and drink manufacture (£ per tonne)



Sources: WRAP (2009), *Gate Fees Report* & Oakdene Hollins & WRAP (2010), Waste *arisings in the supply of food and drink to households in the UK*

Figure 42: Economic analysis of the waste hierarchy for cardboard (£ per tonne)



Source: WRAP Presentation (2010), *Production Ready Packaging Working Group*

8 Review of the barriers and opportunities to realising the savings

8.1 Review of the barriers and opportunities

In the previous sections of this report, resource efficiency opportunities for business with large financial benefits were quantified. Given that businesses are subject to market pressures, the size of these opportunities might seem surprising. This section reviews the barriers and opportunities that exist to realising these savings.

There are a number of different barriers that have been identified as preventing the realisation of resource efficiency and different means of classification have been used in the literature. The most common classification is the following:

- Financial Costs
- 'Hidden' Costs
- Market Failures
- Behavioural and Motivation.

8.1.1 Financial costs

The first type of barrier is financial costs. Resource efficiency measures that have a payback of greater than one year are regarded as investments by the businesses undertaking them and are treated as such in the decision-making process. Key aspects of this decision are the upfront cost and the expected payback period. These are then compared to other projects that are competing for the same capital and often have greater financial returns. A lack of capital can also be a financial barrier, although this is likely to be more of an issue for smaller companies. Evidence on payback periods, from the Chemicals and Retail sectors suggests that companies look for a payback period of 2-4 years[91]. In that study many companies cited a lack of suitable projects in resource efficiency with returns that are attractive in comparison to alternative uses of capital as a reason for not undertaking resource efficiency investments.

8.1.2 'Hidden' costs

The second type of barrier is that of hidden costs. 'Hidden' costs are real costs that are felt by business in implementing resource efficiency measures, but are often not taken account of by those outside of the business assessing which investments would be profitable[92]. These include:

- Management time, which is described as a 'scarce' resource and is viewed as a distraction from the 'day job'[93]
- Transaction costs e.g. information gathering and analysis, negotiation, procurement
- Documentation, auditing and regulatory compliance costs
- Disruption of business activity and inconvenience

[91] PwC for BIS (2009), *Determining cost-effective action for business to reduce emissions*

[92] NERA & Enviros for Defra (2006), *Policy Options to Encourage Energy Efficiency in the SME and Public Sectors*

[93] Chartered Institute of Logistics and Transport (2008), *An Inconvenient Truck*

- Equipment incompatibility
- Staff training and replacement
- Technical support and maintenance.

Additionally there is often much less certainty over these costs, and therefore greater risk. This may lead firms to put a higher risk premium on these types of investment[94]. Within 'hidden' costs it is noted that some types of business find resource efficiency particular costly such as rural businesses that are often limited by local infrastructure[95].

8.1.3 Market failures

Market failure is a term used in economics to refer to a situation where the market has not, and cannot by itself be expected to deliver an efficient outcome and where policy intervention can be justified[96]. Three types of market failure have relevance in this context:

- Externalities
- Incomplete information
- Split incentives.

The first market failure of externalities is where there are spillover effects on third parties not involved in the transactions that are not captured by prices. The most obvious type of externalities in this context are the environmental benefits such as reducing CO_2 and other emissions, although another might be the positive impact on energy supply security from energy efficiency. Technological externalities are often relevant as well. For innovative investments businesses may decide to 'wait and see' the success or otherwise of the technology before investing themselves[97]. This can add to the time required for the adoption of the technology to business. A wide range of factors are known to influence the rate of adoption. These include the relative advantage over existing technology, compatibility with other technologies, complexity of the technology, and the ability to trial the technology and observe its benefits[98]. This ability to trial technologies has been borne out by evidence from the Chemicals and Retail sectors. With large numbers of small sites retailers have greater opportunity to trial technologies, whereas chemical companies have small numbers of large sites so trialling technologies is risky so only proven technologies are likely to be adopted, and even this may not occur until major refits take place[99].

The second market failure is incomplete information. For effective choices to be made information must be readily available or at a cheap cost and the individuals must be able to process it[100]. It is noted that since acquiring information is costly, it is rational that companies may not be completely informed about potential resource efficiency savings. However with insufficient or inaccurate information it will generally be the case that optimal decisions will not be made. For resource efficiency measures, businesses may not be aware of the opportunities or alternatively they may be aware, but have inaccurate information about the costs and benefits of particular measures. Research from the Freight sector indicates that many operators lack the necessary data and information on how they

[94] NERA & Enviros for Defra (2006), *Policy Options to Encourage Energy Efficiency in the SME and Public Sectors*

[95] AEA for SDRN (2009), *Business Resource Efficiency: Final Workstream Report*

[96] HM Treasury (2009), *The Green Book – Appraisal and Evaluation in Central Government*

[97] Carbon Trust (2005), *The UK Climate Change Programme: Potential evolution for business and the public sector*

[98] Rogers (1995), *Diffusion of Innovations*

[99] PwC for BIS (2009), *Determining cost-effective action for business to reduce emissions*

[100] Simon (1955), *A Behavioural Model of Rational Choice*, Quarterly Journal of Economics

could save fuel. Even where tools are available to assist operators, they can be of little use without the information and skills to use them; or they may target business areas that do not reflect the priorities of the businesses concerned[101].

The third market failure identified is that of split incentives. The most common example is that between tenants and landlords, prevalent for commercial buildings. Tenants often have little influence on energy saving measures used in buildings for example, and conversely landlords are often unable to pass through the costs of these measures through higher rents[102]. Similarly in industry, often the relevant person making the decision e.g. the engineer or designer may have little interest in environmental performance[103], possibly because the resulting savings may not accrue to their department.

8.1.4 Behaviour and motivation

The last type of barriers is those that relate to behaviour and motivation. These barriers are wide ranging and can be hard to predict and to distinguish from the other types of barriers[104]. Behaviour and motivation barriers include:

- Lack of prioritisation with many businesses viewing resource efficiency as a 'non-core' business activity[105].
- Inertia where individuals are reluctant to implement change.
- Rules of thumb approach to investment decisions.
- Distrust of the potential savings leading to excessive risk aversion.
- Loss aversion where individuals overweight the upfront costs relative to the long run benefits of investment.
- Organisational aspects, such as who has power to influence the culture and decision-making.
- Managerial quality has been shown to be linked to the energy intensity of production, in particular use and analysis of performance indicators and people management. An improvement from the 25th to 75th percentile in management quality is associated with a 17.4% reduction in energy intensity[106].

8.1.5 Policy and regulation

At this point a discussion on policy and regulation is appropriate. On the one hand policy and regulation can act as a barrier to implementing resource efficiency through administrative, compliance and enforcement costs. However, in general regulation is not a key barrier in comparison to the barriers discussed above[107]. Some particular regulations are noted including:

- Waste – clarity on definitions and end of waste; consistent enforcement; and overlapping regulations.

[101] Chartered Institute of Logistics and Transport (2008), *An Inconvenient Truck*

[102] NERA & Enviros for Defra (2006), *Policy Options to Encourage Energy Efficiency in the SME and Public Sectors*

[103] Carbon Trust (2005), *The UK Climate Change Programme: Potential evolution for business and the public sector*

[104] NERA & Enviros for Defra (2006), *Policy Options to Encourage Energy Efficiency in the SME and Public Sectors*

[105] AEA for SDRN (2009), *Business Resource Efficiency: Final Workstream Report*

[106] Bloom et al (2010), *Modern management: good for the environment or just hot air?*, Economic Journal May 2010

[107] BIS (2010), *Green light? A review of regulatory barriers to small businesses' resource and energy efficiency*

- Building regulations.
- Clarity on the multiplicity of delivery bodies and services offered.
- Providing consistent messages and certainty on resource efficiency.

On the other hand policy and regulation offers solutions to overcoming the above mentioned barriers such as:

- Loans to reduce the up-front costs of investments
- Information provision of opportunities and performance e.g. benchmarking
- Technical support
- Equipment standards and labelling of product performance
- Demonstration projects of technologies.

8.1.6 Summary

The main barriers to realising the resource efficiency savings are listed in Table 57. The first two types of barriers, financial and 'hidden' costs, may prevent investment in resource efficiency, but they nonetheless represent rational behaviour; encompassing all real costs, some of which may be ignored in modelling[108]. Because the decision-making for these barriers is rational, there is no case for policy intervention on these grounds. The market failures and behavioural and motivational barriers, however do offer a case for policy intervention.

Table 57: Summary of barriers

Genuine Constraints		**Potential for Policy Intervention**	
Financial	**'Hidden' Costs**	**Market Failures**	**Behaviour & Motivation**
Upfront cost	Management time	Externalities	Lack of prioritisation
Payback period	Transaction costs	Information	Inertia
Lack of capital	Regulatory compliance	Split incentives	Rules of thumb
	Disruption		Distrust
	Incompatibility		Loss aversion
	Training		Organisation
	Support / maintenance		

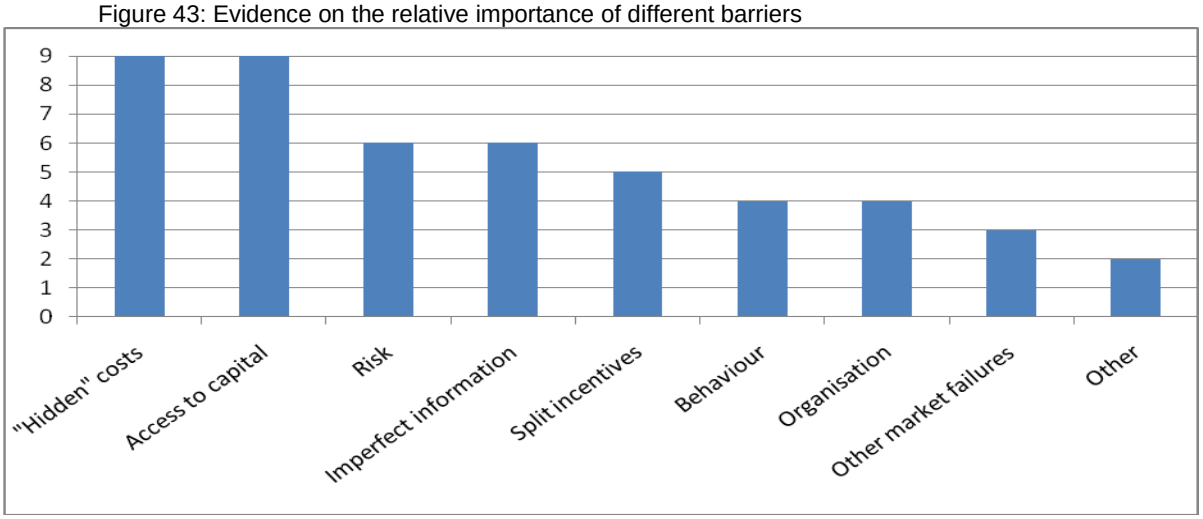
Evidence is available on the relative importance of these barriers in a study by SPRU (2000) based upon case studies performed for Higher Education, Brewing and Mechanical Engineering in the UK, Germany and Ireland. Each barrier was assessed as whether it was of particular importance to preventing investment in energy efficiency for that sector in each country. Aggregating these together gives a maximum score of 9 (where a particular barrier was considered important for all the sectors in all three of the countries). The results of this exercise are shown in Figure 43. Overall impressions from the study were that there are a large number of highly cost effective opportunities available but a wide range of barriers limited their exploitation[109]. The two most significant barriers identified were 'Hidden' costs, (in particular staff time constraints) and access to capital. Other important barriers were risk, imperfect information and split incentives.

[108] SPRU (2000), *Reducing barriers to energy efficiency in public and private organisations*

[109] This finding is in contrast to some later studies e.g. PwC for BIS (2009), which suggested that "much of the low hanging fruit had already been picked" in the Chemical and Retail sectors. This discordance could reflect the different choice of sectors, or it could represent progress having been made in general terms.

A somewhat different approach is taken by Schmidt (2009)[110] in his investigation into the reasons behind market failure with respect to business resource efficiency. His work looks at companies in terms of character traits, and what these imply for the likelihood of a company embracing resource efficiency. He finds that those companies least likely to implement resource efficiency struggle with a lack of short-term liquidity, a lack of funds for investment and a lack of strategy and structure. His conclusion is that it is the innovative and dynamic companies that are the most likely to introduce resource efficiency. The next section will discuss how these barriers relate to the size of an organisation.

Figure 43: Evidence on the relative importance of different barriers



Source: From SPRU (2000), *Reducing barriers to energy efficiency in public and private organisations*

8.2 Issues regarding the size of an organisation

Some indicative data are available that quantify the relative energy savings available for different sizes of organisations. NERA & Enviros for Defra (2006) estimate that available energy savings of 15% are worth £90 for a micro company, £720 for a small company and £4,500 for a medium sized company per year (Table 58). This can be translated into equivalent person days (£500 per day for management time is assumed) to assess how many days should be spent on improving resource efficiency. For micro and small companies, improving energy efficiency savings are worth only around 0.2 and 1.4 days of manager time, so it can be understood why energy efficiency might be a low priority. For medium sized companies the opportunities are more significant at 9 days of manager time.

Table 58: Indicative 'private benefit' calculation by organisation size

Organisation Size	**Micro (<10)**	**Small (<50)**	**Medium (<250)**
Total Category Emissions (KtC)	5,578	4,198	1,188
Emissions (tC/organisation)	5	40	250
Energy costs (£/organisation)	£600	£4,800	£30,000
Energy savings at 15% (£/organisation)	£90	£720	£4,500
Equivalent person-days / organisation	0.2	1.4	9

Source: NERA & Enviros for Defra (2006), Policy Options to Encourage Energy Efficiency in the SME and Public Sectors

[110] Schmidt (2009), *Why do companies ignore economic efficiency potentials?,* Chapter 9 in *Sustainable Growth and Resource Productivity*, Bleischwitz, Welfens & Zhang eds.

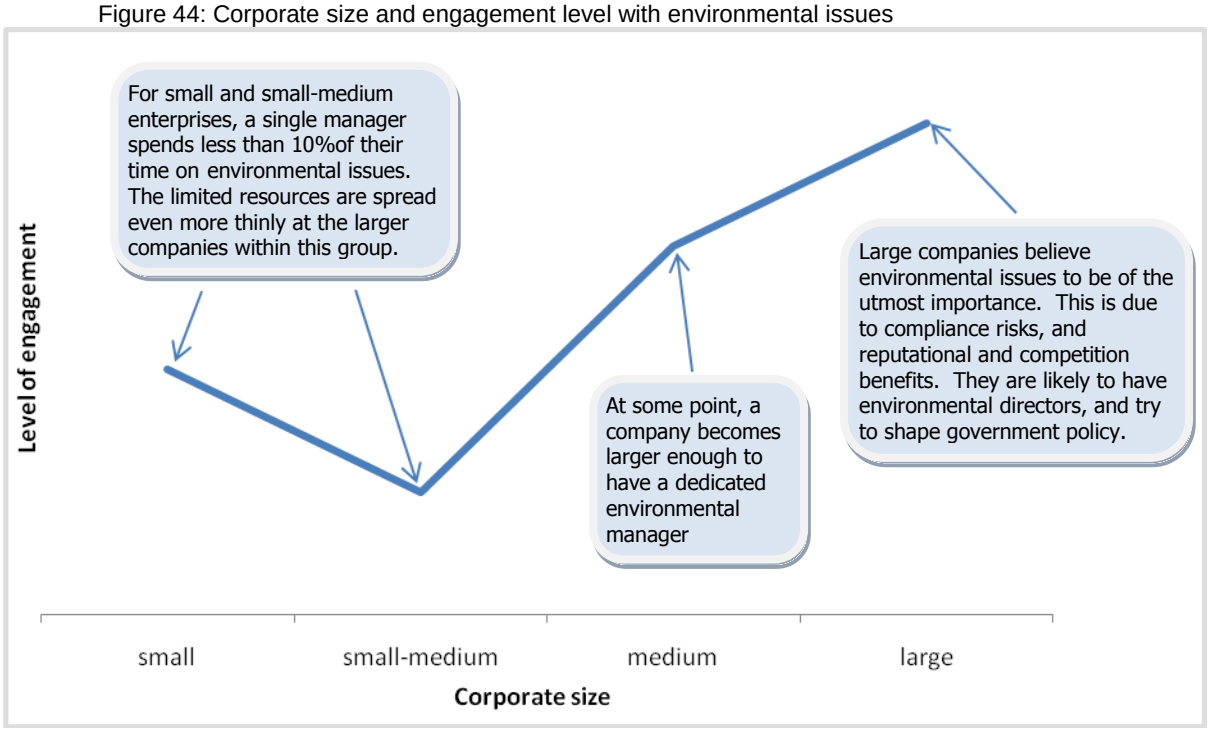
8.2.1 Engagement

The first aspect to note relates to the relative engagement levels of different sized companies (see Figure 44). The least engaged companies tend to be small to medium sized companies where a single manager (often the owner) may spend less than 10% of their time on environmental issues, which is therefore spread thinly over the company. Once a company reaches a certain size however it will hire a specialist manager for environmental issues, which increasing the level of engagement. Large companies tend to be the most engaged. To some extent this is non-optional in order to manage their reputation, but many believe that environmental excellence offers a competitive advantage. Even between large companies, evidence shows that FTSE 100 companies are considerably more engaged on environmental issues compared to FTSE 250 companies[111].

These qualitative observations on engagement are borne out in quantitative data:

- 91% of large companies are reported to have an environmental policy, compared to 56% of medium-sized companies and 19% of small companies (Table 59), although it should be noted that there are often wide-ranging definitions of what constitutes a policy in terms of scope and level of detailed actions and commitments[112].
- Large companies are more willing to pay for services that will improve their resource efficiency than medium-sized or small companies (Figure 45).

Figure 44: Corporate size and engagement level with environmental issues



Source: Defra (2010), Resource Efficiency Delivery Landscape Review

[111] Carbon Neutral (2006),*FTSE 350 Survey*

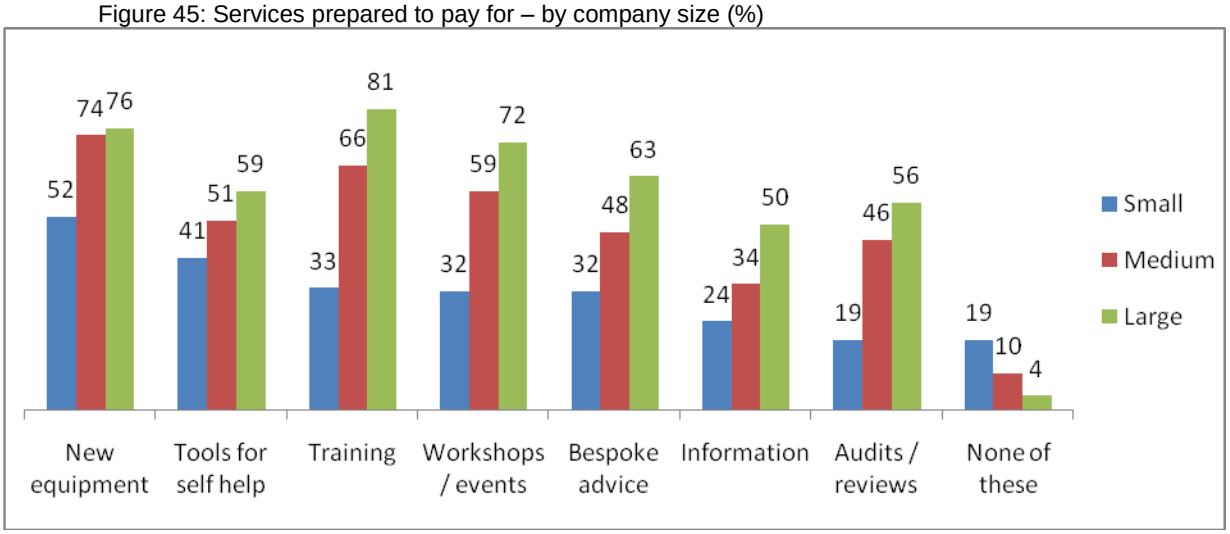
[112] PwC for BIS (2009), *Sectoral Progress on Sustainability*

Table 59: Companies with an environmental policy (%)

Size (No. employees)	Small (1-25)	Medium (26-250)	Large (251+)
% With Environmental Policy	19	56	91

Source: Defra (2010), Resource Efficiency Delivery Landscape Review

Figure 45: Services prepared to pay for – by company size (%)



Source: Defra (2010), Resource Efficiency Delivery Landscape Review

8.2.2 Discussion of barriers

For the financial barriers the evidence is that these are more severe for SMEs than for larger companies for two reasons. The first is that SMEs use higher discount rates in their investment decisions because of a higher cost of credit and a lower company survival rates[113]. The second relates to a more pronounced lack of access to capital for SMEs. For 'Hidden' costs the evidence is that management time for environmental issues is more limited and it is likely that transaction costs are higher.

For market failures the evidence does point to a greater burden for SMEs. Under externalities large companies may have greater ability to trial new technologies. Under information, the evidence points to large companies being better informed. SMEs are often informed by solely information acquired from the media or from within their network[114]. Large companies however have access to more diverse sources of information[115] and benefit from having specialist managers for environmental issues. Under split incentives as many as 90% of SMEs operate from rented offices[116] meaning this failure is likely to be more acute for SMEs. However SMEs do not have the split incentives problem of allocating budgets between departments.

[113] BIS (2010), *Green light? A review of regulatory barriers to small businesses' resource and energy efficiency*

[114] IPTS (2007), *Promoting Environmental Technologies in SMEs: Barriers and Measures*

[115] Defra (2010), *Resource Efficiency Delivery Landscape Review*

[116] Scrase (2001), *Research for the Association for the Conservation of Energy*, cited in NERA & Enviros for Defra (2006)

For behaviour and motivation the evidence for a greater burden on SMEs is more mixed. On the one hand, management time tends to be more stretched at SMEs, but on the other hand the bureaucratic nature of larger organisations means that SMEs can make decisions more quickly and requiring the support of fewer individuals. For large companies the latter point can be a real issue particularly for multinationals where strategic decisions may be taken overseas limiting the options for UK subsidiaries[117]. Evidence from the Food and drink industry for waste opportunities showed that these bureaucratic issues are important. Resource efficiency is often the responsibility of an individual without sufficient power and influence to implement waste reduction or Lean production, which requires embedding a new culture into mindset of the whole organisation. Such major changes in working practices require strong leadership involving senior management. In contrast end-of-pipe waste management solutions tend to be easier to implement. Other evidence points however towards SMEs having limited internal motivation towards environmental issues. Reasons for this include the concentration of management and ownership in the same hands and a feeling that the issues are not related to the core business[118].

In a study for DECC, which included an assessment of the relative importance of barriers for small organisations implementing energy efficiency savings the following conclusions were reached[119]:

- Access to capital and transaction costs were thought to be high across all sectors
- Attitudes and split incentives were not thought to be as important overall, although they were significant for some sectors, notably within services.

8.2.3 Issues relating to waste and recycling for SMEs

The literature review identified a number of barriers specifically relevant to waste opportunities in SMEs. WRAP identifies the following barriers to SMEs increasing their recycling rates[120]:

- A lack of volume makes it uneconomic to collect the waste
- A lack of resources to establish and manage a recycling scheme
- Waste management structures for SME mean they lack the incentives for recycling
- A Lack of space for collection and storage of materials
- A lack of service provision.

A survey on recycling activities in SMEs found that many SMEs did not have access to a good quality, cost effective recycling service due to a disconnect between what SMEs want and what is offered by providers[121]. The main issue being SMEs preferring multi-material collection, whereas providers prefer segregated material due to its higher value (but volumes for segregated material are understandably low). A third of those surveyed did not have their waste collected for recycling at all, meaning there is currently considerable disposal of recyclable materials. For those SMEs that do recycle, many do so through the household system, which explains the current policy direction of trying to harmonise the collection and sorting of household and commercial waste[122].

[117] PwC for BIS (2009), *Determining cost-effective action for business to reduce emissions*

[118] IPTS (2007), *Promoting Environmental Technologies in SMEs: Barriers and Measures*

[119] BRE for DECC (2009), *Potential for energy efficiency savings in small and medium sized organisations – Preliminary Assessment*

[120] WRAP (2006), *SME recycling feasibility trials evaluation report*

[121] GHK for Defra (2010), *Recycling activities in SMEs – a survey*

[122] BIS / Defra (2010), '*Less is more': Business Opportunities in Waste & Resource Management*

8.2.4 Policy

On policy it is estimated that there is a 'Policy Gap' (that is companies whose energy consumption is not covered by the EU ETS or CCAs) of 10.5 Mt of carbon emissions per year, three quarters of which is accounted for by organisations with fewer than 50 employees[123]. The Carbon Trust (2005) asserts that:

"Other instruments will be required to overcome specific barriers for SMEs ... [who] are difficult to target cost effectively, both because of their diversity and the lack of time, resource and expertise they have to apply to these 'non-core' issues."

A recent DECC study[124] reported that cost savings was the major driver for businesses to take action to reduce energy consumption and this is considered the principal motivator for all resource efficiency interventions. Cost savings can be significantly underestimated due to the 'hidden' savings being excluded from any cost benefit analysis type activities associated with resource efficiency. Envirowise have attempted to communicate the full extent of the savings opportunity through their message that[125] "*waste costs money, typically up to 4% of business turnover*".

Further work is required to target SMEs regarding resource efficiency measures, but policy options include:

- Information awareness campaigns targeted at SME networks such as suppliers and trade associations
- Low cost loans for SMEs to reduce the cost of capital
- Benchmarking of SME resource efficiency performance
- Voluntary agreements.

[123] NERA & Enviros for Defra (2006), *Policy Options to Encourage Energy Efficiency in the SME and Public Sectors*

[124] AEA Technology and Databuild for DECC (2010), *Assessing the carbon dioxide emissions and cost-effective carbon savings potential for organisations not covered by EU ETS, CCAs or CRC*

[125] MAS Website available at URL: http://www.mas.bis.gov.uk/news/it2019s-easy-being-green

9 Conversion of sector level resource efficiency measures into competitiveness measures

9.1 Resource Efficiency and International Competitiveness

Financial savings from resource efficiencies will improve the profitability of UK industry when compared to the *status quo*, all else being equal. Whether this improvement in profitability leads to an improvement in international competitiveness will depend on the scale of the savings made by UK companies relative to their international competitors, and whether the savings make a meaningful contribution to profitability.

9.1.1 Improvement in profitability

Gross profitability is defined as GVA less employment costs. Table 60 shows the improvement in sectors' gross profitability due to waste, and low-cost water and energy savings. The data for GVA and employment costs are from ONS Annual Business Inquiry (ABI)[126]. The sector definitions differed between waste, and water and energy due to how they were defined in the reference material. The broader classification used by waste was chosen since it was a) easier to fit the narrower definitions used for waste and water into these categories; and b) waste diversion and reduction was the largest source of savings opportunities. Sectors for which the overall savings opportunity was not significant were aggregated into 'Other industrial' or 'Other service'. Public service sectors have not been included.

Overall, industrial sectors have the opportunity to increase their gross profits by 16% if they implement all potential waste, and low-cost water and energy savings. The potential increase in profits for the service sector is 2%, but if you exclude transport this figure drops to 0.5%. The potential increase in profits in the agricultural sector due to water savings is nearly 10%.

Transport is the service sub-sector with the greatest opportunity. The majority of this saving comes from fuel savings although the inexplicably high waste saving also plays a part. Within Industrial subsectors, Metal manufacturing and Chemicals/ Non-metallic mineral products stand-out with the opportunity to more than double their profits through waste reduction. The opportunities are particularly large for the Metal manufacturing and Chemicals and non-metallic mineral products sectors in light of the very large waste opportunities estimated in Section 4.2. The very large opportunity for the Metals sector originates mostly from waste as a result of waste arisings increasing in the recent C&I waste survey. The opportunity within Chemicals / non-metallic mineral products comes largely from lean production savings estimated by WRAP, so a portion of this saving may be forward looking.

[126] ONS (2010), ABI 2009, available at URL: http://www.statistics.gov.uk/StatBase/Product.asp?vlnk=15361 (accessed 30 November 2010)

Table 60: Total sector savings opportunities as a percentage of gross profit

Sector, £m	Waste	Water	Energy	Total	GVA (£m)	Employment cost (£m)	Gross profit (£m)	Savings as a % gross profits
Construction	2,601	2	-	**2,603**	67,991	37,312	30,679	**8.5**
Chemicals and non-metallic mineral products	4,396	11	105	**4,512**	18,445	14,399	4,046	**111.5**
Food, drink & tobacco	219	76	32	**327**	26,076	11,633	14,443	**2.3**
Metal manufacturing	3,675	5	40	**3,720**	15,171	12,340	2,831	**131.4**
Other industrial	1,847	42	207	**2,096**	73,545	40,218	33,327	**6.3**
Industrial total	**12,738**	**123**	**384**	**13,245**	201,228	115,902	85,326	**15.5**
Retail & wholesale	111	-	140	**251**	149,867	83,786	66,081	**0.4**
Hotels & catering	5	7	99	**111**	29,900	19,234	10,666	**1.0**
Other service	633	65	188	**886**	318,864	143,988	174,876	**0.5**
Transport & storage	912	-	2,842	3,754	56,163	35,541	20,622	**18.2**
Service (private) total	**1,661**	**71**	**3,269**	**5,001**	554,794	282,549	272,245	**1.8**
Agriculture	**362**	**84**	-	**446**	1,499	621	878	**50.8**
Total private sector savings	**14,761**	**278**	**3,653**	**18,691**	**757,521**	**399,072**	**358,449**	**5.2**

9.1.2 Globalisation of sectors

It is not possible to estimate the average resource efficiencies by global sector, nor weight them according to their relationship with UK sectors. Therefore we take UK trade in a sector (imports plus exports) as a proportion of the sector's turnover as a measure of its globalisation, and hence where the benefits of resource efficiency may be most acutely felt.

For Industrial sub-sectors the ONS categorise trade data[127] by the same sectors as their ABI. Therefore a direct comparison of trade and turnover data is possible for the key sectors identified in Section 4 (Table 61).

Table 61: Globalisation of Industrial sub-sectors in the UK

Industrial sub-sector	Total trade as a % of turnover
Metal manufacturing	77%
Chemicals and non-metallic mineral products	99%
Food Products, Beverages & Tobacco	42%
Other Manufacturing	124%
Industrial Total	105%

On average, trade in Industrial sectors is 105% of total revenues confirming that UK manufacturing companies are heavily reliant on their international competitiveness.

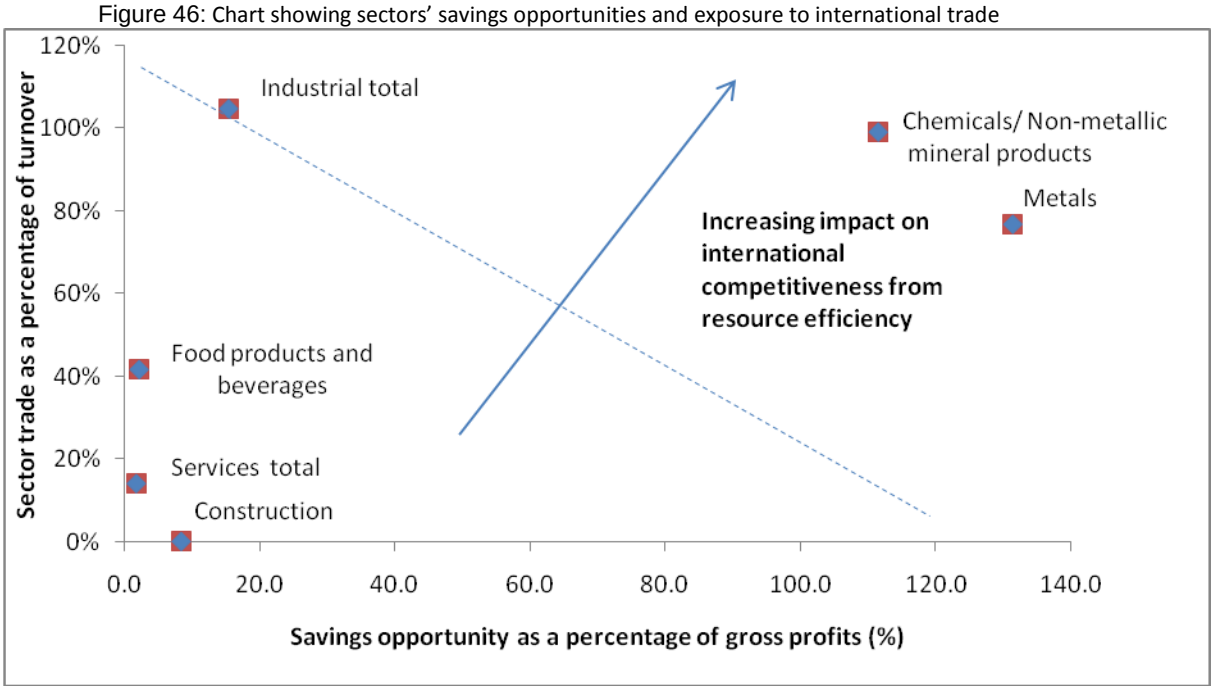
For Service sub-sectors, the classifications of sectors for trade do not correspond with those for turnover or other measures of output. Therefore total trade to turnover was calculated for the overall Service sector excluding Public Sector Services at 14%.

9.2 Summary

The opportunity for Service sectors to increase their profits is limited with the exception of Transport. Furthermore their international exposure is generally low. For Industrial sectors, the profit impact of resource efficiencies is compared to their international trade in Figure 46, along with the Service sector total. Those sectors towards the top right hand side of the scatter plot have the greatest opportunity to leverage the benefit of energy efficiencies due to an increase in international competiveness. On the basis that opportunity and international exposure are equally important (represented by the dash line in Figure 46), the manufacturing of Chemicals/ Non-metallic mineral products and Metals and metal products have opportunities at least as great as the majority of the overall Industrial sector.

[127] ONS (2009), UK Goods analysed in terms of industries, available at URL: http://www.statistics.gov.uk/downloads/theme_commerce/Mq1009Q2.pdf

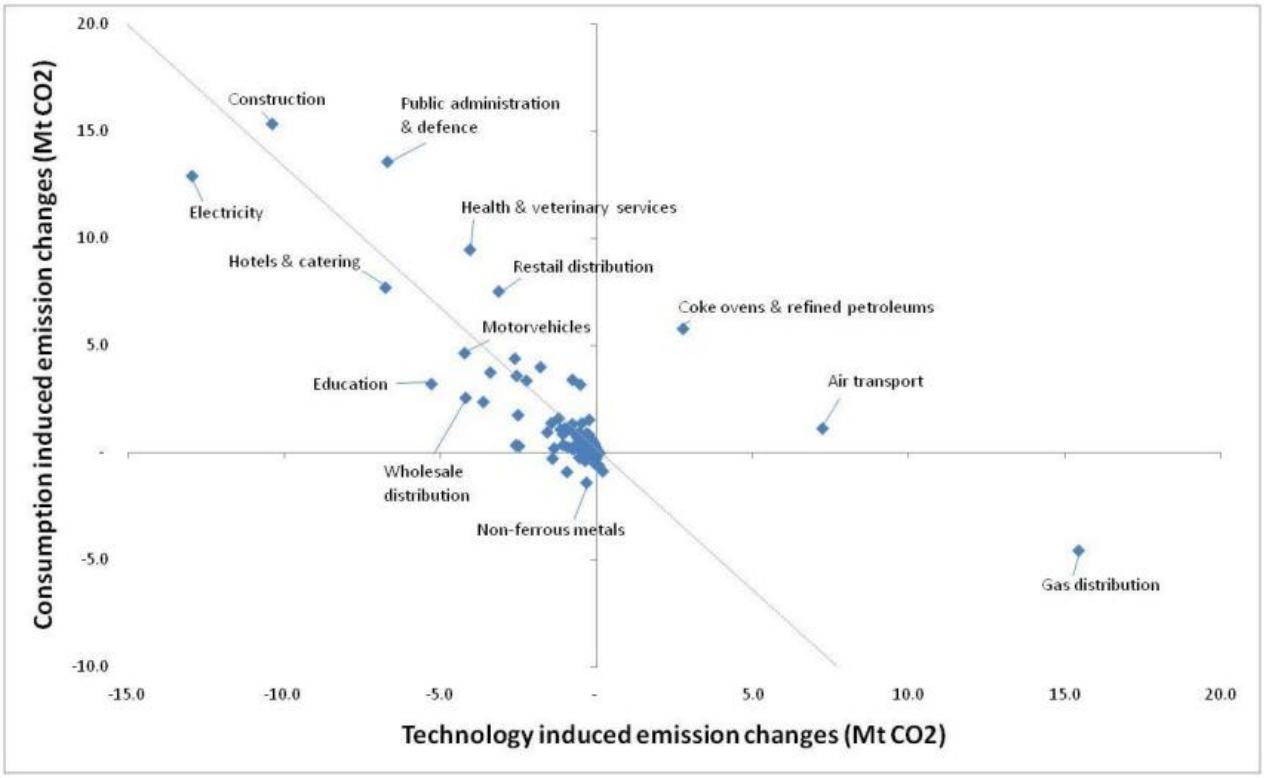
Figure 46: Chart showing sectors' savings opportunities and exposure to international trade



Annex A: Structural decomposition

In December 2009 Defra published a report produced by the Stockholm Environment Institute and the University of Durham entitled U*nderstanding changes in UK CO_2 emissions 1992 – 2004: A structural decomposition approach*. Part of the report explores the impact technological change had on sector level emissions over the 12 year period and one of the conclusions from the report is that while the volumes of global consumption have grown considerably over the last few decades; changes in technology have enabled more efficient production of the products consumed. Figure 47 shows the relationship between global consumption and technological development in a simple scatter plot.

Figure 47: Consumption versus technologically induced CO_2 emission changes of 123 product groups consumed in the UK 1998 - 2004, $MtCO_2$.



Source: Stockholm Environment Institute & the University of Durham for Defra (2009*), U*nderstanding changes in UK CO2 emissions 1992 – 2004: A structural decomposition approach.

One of the conclusions made within the study was "*the fact that technological development has not kept up with CO_2 emission rise from growing consumption levels in the UK suggests the need for an efficiency revolution on the production and consumption side of the economy*"

For this study the sectors shown to the left of the y – axis in Figure 47, i.e. those showing the highest reductions in emissions due to technological change are considered those most likely to represent the innovators in terms of resource efficiency interventions. Focus will be placed on these sectors within the study to identify any innovation that has occurred. The five key sectors are Construction, Electricity, Hotels and catering, Public Administration and Defence, and Education.

Annex B: Energy

Using DECC and ONS data to measure changes in energy intensity

The original methodology for calculating the change in sector energy intensity had been based on DECC energy consumption data and ONS Blue Book real gross value added (GVA). However, possibly due to the problems associated with using GVA (or sales) as a measure of sector activity where output prices are volatile, this methodology returned some illogical results for changes in industrial sub-sectors' energy intensity (see Figure 48). The same was true for Service sectors although in this case DECC explained that this was due to a change in their methodology.

Table 62: Industrial sub-sectors' real YoY change in energy intensity (ONS Blue Book, DECC)

Manufacturing of	2007	2008	2009
Food; beverages & tobacco	0.0%	-6.4%	-12.2%
Textiles & textile products	2.0%	-8.5%	-4.6%
Leather & leather products	-2.8%	-1.6%	-6.9%
Wood & wood products	-3.9%	-11.5%	1.6%
Pulp, paper & paper products; publishing & printing	-0.3%	14.6%	-6.1%
Coke, petroleum products & nuclear fuel	-2.3%	-32.8%	-18.1%
Chemicals, chemical products & man-made fibres	0.9%	-17.2%	-9.9%
Rubber & plastic products	0.9%	-6.8%	-0.2%
Other non-metallic mineral products	0.0%	29.9%	1.3%
Basic metals & fabricated metal products	-0.7%	-8.5%	2.3%
Machinery & equipment not elsewhere classified	-3.7%	-6.2%	9.5%
Electrical & optical equipment	1.3%	-2.4%	-1.6%
Transport equipment	-0.9%	-4.3%	1.8%

Table 63 compares the change in energy intensity according to the Carbon Trust and DECC/ONS. The Carbon Trust figure is the total energy savings opportunity identified in 2006/07 multiplied by the total realisation rate to 2009.

Table 63: Change in energy intensity 2006-2009 according to DECC[13] and that implied by the Carbon Trust[16]

Sector	Change in energy intensity	
	DECC/ ONS	Carbon Trust
Public	-11.3%	-4.8%
Services	-3.3%	-4.0%
Retail	-35.3%	-6.6%
Chemicals	3.7%	-1.8%

Detailed Climate Change Agreement data

The change in energy intensity by CCA by period is shown in Table 64.

Table 64: Details of Climate Change Agreements for which energy consumption and output data are available[22]

Sector		Energy Consumption (GWh)				Output				Unit of output	% Change in energy intensity					
		2002 (TP1)	2004 (TP2)	2006 (TP3)	2008 (TP4)	2002 (TP1)	2004 (TP2)	2006 (TP3)	2008 (TP4)		TP2 - TP1	TP3- TP2	TP4- TP3	Total change	Annual Average	TP4- TP3 Ann. Avg.
Brewing		3533	3343	2913	2693	59.38	58.33	56.55	53.11	Mhl	-3.7	-10.1	-1.6	-14.8	-2.6	-0.8
Calcium Carbonate		n/a	n/a	374	339	n/a	n/a	2,497.00	2,354.00	kT	n/a	n/a	-3.9	-3.9	-0.7	-1.9
Cement		16216	15659	14965	11799	11,537	11,784	12,248	10,562	kT	-5.5	-8.1	-8.6	-20.5	-3.8	-4.4
Ceramics:											4.0	-5.0	-6.1	-13.9	-2.5	-3.1
Bricks (Non-Fletton)		6082	6054	5366	4806	6,194	6,368	5,671	5,039	kT	-3.2	-0.5	0.8	-2.9	-0.5	0.4
Bricks (Fletton)		280.5	354.2	336.6	188.9	324.7	326.4	308.0	234.1	kT	25.6	0.7	-26.2	-6.6	-1.1	-14.1
Refractories		1445	1425	1346	1193	383.3	333.5	306.5	267.3	kT	13.3	2.8	1.6	18.4	2.9	0.8
Whitewares		2690	2197	1760	1443	284.9	248.3	237.7	212.7	kT	-6.3	-16.3	-8.4	-28.1	-5.4	-4.3
Materials		502.7	459.7	392.5	526.1	576.9	583.4	565.2	746.6	kT	-9.6	-11.9	1.5	-19.1	-3.5	0.7
Food and Drink(FDF)		35406	35223	32559	31768	37,500	37,534	36,483	37,196	kT	-0.6	-4.9	-4.3	-9.5	-1.7	-2.2
Food (other):											-1.8	-5.6	-2.1	-9.0	-1.6	-1.1
Craft Baking		1236	1364	1325	1310	827.2	991.6	1,045.2	1,110.2	£M	-7.9	-7.8	-6.9	-21.0	-3.9	-3.5
Dairy processing		4738	4606	4169	3938	10,330	10,049	9,939	9,819	kT	-0.1	-8.5	-4.4	-12.6	-2.2	-2.2
Egg processing		76.9	74.1	81.2	79.1	95.6	93.4	107.9	97.1	kT	-1.4	-5.1	8.2	1.3	0.2	4.0
Egg production		293.8	271.3	235.2	218.6	874.0	883.6	804.3	781.3	Mdozen	-8.7	-4.8	-4.3	-16.8	-3.0	-2.2
Poultry processing		2110	2030	1892	1797	3,379.0	3,265.0	3,222.0	3,216.0	kT	-0.4	-5.6	-4.8	-10.5	-1.8	-2.5
Red meat processing		1528	1904	1950	2017	2,242.0	2,588.0	2,698.0	2,801.0	kT	7.9	-1.8	-0.4	5.7	0.9	-0.2
Foundries		7676	6836	5452	4149	1,171.0	1,015.0	855.7	606.3	kT	2.7	-5.4	7.4	4.4	0.7	3.6
Geotextiles		n/a	n/a	131.0	105.4	n/a	n/a	38.2	38.4	kT	n/a	n/a	-20.0	-20.0	-3.6	-10.5
Glass		10584	10461	10322	10362	3,122.0	3,201.0	3,314.0	3,397.0	kT	-3.6	-4.7	-2.1	-2.1	-0.3	-1.0
Industrial gases		n/a	n/a	3133	3062	n/a	n/a	2,595.0	2,522.0	kT	n/a	n/a	0.6	0.6	0.1	0.3
Leather		187	186.9	115.4	97.6	17.90	16.87	13.91	12.84	km^2	6.0	-25.1	-8.4	-8.4	-1.4	-4.3
Lime		2566	2775	2967	2890	2,650.0	2,966.0	3,294.0	3,073.0	kT	-3.4	-3.7	4.4	4.4	0.7	2.2
Metal forming		2351	2396	2255	2280	948.0	1,083.0	1,014.0	1,253.0	kT	-10.8	0.5	-18.2	-26.6	-5.0	-9.5
Mineral wool		1168	1258	1432	1419	240.0	290.0	351.0	358.0	kT	-10.9	-6.0	-2.8	-18.6	-3.4	-1.4
Motor manufacturers		4799	5069	4365	4396	1,709.0	1,875.0	1,709.0	1,774.0	kT	-3.7	-5.5	-3.0	-11.8	-2.1	-1.5
Paper		28596	27216	22856	20697	6388	6359	5,630.0	5,253.0	kT	-4.4	-5.1	-2.9	-12.0	-2.1	-1.5
Printing		2848	3442	3595	4007	49029	56466	59371	57699	km^2	4.9	-0.7	14.7	19.6	3.0	7.1
Rubber tyre		1756	1662	1422	1320	289.2	332.3	290.3	263.7	kT	-17.6	-2.1	2.2	-17.6	-3.2	1.1
Slag grinding		438.2	507.0	515.8	451.0	1,703.0	2,059.0	2,174.0	1,997.0	kT	-4.3	-3.6	-4.8	-12.2	-2.2	-2.4
Steel (enery in PJ)		281	308	307.6	293.6	14,484.0	17,024.0	17,142.0	16,655.0	kT	-6.7	-0.8	-1.8	-9.1	-1.6	-0.9
Textiles		3141	2435	1750	1635	790.5	770.8	700.1	771.7	million units	-20.5	-20.9	-15.2	-46.7	-9.9	-7.9
Wood panels		3170	3130	3009	2551	3,230,814	3,609,403	3,693,844	3,257,582	m^3	-11.6	-6.1	-3.9	-20.2	-3.7	-2.0

Industrial weighted average price of energy

To convert the savings opportunity for each sub-sector to a financial value, the saving in energy units must be multiplied by the sub-sector weighted average Industrial sector's unit energy price[17]. The savings opportunity in thousands of tonnes of oil equivalents is converted to kWh using a factor of 11.65m[128]. The Basic metals and the Coke, refined petroleum products and nuclear fuels sectors have a significant proportion of their energy needs derived 'manufactured fuel' (process by-products): 18% and 44% respectively. It has been assumed that any savings opportunity will not be applied to these sources of energy and therefore they are not included in the energy mix for the weighted average price.

Industrial sector energy consumption outside of the five big energy-consuming sub-sectors ('Other') also includes a significant proportion (25%) of energy derived from liquid petroleum gas, renewable sources and manufactured fuel. This has not been included in the weighted average price calculation.

Calculating 2009 Service sub-sector energy consumption

To calculate 2009 energy consumption for each Service sub-sector (DECC only provide Service sub-sector data to 2008), 2008 energy consumption is multiplied by the change in sub-sector real GVA (see Table 66).

[128] Carbon Trust (2010), Resources – conversion factors, Energy Units into kWh – conversion tables, available at URL: http://www.carbontrust.co.uk/cut-carbon-reduce-costs/calculate/carbon-footprinting/pages/conversion-factors.aspx (accessed 22 October 2010).

Table 65: Industrial sub-sector energy mix, energy prices and the weighted average unit energy cost[14] [17]

Industrial sub-sector	Energy mix (excluding process energy where applicable)					Energy prices (p/kWh)					Weighted average electricity price (p/kWh)
	Coal	Gas oil	Fuel oil	Gas	Electricity	Coal	Gas oil	Fuel oil	Gas	Electricity	
Coke, refined petroleum products & nuclear fuel	32%	0%	36%	16%	17%	0.80	3.85	3.19	1.89	7.26	**2.98**
Chemicals, chemical products & man-made fibres	2%	2%	2%	57%	38%	0.80	3.85	3.19	1.89	7.26	**3.97**
Food products & beverages	1%	7%	2%	59%	31%	0.80	3.85	3.19	1.89	7.26	**3.70**
Non-metallic mineral products	29%	2%	0%	50%	19%	0.80	3.85	3.19	1.89	7.26	**2.64**
Basic metals	4%	1%	5%	40%	53%	0.80	3.85	3.19	1.89	7.26	**4.84**
Pulp, paper & paper products	4%	1%	2%	58%	35%	0.80	3.85	3.19	1.89	7.26	**3.75**
Other	2%	24%	2%	32%	43%	0.80	3.85	3.19	1.89	7.26	**4.68**

Table 66: Service sub-sectors' remaining low-cost savings opportunity calculation

Service sub-sector	Estimated savings opportunity in 2006 (%)	Carbon Trust realisation rate	Remaining opportunity (%)	2008 energy consumption (Ktoe, DECC)	Change in sub-sector real GVA2008-2009	Estimated 2009 energy consumption	2009 savings opportunity (Ktoe)
Retail	11.3	58%	4.7%	3,458	-3.80%	3,326	164
Hotels	13.0	41%	7.7%	2,175	-4.92%	2,068	167
Warehouses	10.0	41%	5.9%	2,107	-8.78%	1,922	124
Commercial offices	17.4	41%	10.3%	1,482	-4.71%	1,412	152
Education	10.0	48%	5.2%	2,675	0.80%	2,697	139
Government	15.0	48%	7.8%	1,726	2.35%	1,767	135
Sports & leisure*	7.4	41%	4.4%	835	-3.27%	807	36
Health	6.7	48%	3.5%	1,465	2.00%	1,494	51
Communication**	11.0	41%	6.5%	469	-1.99%	460	30
Other	11.0	41%	6.5%	828	-7.50%	766	54

Service sector weighted average energy prices

Service sector energy prices for each gas and electricity were taken as the 2009 average 'non-domestic' prices for these fuels[17].

Table 67: Service sub-sectors' energy mix and weighted average unit energy cost

Service sub-sector	Energy mix			Energy prices (p/kWh)			Weighted average energy price (p/kWh)
	Electricity	Natural Gas	Oil	Electricity	Natural Gas	Oil	
Retail	75%	24%	2%	9.05	2.27	3.85	7.36
Hotels	42%	55%	3%	9.05	2.27	3.85	5.13
Warehouses	44%	40%	16%	9.05	2.27	3.85	5.50
Commercial offices	49%	43%	7%	9.05	2.27	3.85	5.74
Education	29%	60%	10%	9.05	2.27	3.85	4.42
Government	32%	59%	8%	9.05	2.27	3.85	4.60
Sports & leisure*	50%	50%	1%	9.05	2.27	3.85	5.65
Health	26%	70%	4%	9.05	2.27	3.85	4.06
Communication**	86%	13%	1%	9.05	2.27	3.85	8.10
Other	44%	49%	7%	9.05	2.27	3.85	5.36
Total Services							

Annex C: The water savings opportunity identified (Defra *Business Benefits* for 2006)

Table 68: A summary of the water savings opportunity in the UK in 2006

Sector	Subsector	Water supply (input) savings		Estimated total savings including wastewater (£M)
		Estimated savings (%)	Estimated savings (£M)	
Industrial	Chemicals	8.1	13.6	38.9
	Food & drink	20.0	34.3	60.0
	Basic metals	7.0	6.7	11.2
	Transport equipment	2	1.3	2.0
	Paper, publishing & printing	11.4	6.5	11.5
	Electricity, gas & water	2.7	1.6	2.5
	Construction	12.0	1.6	2.0
	Other	11.3	25.2	56.3
Commercial (Service)	Public administration	31	66.3	85.8
	Health & social work	20	23.8	30.4
	Education	28	30.8	39.7
	Other community activities	21	10.4	13.3
	Real estate, renting & business activities	31	12.2	15.6
	Hotels & restaurants	33	3.4	4.7
	Other	21.9	26.1	29.6
Agriculture	All	32	37.8	37.8
Total			**301.6**	**441.3**

Annex D: Analysis of the road freight sector

Road Freight

Background

The Defra *Business Benefits* study for 2006 used government statistics (from the then Department for Business, Enterprise and Regulatory Reform) as the baseline on energy consumption within the UK Road freight sector. The no cost / low cost savings opportunity within the UK Road freight sector in 2006 were estimated using case study evidence from initiatives run or funded by the Department for Transport (DfT) and government reports. The initiatives and reports used were:

- The Freight Best Practice Programme
- Transport Energy Best Practice Programme
- 2002 Energy Review.

A detailed breakdown of the types of resource efficiency interventions is provided in the Defra study for 2006 but examples from the Freight Best Practice Programme include:

- Minimising demand
- Virtual delivery
- De-massing (material selection, design)
- Size minimisation (material selection, design, packaging, etc)
- Source location (the closer the better)
- Modal choice
- Consolidation
- Equipment (match the truck specification to suit the underlying contract)
- Routing
- Training
- Management information (KPIs).

The overall savings opportunity was estimated at 11% (1,712 Ktoe) or £2,017 million. The supplementary CO_2 report[129] converted the financial savings to environmental savings, estimating that 5.1 $MtCO_{2e}$ of the total 46.7 $MtCO_{2e}$ attributed to Road freight could be saved through no cost / low cost interventions.

This section provides an estimate of the no cost / low cost savings opportunity in the UK Road freight sector in 2009 but starts with a review of the methodology used in the Defra *Business Benefits* study for 2006.

Review of the Defra Business Benefits study for 2006 – transport section

Three key discussion points associated with the original study are:

- The overall magnitude of the economic saving.
- Recent studies have questioned the accuracy of UK government statistics on emissions within the Road freight sector.
- The fuel price.

[129] Oakdene Hollins for Defra (2009), *Quantification of the potential CO_2 savings from resource efficiency in the UK*

The overall magnitude of the economic saving

The £2.0 billion savings opportunity identified in the previous Defra 2006 study represented over 60% of the overall energy efficiency opportunity and 31% of the total resource efficiency savings opportunity. It was therefore considered necessary to challenge the valuation to ensure its robustness.

One source not used in the original study was the final report[130] on the Safe and Fuel Efficient Driving (SAFED) driver training scheme. This reported that the training of 6,375 HGV drivers resulted in an average reduction in fuel consumption of 10.01% with an estimated industry saving of £10.5 billion and 37,364 tonnes of CO_2 (Table 69). The DfT reports, in Road Freight Statistics 2009, that 324,000 heavy goods vehicle drivers were employed in the UK in 2006. Based on this it is estimated that if applied to the whole industry that a saving of £531 million or 1.9MtCO_2 would be generated.

Table 69: Results from the SAFED driver training scheme

Parameter	Value
Total number of km driven for the total number of drivers trained	587,232,628 km
Estimated amount of fuel used before training (litres)	153,173,316 ltr
Estimated amount of fuel used after training (litres)	139,231,375 ltr
Fuel saved (litres)	13,941,941 ltr
CO_2 savings due to SAFED programme (tonnes)	37,364 tonnes
Fuel cost/litre	0.75 £/ltr
Fuel cost savings	£10,456,455

The SAFED study on vans found an average fuel consumption saving of 14% with the fuel consumption alone representing a saving of £500 of fuel per vehicle. The DfT reports, in Road Freight Statistics 2009 that in 2006 there were 3,060,000 vans licensed in Great Britain. Based on this it is estimated that if applied to the whole sector a saving of £1,530 million would be generated.

Combining the savings from the two SAFED studies results in an estimated savings opportunity of £2,060 million. This is in line with the valuation made in the previous Defra 2006 study (£2.0 billion).

Additionally, using the Freight Best Practice (FBP) estimate that typical fleets save £20,500 per annum it is estimated using Road Freight Statistics 2009 data that the savings opportunity would be £2,046 million. This, again, is in line with the original estimate. *Please note: the FBP case study data were used within the original study and hence this does not represent an independent validation of the estimates within the original study.*

The accuracy of the emissions data

The analysis in the original study used the UK Government Road Freight data and the DfT (2004) stated[131] that data users should be *"aware that the road freight industry comprises solely the specialist road haulage companies and not all road freight activities",* i.e. it excludes 'own account' or 'in-house' operators. Within the study the emissions and associated savings opportunities for own account operators were not calculated as a specific item but instead were included within the general analysis of savings opportunity within each sector. The same convention is followed within this study but with the 'own account' data shown for reference purposes.

[130] Momenta for the Department for Transport (2005), *Safe and fuel efficient driver training programme*

Since the Defra report for 2006, greater focus has been placed on the contribution of the UK Road freight sector to global warming and the methods of quantifying emissions from the sector.

The Heriot-Watt University study[132] *Measurement of CO_2 emissions from road freight transport: a review of UK experience* in 2009 reported that:

"*In recent years differing estimates of CO_2 emissions from heavy goods vehicles (HGV) have emerged from official sources, while the corresponding statistical series have undergone major revisions. This can frustrate the policy-making process and erode the confidence of industry stakeholders in the validity of the figures. For example, between January 2008 and March 2008 the estimated growth in CO_2 emissions from HGVs in the UK between 1990 and 2004-5 was revised downward from 30% to 10%*".

The original report used DECC (formerly DTI) data to calculate the emissions from UK road freight. Table 70 shows the estimated emissions from UK road freight calculated using the most recent UK Government (DECC) data. This shows that the emissions for 2006, the base year in the previous Defra (2007) report, are significantly lower than that estimated previously, i.e. 39.3MtCO_2 as opposed to 46.7 MtCO_2. In addition, the results of a Heriot-Watt study[133] in 2007 estimates the emissions in 2004 at 33.7 MtCO_2 as opposed to the 37.147 MtCO_2 shown in Table 70.

Table 70: Estimated carbon emissions from the UK road freight sector in MtCO_2e

Year	LGV	HGV	Total
2004	14.995	22.152	37.147
2005	15.317	23.048	38.365
2006	15.670	23.656	39.326
2007	16.279	24.584	40.863
2008	15.865	23.752	39.617

Source: Produced using data contained in: DECC *Energy consumption in the UK* Transport data tables. 2010 update, July 2010; DECC *2010 guidelines to Defra / DECC's GHG conversion factors for company reporting* August 2010.

Based on this analysis the emissions savings shown in the original study are likely to represent a significant overestimate. Using the 2006 estimate shown in Table 70 an 11% saving would be 4.32 MtCO_2 as opposed to the 5.47 MtCO_2 estimate made previously.

The fuel price

The original study used BERR retail fuel price data. However, many freight operators either pay a bulk diesel price or at least claim back VAT, which reduces the price of fuel significantly. Table 71 shows the price variation in October 2010 and in the Defra report for 2006 a fuel price of 97.6p/l was used and the mean bulk fuel price in 2006 was circa 80.1p/l.

Table 71: Comparison of fuel prices on October 8th 2010, in pence per litre

Bulk fuel price	Forecourt (retail) fuel price	
	Excluding VAT	Including VAT
99.43	102.13	120.00

Source: Freight Transport Association

[132] Heriot-Watt University, Professor Alan McKinnon (2007), Logistics Research Centre *Measurement of CO_2 emissions from road freight transport: a review of UK experience*

[133] Heriot-Watt University (2007), CO_2 emissions from freight transport in the UK

For this study, the bulk fuel price will be used to provide a minimum economic level of savings opportunity and the forecourt fuel price including VAT will be used to provide the maximum valuation.

An estimate of total energy consumption, fuel consumption and emissions 2006-09

Unfortunately, the DECC dataset for 2010 shown in Table 70 does not include the 2009 data and hence an alternative 'headline level' DECC dataset was used. These data were converted to fuel consumption using the DECC[134] conversion factor of 1,203 litres of fuel per toe and to CO_2 using the conversion factor 2.87 tCO_2 per toe, Table 72. *Please note: the emissions estimates can be seen to vary slightly from those detailed in Table 70 due to rounding errors.* The analysis shows that emissions peaked in 2007 and have dropped back in 2008 and 2009 with the emissions in 2009 being lower than in 2006.

Table 72: A summary of the UK road freight energy consumption, fuel consumption and emissions, 2006 to 2009

Year	Base data Energy consumption (Mtoe)	Fuel consumption (Ml)	Emissions ($MtCO_2$)
2006	13.79	16,600	39.49
2007	14.36	17,300	41.22
2008	14.08	16,900	40.41
2009	13.60	16,400	39.02

For reference, Table 73 shows the data when the 'mainly own account' operations are included. The analysis differs significantly to that shown in Table 67 with a significant increase in emissions being observed over the four year period.

Table 73: a summary of the UK road freight energy consumption, fuel consumption and emissions, 2006 to 2009 including 'mainly own account' operators

Year	Base data Energy consumption (Mtoe)	Fuel consumption (Ml)	Emissions ($MtCO_2$)
2006	19.15	23,055	54.85
2007	19.94	24,028	57.25
2008	20.71	24,853	59.43
2009	21.94	26,452	62.94

Table 74 provides a summary of the analysis within this section for 2009.

Table 74: A summary of UK road freight energy consumption split by activity in 2009

Activity	Energy consumption (Mtoe)	Fuel consumption (Ml)	Emissions ($MtCO_2$)
HGV – mainly public haulage	8.16	9,840	23.41
LGV – mainly public haulage	5.44	6,560	15.61
Mainly own account – HGV and LGV	8.34	10,052	23.92
Total	**21.94**	**26,452**	**62.94**

A review of resource efficiency activities 2006-09

CILT conclude in their 2009 report that[135]:

[134] DECC guidelines to Defra (2010), *DECC's GHG conversion factors for company reporting*

[135] CILT (2009), *An Inconvenient Truck? CILT Guide to CO_2 emissions from freight*

"*With the exception of some major players in the market place, in general, there appears to be a widespread lack of focus on carbon reduction within the road freight industry. Naturally, transport operators are focussed on the cost of fuel and direct a great deal of management attention to obtaining fuel at the best possible price. As the report has shown the level of attention given to purchasing cheaper fuel at the expense of pursuing other solutions increases disproportionately at smaller companies. This is in spite of the evidence which shows that seeking to reduce the amount of fuel actually used would be a much better use of management time. It would reduce companies' costs and would usually lead to a genuine reduction in their carbon footprint too*".

In addition, CILT provided examples of typical economic and environmental benefits which can be gained from relatively low cost measures, Table 75. This appears to show that the 11% savings opportunity identified in the Defra study for 2006 remains unrealised.

Table 75: Examples of relatively low cost resource efficiency interventions

Action	Potential economic saving	CO_2 reduction
Greater capacity vehicles	5.3%	6.5%
Out of hour deliveries	2.0%	(0%)
Engine specifications	3.5%	0.4%
Vehicle telematics / CVRS	3.0%	2.3%
Transport collaboration	3.2%	3.8%
Logistics systems redesign	2.3%	2.8%
Total	**17.3%**	**14.2%**

Source: CILT (2009), *An Inconvenient Truck? CILT Guide to CO_2 emissions from freight*

This assertion appears to be supported by the data shown in Table 76. This shows that DECC attributes the change in consumption observed between 1990 and 2008 to changes in output with no changes in intensity.

Table 76: Output and intensity factors affecting changes in road freight transport energy use between 1990 and 2008 (Mt of oil equivalent)

Energy consumption						Reason for change	
1990	2000	2006	2007	2008	Change between 1990 and 2008	Output	Intensity
11.7	12.2	13.8	14.4	14.1	2.4	2.3	0.0

Source: DECC, Energy Consumption in the UK. Transport data tables. 2010 update.

In addition, the SAFED final report suggests that persistence levels associated with driver training can be very short and hence the need for frequent refresher courses. This does not undermine the benefit of such initiatives since the DfT transport Statistics Great Britain reports that such initiatives offer rapid benefits to the operators and quick recovery of course costs.

Conversely, CILT reports that[136]:

"*We would not wish to underplay some excellent initiatives currently underway in the freight sector. However, they are not sufficiently widespread within the industry, or even within companies which have made commitments to change behaviour. Furthermore, this work*

[136] CILT (2009), *An Inconvenient Truck? CILT Guide to CO_2 emissions from freight*

tends to be tactical rather than strategic in its nature. While useful case studies exist, more needs to be done to roll them out more widely, and gaps and weak areas need to be addressed urgently. To reduce emissions a number of measures needs to be adopted across the board:

- *Continue to improve the efficiency of goods transport vehicles;*
- *Improve driving style;*
- *Reduce the distances travelled, relative to the goods transported;*
- *Utilise and share network capacity better;*
- *Shift freight towards the least polluting mode of transport;*
- *Provide economic incentives and penalties for polluting behaviour".*

Table 77 shows examples of the resource efficiency savings that have been realised.

Table 77: Examples of resource efficiency interventions

Company	Intervention	CO_2 saving		Economic saving
		%	CO_2	
Tesco	Improved utilisation of existing assets Adopting alternatives to road transport Moving to multi-modal transport Reduction in road miles	10.2% in 2007		
Marks and Spencer / DHL	Introduction of 'Tear Drop' trucks and trailers (increasing capacity by 16%)	20%	840 tonnes	
Energizer Wilkinson	Combined two business units' products into the same trucks and local warehouses		355,000 tonnes	€300,000
Boots / Imperial Tobacco	Shared distribution to accommodate increased demand for high cube loads		92 tonnes	

Source: CILT (2009), *An Inconvenient Truck? CILT Guide to CO_2 emissions from freight*

Savings opportunity

Table 78 shows the estimated savings opportunities assuming an 11% saving can be achieved through no cost / low cost interventions. The savings opportunity is much higher than the previous Defra study estimates for 2006 due to the inclusion of the 'mainly own account' operations. On a like for like basis the savings opportunity would be £1.9 billion, i.e. the forecourt price for the two 'mainly public haulage' components, instead of the £2.0 billion estimated in the previous study.

Table 78: A summary of UK road freight savings opportunity split by activity

Activity	Energy consumption (Mtoe)	Fuel consumption (Ml)	Emissions ($MtCO_2$)	Economic savings (£M)	
				Using bulk diesel price	Using forecourt price
HGV – mainly public haulage	0.90	1,082	2.58	924	1,130
LGV – mainly public haulage	0.60	722	1.72	617	754
Mainly own account – HGV and LGV	0.92	1,106	2.63	945	1,155
Total	**2.42**	**2,910**	**6.93**	**2,486**	**3,039**

Annex E: Analysis of CDEW

Type and end fate of CDEW		North West	North East	Yorkshire & Humber	West Midlands	East Midlands	East of England	London	South East	South West	Total	
Estimated production of recycled;	graded aggregate	3,758,097	953,127	3,071,057	2,551,655	2,845,598	2,884,291	2,514,616	3,525,843	1,928,015	24,032,299	
	ungraded aggregate	2,259,397	754,691	2,184,463	1,895,768	2,240,550	2,654,663	1,830,899	2,451,493	1,769,873	18,041,797	**46,438,839**
	Soil (excluding top soil)	703,320	173,123	549,951	470,201	504,968	492,199	500,821	637,508	332,652	4,364,743	
Estimated tonnage of unprocessed CDEW entering licensed landfill for Engineering use;	Clean hard C&D waste	65,631	34,658	129,941	138,710	73,035	110,428	35,563	140,736	121,542	850,244	
	Contaminated hard C&D waste	564	1,449	971	324	564	660	96	2,376	624	7,628	
	Clean excavation waste	177,340	559,021	316,979	277,420	215,359	239,980	229,340	304,132	331,547	2,651,118	
	Contaminated excavation waste	5,999	5,321	35,339	3,446	7,793	7,021	1,021	8,605	6,638	81,183	**4,198,797**
	clean mixed CDEW	26,852	40,472	42,543	35,654	63,125	33,718	4,071	49,429	33,690	329,554	
	Contaminated mixed CDEW	91	493	156	52	91	106	15	121	100	1,225	
	Other	18,969	19,297	116,070	12,265	20,900	22,875	3,065	36,461	27,943	277,845	
Estimated tonnage of unprocessed CDEW entering licensed landfill for capping use;	Clean hard C&D waste	6	11	11	8	25	128	-	19	25	233	
	Contaminated hard C&D waste	-	-	-	-	-	-	-	-	-	-	
	Clean excavation waste	578,277	254,804	849,623	357,173	589,276	959,351	417,696	772,138	595,681	5,374,019	
	Contaminated excavation waste	-	-	-	-	-	-	-	-	-	-	**5,414,694**
	clean mixed CDEW	1,250	622	8,322	724	1,274	1,609	212	1,690	1,406	17,109	
	Contaminated mixed CDEW	-	-	-	-	-	-	-	-	-	-	
	Other	556	1,111	1,111	833	2,500	12,778	-	1,944	2,500	23,333	
Estimated tonnage of unprocessed CDEW entering licensed landfill as waste;	Clean hard C&D waste	109,180	15,189	106,231	19,979	41,716	55,931	5,377	42,118	46,889	442,610	
	Contaminated hard C&D waste	5,668	5,637	9,079	3,026	16,338	7,405	897	9,906	13,328	71,284	
	Clean excavation waste	1,367,749	890,571	1,422,466	586,007	1,942,534	1,785,660	381,003	2,638,557	1,489,220	12,503,767	
	Contaminated excavation waste	82,259	33,182	179,094	42,626	181,220	129,291	37,277	195,974	99,306	980,229	**18,136,106**
	clean mixed CDEW	104,901	82,288	326,696	161,114	211,511	293,677	10,816	742,358	517,623	2,450,984	
	Contaminated mixed CDEW	31,568	15,380	206,337	18,055	31,429	36,779	5,350	42,129	38,273	425,300	
	Other	89,399	170,613	155,515	354,054	98,385	141,637	14,905	128,662	108,762	1,261,932	
Estimated weight of waste materials (mainly excavation waste) used on Paragraph 9A(1) and 19A(2) registered exempt sites		1,958,148	803,643	784,947	2,910,592	733,166	1,683,111	2,040,590	2,512,966	2,016,789	15,443,952	**15,443,952**
Total		**11,345,221**	**4,814,703**	**10,496,902**	**9,839,686**	**9,821,357**	**11,553,298**	**8,033,630**	**14,245,165**	**9,482,426**	**89,632,388**	**89,632,388**

Source: Communities and local government, *Survey of arisings and use of alternatives to primary aggregates in England, 2005*

Annex F: Commercial and industrial waste data

C&I Waste Arisings

Baseline data

The baseline data for Commercial and Industrial waste arising in the UK is Defra submission to Eurostat for 2006 (Table 79). In line with the later C&I waste surveys, waste arising within the waste management and household sectors have been excluded. Total waste arisings in 2006 were 273Mt.

Table 79: Waste generation in the UK by non-household and waste management sectors, 2006 (Mt)

Sector Code	Sector	England	Wales	Scotland	Northern Ireland	UK TOTAL
A	Agriculture	318	58	85	38	500
B	Fishing	29	3	129	5	167
C	Mining and quarrying	61,160	12,731	9,219	3,669	86,779
DA	Food, drink & tobacco	6,475	432	763	188	7,859
DB+DC	Textiles & Leather	364	8	50	8	430
DD	Wood	1,455	81	288	12	1,835
DE	Paper & Publishing	3,349	184	147	18	3,697
DF	Fuel production	111	15	3	0	129
DG+DH	Chemicals, rubber & plastic	3,464	238	303	60	4,065
DI	Non-metallic minerals	2,211	122	79	36	2,449
DJ	Metals	3,002	591	86	80	3,758
DK-DM	Machinery & equipment	2,611	201	124	345	3,282
DN	Other manufacturing	582	41	10	25	657
E	Power & utilities	5,698	551	424	200	6,873
F	Construction	89,016	6,965	11,481	2,083	109,546
G-Q	Services	33,867	1,563	4,734	924	41,088
Total	**TOTAL**	**213,712**	**23,786**	**27,925**	**7,691**	**273,113**

Source: Defra submission to Eurostat

C&I Waste Arisings 2009

In 2010 Defra commissioned a survey to provide up-to-date estimates of C&I waste arisings and management to inform national policy, enable baselines to be established and improve the evidence base. Final results of this survey were published for England in December 2010; using 2009 as the reference year. Table 80 presents the estimates for C&I waste arisings for England for the sectors included in the survey. Total waste arisings for England amounted to 48.0Mt.

Table 80: C&I waste arisings for England, 2009 (Mt)

Sector	Waste Arising
Food, drink & tobacco	4.8
Textiles / wood / paper / publishing	3.5
Power & utilities	5.7
Chemicals / non-metallic minerals	3.8
Metal manufacturing	4.2
Machinery & equipment (other)	2.2
Subtotal – Industrial	***24.2***
Retail & wholesale	9.2
Hotels & catering	2.7
Public administration & social work	2.9
Education	1.5
Transport & storage	2.3
Other services	5.2
Subtotal – Commercial	***23.8***
TOTAL	**48.0**

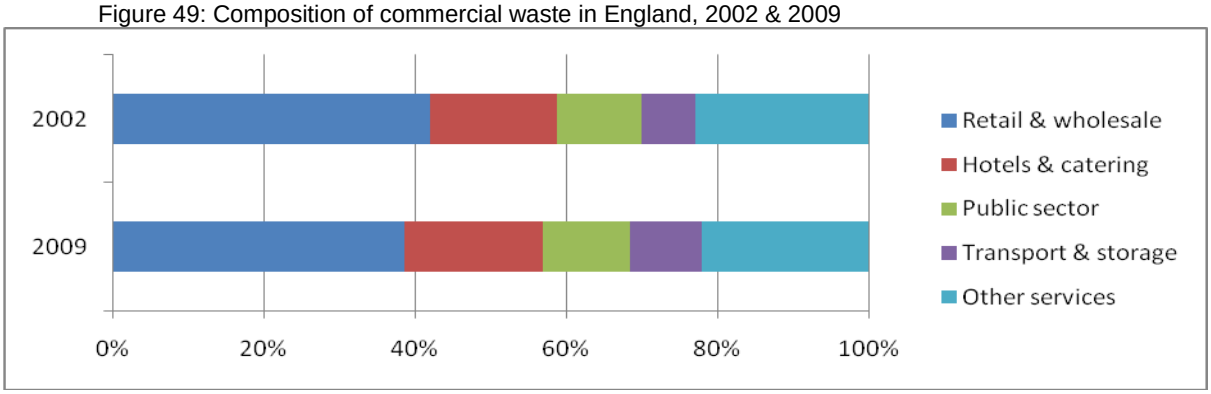
Source: Jacobs for Defra (2010), *Commercial and Industrial Waste Survey 2009, Final Report*

Service Sector Breakdown

In order to provide targeted recommendations regarding waste in the services sector, it is necessary to subdivide the waste estimates for services. This is because the 2006 C&I waste arisings data, which have been used as the baseline for this study, do not provide estimates for individual service sectors. The approach taken to disaggregate the 2006 data based upon the composition of commercial sector waste for 2002 and 2009 between each of the service sectors.

The changes in composition of commercial waste in England between the different service sectors can be seen in Figure 49, although the changes in composition between the two years are relatively minor. A decline in retail and wholesale waste as a share of commercial waste is apparent, with the shares associated with Hotels and catering and Transport and storage sectors increasing. As the base year, 2006, lies between these two survey years, an intermediate composition can be determined from averaging the compositions obtained for 2002 and 2009. This composition can then be applied to the 41.1Mt of commercial waste estimated for the UK in 2006.

Figure 49: Composition of commercial waste in England, 2002 & 2009



Sources: calculated from Defra & EA C&I Waste Datasets

Grossing-up to the UK

Two approaches are available to gross-up the England 2009 C&I waste data to the whole of the UK:

- Extrapolate the England data on the basis of England's share UK waste for each sector (derived from Table 79)
- Use the results of national C&I waste surveys from Scotland, Wales and Northern Ireland.

Both of these approaches are outlined below, although it is noted that the results obtained do not greatly differ.

Table 81 shows the results of the first approach, which obtained a UK total of 58.0Mt of C&I waste arising for the UK. England represented 83% of the overall total, although this proportion varied amongst the Industrial sectors. Table 82 shows the results of the second approach, which obtained a UK total of 60.7Mt of C&I waste arising for the UK. England represented 79% of the overall total.

Of the two approaches it was decided that the first approach, grossing-up based on England's share of UK waste was the preferred approach. The reasons behind this were:

- The different survey years used for the national C&I surveys (older survey years outside of England may explain the slightly higher estimate).
- A lack of detail on the commercial sector in the Northern Ireland survey
- A lack of robustness in the Northern Ireland: 94% of the industrial waste was in the power was in the Power and utilities sector, there were marked changes in waste arisings in the 2008 survey versus 2006 and a large tonnage of waste, 1.1Mt was listed under waste treatment and disposal (not included in or in 2006)

Table 81: Grossing-up to the UK based on England's share of UK waste (Mt)

Sector	England 09	% of UK in 2006	UK 09
Food, drink & tobacco	4.8	82%	5.8
Textiles / wood / paper / publishing	3.5	87%	4.0
Power & utilities	5.7	83%	6.9
Chemicals / non-metallic minerals	3.8	87%	4.4
Metal manufacturing	4.2	80%	5.3
Machinery & equipment (other)	2.2	81%	2.7
Subtotal – Industrial	***24.2***	***83%***	***29.0***
Retail & wholesale	9.2	82%	11.2
Hotels & catering	2.7	82%	3.3
Public sector	4.4	82%	5.3
Transport & storage	2.3	82%	2.7
Other services	5.2	82%	6.4
Subtotal – Commercial	***23.8***	***83%***	***28.9***
TOTAL	**48.0**	**83%**	**58.0**

Sources: calculated from Defra C&I Waste Datasets

Table 82: Grossing-up using National Surveys (Mt)

Sector	England 2009	Scotland 2008	Wales 2007	Northern Ireland 2008	UK Total
Food, drink & tobacco	4.76	0.50	0.48	0.01	5.74
Textiles / wood / paper / publishing	3.45	0.44	0.18	0.01	4.08
Power & utilities	5.72	0.54	0.42	0.89	7.57
Chemicals / non-metallic minerals	3.85	0.40	0.19	0.02	4.47
Metal manufacturing	4.24	0.10	0.39	0.00	4.73
Machinery & equipment	2.16	0.14	0.24	0.01	2.55
Industrial Sub-total	***24.17***	***2.13***	***1.90***	***0.94***	***29.14***
Commercial Sub-total	***23.84***	***5.60***	***1.68***	***0.40***	***31.53***
Total	**48.02**	**7.73**	**3.57**	**1.35**	**60.67**

Sources: calculated from Defra, SEPA, Urban Mines for EAW, Capita Symonds for NIEA C&I Waste Datasets

Trends in UK C&I Waste

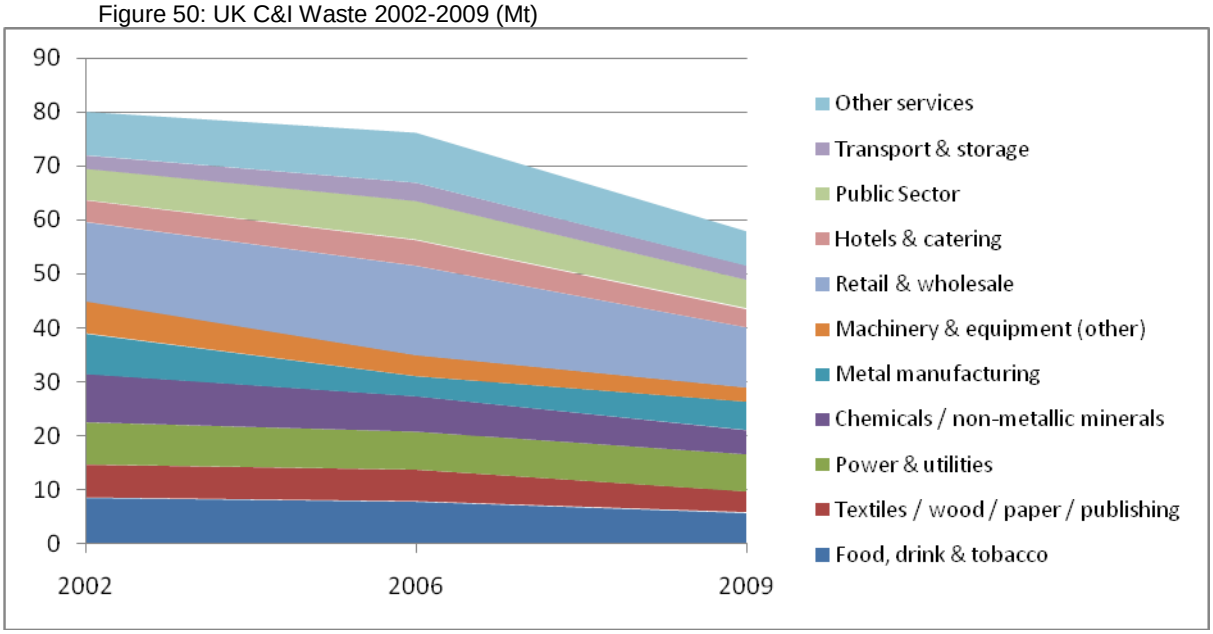
UK C&I waste arisings estimates for 2002, 2006 and 2009 are shown in Table 83 and graphically in Figure 50. The overall trend for C&I waste arising is a falling one; down 28% between 2002 and 2009. The fall in waste arisings in the Industrial sector over the period is 35% and for the Commercial sector waste has fallen by 17% (rising between 2002 and 2006 but falling by 30% between 2006 and 2009). These data have been used to determine the performance in waste reduction for the different sectors.

Table 83: UK C&I Waste 2002-2009 (Mt)

Sector	2002	2006	2009	% change 2002-09	% change 2002-06	% change 2006-09
Food, drink & tobacco	8.6	7.9	5.8	-33%	-8%	-27%
Textiles / wood / paper / publishing	6.2	6.0	4.0	-36%	-4%	-33%
Power & utilities	8.9	6.5	4.4	-51%	-27%	-32%
Chemicals / non-metallic minerals	7.8	7.0	6.9	-11%	-10%	-2%
Metal manufacturing	7.5	3.8	5.3	-29%	-50%	41%
Machinery & equipment (other)	6.0	3.9	2.7	-56%	-35%	-32%
Subtotal – Industrial	***45.0***	***35.0***	***29.0***	***-35%***	***-22%***	***-17%***
Retail & wholesale	14.7	16.6	11.2	-24%	13%	-33%
Hotels & catering	4.0	4.7	3.3	-16%	18%	-29%
Public sector	5.9	7.2	5.3	-9%	23%	-26%
Transport & storage	2.5	3.4	2.7	11%	37%	-19%
Other services	8.0	9.2	6.4	-20%	15%	-31%
Subtotal – Commercial	***35.0***	***41.1***	***28.9***	***-17%***	***18%***	***-30%***
TOTAL	**80.0**	**76.1**	**58.0**	**-28%**	**-5%**	**-24%**

Sources: calculated from Defra & EA C&I Waste Datasets

Figure 50: UK C&I Waste 2002-2009 (Mt)



Sources: calculated from Defra & EA C&I Waste Datasets

C&I Waste to Landfill

The data used to determine C&I landfill volumes are outlined in this section. The main data source used is from the EA on landfill returns, which provides data on total landfill volumes, as well as the share that is inert / C&D (which can be taken as mining and C&D landfill waste). WasteDataFlow provides data on municipal landfill, so by subtraction the remaining waste landfill is non-municipal, inert waste, which provides a proxy for C&I Waste. This methodology is that used by Defra in the Environment in Your Pocket Publication[137].

Table 84 presents these data for England for 2006-2009. Overall landfill volumes are shown to have fallen by 32%. Within this, landfill volumes for C&I waste have fallen by 25%; and landfill volumes for construction and mining waste have fallen by 11%.

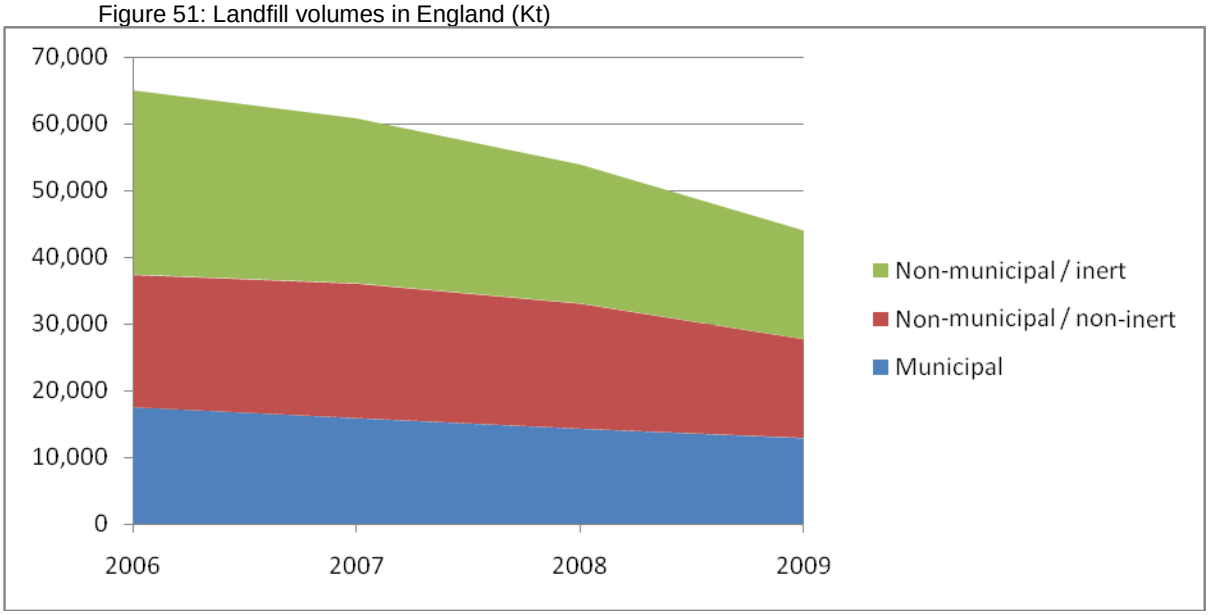
Table 84: Landfill volumes in England (Kt)

Year	Municipal	Non-municipal / non-inert (C&I)	Inert / C&D	Total Landfill
2006	17,462	19,927	27,548	**64,937**
2007	15,819	20,263	24,657	**60,738**
2008	14,224	18,828	20,786	**53,838**
2009	12,820	14,881	16,262	**43,964**
% change 06-09	-27%	-25%	-41%	**-32%**
Source:	WasteDataFlow	Own calculation	EA landfill returns	EA landfill returns

[137] Defra (2009), *The environment in your pocket 2009*

These data can be extrapolated to the whole of the UK, using the same approach as above – i.e. on the basis of England's share UK waste for each sector (76% for construction and mining waste; and 83% for C&I waste). The assumption implicit in this of course is that the proportion of waste sent to landfill in Scotland, Wales and Northern Ireland collectively mirrors that in England. The indications are that it may underestimate UK landfill volumes. For 2006, the percentage C&I waste to landfill for England implied by Table 79 and is 31.5%. The Welsh C&I survey reports a landfill percentage of 39% for C&I waste[138]. SEPA does not publish comparable data; and the NIEA data, as discussed, lack the robustness to enable a similar calculation.

Figure 51: Landfill volumes in England (Kt)



Sources: calculated from Defra, EA Landfill Datasets

With these caveats in mind, the estimated landfill volumes for the UK are shown in Figure 51. C&I waste to landfill is estimated to have fallen in the UK by 6.1Mt between 2006 and 2009; and by 14.8 Mt for construction and mining waste. By combining the C&I landfill volumes in with C&I waste arisings in Table 85, it can be shown that the fraction of C&I waste being sent to landfill has fallen over the period, from 31.5% in 2006 to 30.9% in 2009.

Table 85: C&I and construction landfill volumes in the UK (Kt)

Year	C&I	Construction & Mining	Total
2006	24,006	36,013	**60,019**
2009	17,928	21,259	**39,187**
Change 06-09	-6,078	-14,754	**-20,832**

Sources: calculated from Defra, EA Landfill Datasets

[138] Urban Mines for EAW (2009), Survey of Industrial & Commercial Waste Arisings in Wales

Annex G: Valuation of waste opportunities

This annex outlines the prices that were used to quantify the waste reduction opportunities. For the Power and utilities sector, this is a matter of taking the value that were used in the previous study for 2006 and applying the relevant producer price index input inflation between 2006 and 2009 (Table 86).

Table 86: Valuations of waste reduction used in 2006 study updated for inflation

Sector	Savings £/t (2006)	Savings £/t (2009)	PPI Input Inflation: 06-09
Power & utilities	20	22	11.9%

Sources: previous Defra study for 2006, ONS PPI Data

For the Metals sector, the previous Defra study for 2006 did not identify waste reduction opportunities, and hence no valuation was made. However because in 2009 the Metals sector had increases in their waste arising relative to their GVA, it is necessary to value these new opportunities. The approach taken is to apply the export value of the main input products to the sectors from UK Trade export data[139]. Table 87 exemplifies the approach for another sector, Food and drink manufacturing, where both sets of data are available. It is noted that the value of £628 per tonne is very similar to the £617 per tonne that is obtained by applying the producer price inflation for the sector, which helps provide assurance in the validity of this methodology. The results for the Metals sector are found in Table 88 (a basket of exports of metal ores, concentrates, unwrought, waste and scrap metals) which gives an average value of these commodities is £420 per tonne. Given the variation in value it is worth noting that this may overvalue waste from the industry as it could be assumed that businesses would make an effort to minimise the most valuable scrap.

Table 87: UK exports in agricultural products (2009)

Comcode(s)	Description	£000's	Kt	£/tonne
02	Meat & edible meat offal	1,029,001	625.3	1,646
03	Fish & crustaceans, molluscs & other aquatic invertebrates	1,057,138	453.0	2,334
04	Dairy produce; birds' eggs; natural honey; edible products of animal origin	784,488	859.3	913
05	Other products of animal origin	68,054	94.5	720
07	Edible vegetables & certain roots & tubers	298,693	816.9	366
08	Edible fruit & nuts; peel of citrus fruits or melons	146,079	174.8	836
09	Coffee, tea, mate & spices	278,170	48.2	5,767
10	Cereals	460,229	3,487.6	132
	TOTAL/AVERAGE	**4,121,851**	**6,560**	**628**

Source: HMRC, UK Trade Info

[139] The assumption implicit in this is that the composition of production and exports are comparable

Table 88: UK exports in ores, unwrought and waste and scrap metals (2009)

Comcode(s)	Description	£000's	Kt	£/tonne
2601-2617	Ores & concentrates	17,091	84.2	203
7112	Waste & scrap of precious metal or of metal clad with precious metal	107,045	12.5	8,550
7201	Pig iron & spiegeleisen, in pigs, blocks or other primary forms	5,052	27.3	185
7204	Ferrous waste & scrap; remelting scrap ingots of iron or steel	1,184,791	6,006.7	197
7206	Iron & non-alloy steel in ingots or other primary forms	8,354	45.0	186
7207	Semi-finished products of iron or non-alloy steel	632,904	1,858.3	341
7401-7404	Copper, unrefined, unwrought or waste & scrap	763,273	451.2	1,691
7501-7503	Nickel, unwrought or waste & scrap	249,857	33.0	7,572
7601-7602	Aluminium, unwrought or waste & scrap	718,591	741.7	969
7801-7802	Lead, unwrought or waste & scrap	242,724	212.0	1,145
7901-7902	Zinc, unwrought or waste & scrap	23,881	21.8	1,097
8001-8002	Tin, unwrought or waste & scrap	40,228	23.9	1,686
TOTAL/AVERAGE		**3,993,793**	**9,518**	**420**

Source: HMRC, UK Trade Info

Annex H: Analysis of water efficiency initiatives

Examples of sector specific water efficiency initiatives

Public administration

The most significant sub-sector within public administration in terms of water consumption is the Ministry of Defence (MOD), accounting for 24.2 M m^3 of the annual consumption of water by the public administration sector. The MOD has set itself a target to reduce water consumption by 25% on the office and non-office estate by 2020, relative to 2004/05 levels. In the 2008/9 MOD *Annual report and accounts (Volume 1)* it is reported that they had already reduced their water use by 26% relative to 2004/05; an annual water reduction of 7%. This was achieved mainly through leakage reduction. In addition, water audits have been undertaken at 13 sites and water conservation devices have been installed resulting in water saving of 88,000 m3 in 2008/09.

The 7% annual reduction is much higher than that of the 1.8% attributed above to all sectors. However, the 7% includes capital interventions as well as no cost / low cost interventions and the 2008/09 Annual report implies that a significant proportion of the savings have been through capital investment, namely:

"*Much of the MOD's water infrastructure, dating from the 1930/40s, is reaching the end of its life. Private sector expertise and capital are being utilised to manage the majority of our assets (approximately 4,200 sites) through a twenty-five year water and wastewater Public Private Partnership Project, Aquatrine*".

Food and Drink

The Food and Drink Federation (FDF) manages the Federation House Commitment (FHC), an initiative set up to reduce the total water used by its members (excluding embedded water in products) by 20% by 2020, using a 2007 baseline.

The first FHC progress report: 2009 showed that signatories had reduced their water consumption from 28.0 M m^3 in 2007 to 27.5 M m^3 in 2008; a reduction of 1.7%. This can be seen to be perfectly aligned to that of the estimated annual water savings from non-public water abstraction. However, it is noted that the companies that have signed up to the FHC are likely to be representative of the better performing or forward thinking companies and hence savings made by non participants is likely to be lower.

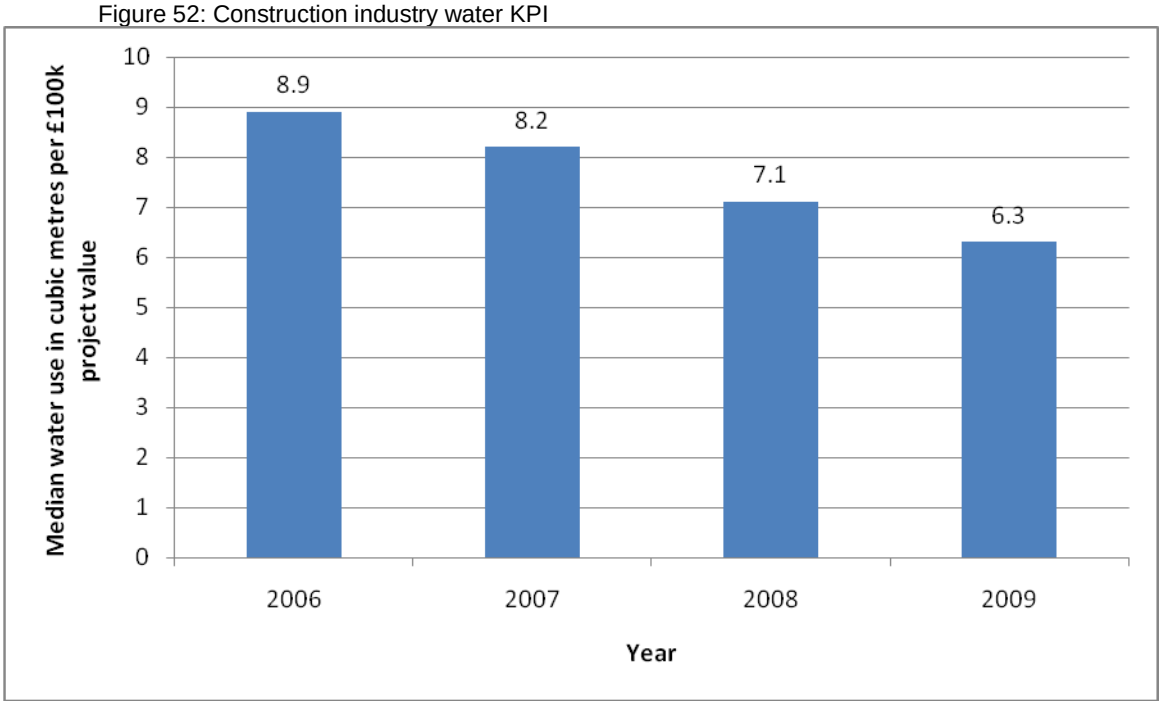
Chemicals

The UK's Chemical Industries Association (CIA) stated in 2006 that its members consumed some 300 M m^3 per year of water. The CIA has targeted a 20% reduction in water usage per tonne of production from 2000 to 2010 (an annual reduction of 2.2%). As of 2006 there had been a 13.5% decrease or an annual reduction of 2.4%. Therefore to deliver their 20% reduction commitment required an annual reduction in water consumption between 2006 and 2010 of 2%, just above the 1.8% a year assumed above.

Construction

Key Performance Indicators are produced for the construction industry by the DBIS and Construction Excellence. Figure 52 shows that between 2006 and 2009 water use reduced by 29% equating to an annual reduction of 11%. This is significantly higher than the 1.9% used above.

Figure 52: Construction industry water KPI



Source: The Construction Statistics Annual (2010)

Annex I: The supply side strategies and assumptions (WRAP study)

Resource Efficiency Strategy	Scenarios		
	Quick Win	**Best Practice**	**Beyond Best Practice**
Lean production	Material requirement to produce the same good is 15% less in 2020	By 2050, the material requirement is reduced by 50%	By 2050 the material requirement is reduced by 75%
Material substitution	10% of carbon-intensive materials used to make goods are replaced with the least carbon-intensive material by 2020	This increases to 20% by 2030	Further efforts are made to reduce this to 40% by 2050
Waste reduction	15% of the raw materials from industry and commerce ending up in the waste stream are taken out of the economy by 2020	This increases to 50% by 2050	Except for 10% unavoidable waste, there is no additional industrial and commercial waste in the economy by 2050
Re-direction of landfill materials	15% of the raw materials from industry and commerce ending up in landfill are recycled and put back into production by 2020	This increases to 50% by 2050	Accounting for 10% unavoidable waste, all waste destined for landfill is recycled by 2050
Dematerialisation of the service sectors	A third of discard rate is reduced for the different product groups, edible food is halved and junk mail is eradicated by 2020	By 2050, 90% of goods reach technological obsolescence and edible food waste is eliminated	The goals of the best practice scenario are achieved earlier, by 2030
Strategies for sustainable building	2% of the construction market is met by modular building design by 2020	5% of the construction market is met by modular building design by 2050	10% of the construction market is met by modular building design by 2050
Efficient use of existing infrastructure	Retrofitting 20% of housing deemed for demolition and vacant properties offsets the need for rebuilding by 2020	This continues to 50% by 2030	By 2050, we assume that 90% of these properties are brought back into use, reducing the need for new builds

Annex J: WRAP study projections

Table 89: Savings opportunity ($KtCO_2$) by sub-sector

Sector	Savings opportunity ($KtCO_2$)							
	2015	2020	2025	2030	2035	2040	2045	2050
Agriculture	274.4	466.0	553.7	617.9	649.8	642.0	696.1	716.3
Forestry	4.5	7.5	11.2	14.7	19.3	22.7	28.1	33.9
Fishing	1.6	3.5	4.1	4.6	4.7	4.5	4.6	4.2
Mining of coal	26.5	48.1	61.3	80.6	96.9	122.8	156.8	192.0
Oil and gas extraction	71.8	135.2	185.5	224.8	255.4	265.3	267.5	234.3
Mining of metal ores	-	-	-	-	-	-	-	-
Other mining	39.6	76.0	89.3	96.3	99.6	91.4	80.8	67.6
Meat products	73.9	122.0	166.4	204.3	223.1	214.6	255.3	259.5
Fish, fruit and vegetable products	11.0	22.7	24.9	26.7	27.5	27.7	31.0	34.8
Oils and fats	7.6	12.6	15.8	17.9	19.8	17.9	18.7	20.6
Dairy products	10.9	27.0	31.2	37.7	45.2	47.4	53.7	50.7
Grain and starch	10.4	16.9	22.4	27.5	27.9	27.7	34.3	35.2
Animal feeds	11.9	25.2	28.6	34.8	39.2	37.3	40.7	54.6
Bread and biscuits	10.6	17.6	27.9	28.7	20.8	19.8	19.5	15.6
Sugar	4.3	6.5	9.4	10.3	11.1	12.2	13.5	15.2
Chocolate	9.9	15.1	22.7	25.2	23.2	23.6	20.4	20.9
Other food products	18.0	30.8	44.9	51.6	58.0	63.6	73.3	78.7
Alcohol	0.6	1.0	1.2	1.2	1.2	1.1	1.0	0.7
Soft drinks	0.3	0.6	0.8	0.9	1.0	1.1	1.3	1.3
Tobacco	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Preparation of textiles	1.0	3.3	6.4	8.4	9.1	13.4	16.8	23.1
Textile weaving	3.0	7.7	10.3	17.4	24.1	30.7	43.5	57.8
Finishing of textiles	3.1	4.2	6.8	15.9	15.7	23.1	32.2	40.6
Textile articles	1.5	2.3	2.2	3.6	4.0	3.3	4.4	4.1
Carpets and rugs	8.0	12.4	14.5	25.6	21.2	25.0	23.9	31.9
Other textiles	1.4	3.4	5.0	7.1	9.7	12.9	17.6	22.8
Knitted products	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Clothes	0.6	1.0	1.4	1.9	2.1	2.2	2.3	2.4
Leather and luggage	0.2	0.4	0.7	1.0	1.3	1.6	2.2	2.8
Footwear	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.4
Wood products	492.9	811.1	1,079.7	1,393.3	1,638.2	1,823.6	2,146.1	2,416.7
Pulp and paper	97.4	203.4	239.6	282.2	304.3	312.1	366.8	363.0
Paper products	37.5	88.0	155.5	247.3	358.4	508.7	712.5	952.0
Recorded media	8.5	18.0	29.5	37.6	45.2	57.3	72.9	92.6
Coke, petroleum and nuclear fuel	113.1	178.2	235.1	271.6	311.3	309.1	297.4	259.6
Industrial gases	13.2	25.7	33.6	39.7	46.8	55.6	67.1	76.6

Sector	Savings opportunity ($KtCO_2$)							
	2015	2020	2025	2030	2035	2040	2045	2050
Other inorganic based chemicals	51.4	114.5	162.1	222.6	292.6	365.6	474.9	599.2
Other organic based chemicals	37.1	81.3	112.7	142.0	165.4	178.0	187.1	164.0
Fertilisers	24.4	30.5	35.8	35.3	32.4	30.3	29.1	25.0
Plastics	73.7	131.2	159.9	190.8	207.6	239.7	263.0	288.1
Pesticides	0.4	0.4	0.5	0.7	0.6	0.9	0.9	1.1
Paints and varnishes	4.7	6.5	6.5	6.6	6.1	5.1	4.3	3.3
Pharmaceuticals	0.4	0.7	1.0	1.4	1.8	2.3	3.1	4.0
Soaps	2.3	5.0	8.1	10.3	15.8	20.5	25.5	32.9
Other chemical products	0.5	0.6	0.8	0.8	0.7	0.7	0.6	0.5
Man-made fibres	1.5	2.5	3.0	3.4	3.8	4.3	4.6	5.0
Rubber products	18.3	31.5	38.0	43.1	49.1	52.1	55.5	59.1
Plastic products	201.4	376.1	454.9	528.8	532.8	519.2	462.4	374.5
Glass products	195.5	319.9	410.1	438.3	459.1	436.6	429.0	359.4
Ceramic goods	14.6	13.1	12.9	12.9	13.1	12.8	11.8	12.2
Construction products	128.7	212.1	189.4	177.7	146.6	141.9	104.7	66.0
Cement and plaster	2,045.3	2,985.3	3,380.0	3,808.7	3,994.2	4,087.8	4,601.4	4,758.9
Articles of cement, plaster etc.	94.3	225.4	221.0	193.8	178.8	148.3	145.1	129.1
Iron and steel	1,611.6	2,741.2	3,790.0	4,850.7	5,451.0	6,214.9	6,950.4	7,700.0
Precious and non-ferrous metals	106.3	167.5	227.1	262.3	311.4	307.5	313.3	261.7
Casting of metals	9.0	28.4	34.6	37.8	54.1	56.6	70.6	106.9
Structural metal products	41.9	74.1	96.9	108.9	115.9	124.1	127.3	129.4
Metal containers, manufacture of boilers…	2.1	5.3	3.7	2.7	2.3	1.9	3.6	1.8
Treatment of metals (e.g. forging)	6.1	9.3	10.3	10.2	10.3	10.1	10.1	9.8
Cutlery, tools and general hardware	1.7	2.7	3.2	3.5	3.8	3.8	3.9	3.9
Other fabricated metal products	4.1	4.6	5.2	4.7	4.8	4.5	4.8	4.7
Machinery for mechanical power	0.7	1.2	1.1	1.0	1.1	1.1	1.1	1.1
Other general purpose machinery	4.5	6.0	7.0	6.6	7.0	8.4	8.0	8.7
Agricultural and forestry machinery	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3
Machine tools	0.4	0.7	0.8	0.9	1.0	1.0	1.1	1.1
Other special purpose machinery	2.0	3.2	4.0	4.6	5.0	5.4	5.6	5.8
Weapons	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.3
Domestic appliances n.e.c.	1.6	2.4	3.0	3.4	3.5	3.6	3.5	3.4
Office machinery and computers	0.3	0.6	0.9	1.2	1.4	1.8	2.1	2.5
Electric motors, generators; manufacture of electricity distribution	3.5	5.2	6.4	3.7	3.9	2.3	1.7	0.9
Insulated wire and cable	1.1	2.1	2.1	1.5	1.8	1.0	1.1	0.6
Electrical equipment n.e.c.	4.9	7.1	8.9	10.9	10.7	9.5	9.2	7.2
Electric valves	0.6	0.9	1.2	1.4	1.4	1.5	1.5	1.6
Television and radio transmitters	1.3	2.4	3.4	4.4	4.8	5.0	5.5	5.8
Television and radio receivers	1.0	2.4	3.6	4.9	5.5	6.1	6.8	7.3
Medical instruments and clocks	0.9	1.1	1.4	1.6	1.7	1.7	1.6	1.4

Sector	Savings opportunity ($KtCO_2$)							
	2015	2020	2025	2030	2035	2040	2045	2050
Motor vehicles	0.6	1.0	1.1	1.2	1.2	1.1	1.0	0.8
Building and repairing of ships	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Other transport equipment	0.4	0.6	0.9	1.1	1.3	1.3	1.3	1.2
Aircraft and spacecraft	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Furniture	3.4	4.3	4.6	4.1	3.8	3.4	3.5	3.4
Jewellery	0.7	1.1	1.5	1.5	1.8	2.2	2.2	2.6
Sports and games	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Manufacturing n.e.c. and recycling	14.7	27.3	37.1	50.9	59.5	64.1	63.3	58.4
Electricity production and distribution	1,018.5	1,832.6	2,383.4	2,850.3	3,310.5	3,756.5	4,384.6	4,954.7
Gas, steam and hot water supply	61.8	127.6	168.3	204.4	226.8	234.9	240.3	209.1
Water	7.8	19.3	32.6	50.4	71.6	98.8	137.9	186.7
Construction	901.0	1,445.9	1,906.8	2,079.0	2,239.9	2,104.9	2,048.9	1,639.3
Sale, maintenance and repair of motor vehicles	10.8	19.6	27.0	31.4	35.1	34.5	34.8	28.9
Wholesale trade	36.4	62.4	76.4	82.8	84.9	79.6	74.9	60.0
Retail trade	0.4	0.9	1.6	2.3	3.4	4.8	6.8	9.3
Hotels and restaurants	1.8	3.3	4.7	5.6	6.5	6.6	6.8	5.8
Railway transport	3.7	6.2	7.9	9.1	10.4	11.5	13.1	14.6
other land transport	251.5	484.3	565.4	616.3	658.6	659.8	723.2	733.4
Water transport	18.6	32.1	37.5	40.8	43.4	45.9	48.7	51.9
Air transport	88.0	166.4	234.1	289.2	352.0	407.7	482.3	547.4
Auxillary transport services	3.9	7.1	9.3	10.8	11.7	11.5	11.4	9.5
Post and courier	2.4	4.4	5.6	6.1	6.5	6.1	6.0	4.9
Telecommunications	3.7	6.4	8.1	8.9	9.3	8.9	8.4	6.8
Financial intermediation	0.9	1.5	1.8	1.9	1.9	1.8	1.7	1.4
Insurance and pensions	1.2	2.3	3.0	3.6	3.9	3.9	3.8	3.2
Auxillary services to financial intermediation	0.4	0.7	0.8	0.9	1.0	0.9	0.8	0.7
Real estate (with own property)	2.9	4.5	5.5	5.8	5.7	5.1	4.6	3.5
Letting	-	-	-	-	-	-	-	-
Real estate (fee or contract basis)	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Renting of machinery, equipment and household goods	35.0	61.5	86.3	101.0	116.9	125.7	137.5	141.8
Computer and related activities	2.0	3.9	5.8	7.2	8.6	9.0	9.6	8.4
Research and development	0.4	0.6	0.7	0.8	0.8	0.8	0.8	0.8
Legal activities	1.6	2.8	3.8	4.4	4.9	4.8	4.9	4.1
Accounting	0.9	1.5	1.9	2.0	2.1	1.9	1.8	1.4
Market research; consultancy services	3.2	5.7	8.0	9.5	10.7	10.7	11.0	9.3
Architectural and engineering services	4.7	8.1	10.9	12.4	13.7	13.3	13.3	11.0
Advertising	1.9	3.4	4.4	5.0	5.3	5.2	5.1	4.2
Other business services	6.8	12.8	18.3	22.0	25.4	26.0	27.0	23.2

Sector	Savings opportunity ($KtCO_2$)							
	2015	2020	2025	2030	2035	2040	2045	2050
Public admin and defence	6.5	11.9	16.7	19.7	22.2	22.2	22.6	19.0
Education	2.3	4.3	5.9	7.0	7.9	8.2	8.4	7.2
Health	0.6	0.9	1.1	1.2	1.2	1.1	1.0	0.8
Social work	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Sewage and refuse disposal	593.3	1,390.2	2,145.9	2,994.9	3,532.6	4,502.1	4,704.7	4,589.9
Activities of membership orgs.	0.5	0.9	1.2	1.5	1.7	1.7	1.8	1.5
Recreation and culture	1.2	2.3	3.3	4.0	4.6	4.8	5.0	4.4
Other service activities	1.4	2.8	4.3	5.5	7.0	8.3	9.6	10.9
Private households with employed persons	-	-	0.0	0.0	0.0	0.0	0.0	-
Total	9,167.8	15,774.0	20,377.5	24,559.9	27,435.1	30,141.6	33,214.1	34,707.1

Table 90: Carbon savings available for Quick Wins to 2020 by intervention (Kt CO_2)

Sector	**Lean Prod.**	**Mat. Sub.**	**Waste Red.**	**Recy-cling**	**Demat.**	**Build-ings**	**Infra-struct.**	**Total**
Agriculture, forestry & fishing	9	0	59	26	66	1	1	**161**
Mining & quarrying	56	0	14	6	2	7	6	**91**
Food, drink & tobacco	2	0	38	16	44	0	0	**100**
Textiles / wood / paper / publishing	289	34	47	13	4	13	5	**404**
Power & utilities	529	0	404	189	36	40	39	**1,237**
Chemicals / non-metallic minerals	834	356	187	68	5	47	73	**1,570**
Metal manufacturing	555	325	94	26	3	17	24	**1,043**
Machinery & equipment (other)	15	0	6	-5	5	2	1	**25**
Construction	447	0	0	0	0	31	31	**510**
Retail & wholesale	21	0	3	1	1	2	2	**29**
Hotels & catering	1	0	0	0	0	0	0	**1**
Public Sector	5	0	0	0	0	0	0	**6**
Transport & storage	166	0	30	11	12	13	15	**246**
Other Services	33	0	2	1	1	2	2	**41**
Total	**2,960**	**715**	**885**	**352**	**180**	**174**	**198**	**5,464**

Key for Intervention Abbreviations:

Lean Prod.	Lean Production	**Waste Red.**	Waste Reduction	**Demat.**	Dematerialisation of services	**Infra-struct.**	Use of existing infrastructure
Mat. Sub.	Material Substitution	**Recy-cling**	Waste Recycling	**Build-ings**	Sustainable buildings		

Table 91: Percentage saving to Reference GDP

Lean Prod.	Mat. Sub.	Waste Red.	Recycling	Demat.	Buildings	Infra-struct.	Total
0.89%	0.00%	0.09%	0.03%	0.04%	0.06%	0.06%	1.17%

Table 92: Financial savings available for Quick Wins to 2020 by intervention (£M)[140]

Sector	Lean Prod.	Mat. Sub.	Waste Red.	Recy-cling	Demat.	Build-ings	Infra-struct.	Total
Agriculture, forestry & fishing	36	0	84	31	206	4	2	**362**
Mining & quarrying	234	0	20	7	7	32	26	**325**
Food, drink & tobacco	8	0	54	19	136	1	1	**219**
Textiles / wood / paper / publishing	1,214	0	67	15	12	61	19	**1,388**
Power & utilities	2,222	0	574	225	112	192	164	**3,489**
Chemicals / non-metallic minerals	3,500	0	265	81	16	227	307	**4,396**
Metal manufacturing	2,329	0	133	31	8	80	101	**2,683**
Machinery & equipment (other)	65	0	8	-6	17	10	4	**98**
Construction	1,876	0	1	0	1	151	132	**2,161**
Retail & wholesale	87	0	4	1	5	7	7	**111**
Hotels & catering	4	0	0	0	0	0	0	**5**
Public Sector	19	0	1	0	1	2	1	**24**
Transport & storage	696	0	43	13	37	60	63	**912**
Other Services	138	0	2	1	2	11	10	**164**
Total	**12,429**	**0**	**1,257**	**419**	**559**	**838**	**838**	**16,339**

[140] The WRAP data did not attribute the financial savings between sectors, so this has been performed here on the basis of the relative weights of the carbon savings for each of the interventions.

Annex K: DECC analysis

Taken from the DECC study: Assessing the carbon dioxide emissions and cost effective carbon savings potential for organisations not covered by EU ETS, CCAs or CRC (CESA 0903). AEA Technology and Databuild. October 2010.

Sector	Total consump-tion	Covered under EU ETS		Covered under CCAs		Total consumption not covered by EU ETS or CCAs		Total consumption not covered by EU ETS, CCAs or CRC	
		GWh	% of total	GWh	% of total	GWh	% of total	GWh	% of total
Iron & steel	75,981	41,186	54	70,548	93	7,598	10	1,520	2
Non-ferrous metals	16,478	27,948	170	11,094	67	1,055	6	211	1
Mineral products	29,693	35,136	118	23,595	79	1,900	6	380	1
Chemicals	72,750	50,957	70	31,175	43	4,656	6	2,328	3
Mechanical engineering, etc	17,886	65	0	5,362	30	11,373	64	5,687	32
Electrical engineering, etc	11,464	70	1	851	7	10,458	91	5,229	46
Vehicles	15,972	2,910	18	4,369	27	9,392	59	2,818	18
Food, beverages, etc	44,638	19,581	44	38,305	86	2,857	6	857	2
Textiles, leather, etc	11,117	54	0	1,698	15	9,041	81	2,712	24
Paper, printing, etc	32,472	14,938	46	22,547	69	2,468	8	494	2
Other industries	94,652	2,301	2	3,570	4	66,256	70	29,743	31
Construction	5,937	-	-	-	-	5,937	100	3,562	60
Total Industry	**429,039**	**195,145**	**45**	**213,114**	**50**	**132,991**	**31**	**55,540**	**13**
Commercial offices	35,180	194	1	-	-	34,946	99	17,473	50
Communication & transport	15,635	778	5	-	-	14,701	94	7,351	47
Education	13,604	1,256	9	-	-	12,097	89	4,839	36
Government	70,285	1,217	2	-	-	68,824	98	17,712	25
Health	20,405	3,973	19	-	-	15,637	77	6,255	31
Hotels & catering	46,906	-	-	-	-	46,906	100	28,144	60
Other	10,443	-	-	-	-	10,443	100	5,222	50
Retail	82,086	-	-	107	0	81,957	100	22,756	28
Sports & leisure	10,443	-	-	-	-	10,443	100	5,222	50
Warehouses	11,727	-	-	-	-	10,870	93	5,435	46
Agriculture	13,746	425	3	2,792	20	9,952	72	6,967	51
Total Services	**330,460**	**7,843**	**2**	**2,899**	**1**	**316,778**	**96**	**127,374**	**39**
Total Industrial & Services	**759,499**	**202,988**	**27**	**216,013**	**28**	**449,769**	**59**	**182,914**	**24**

At first glance the % of covered under EU ETS for non-ferrous metals and for mineral products; both above 100%, may seem strange. However this is possible if emissions permits have been grandfathered based upon historical production, which will have fallen during the recession.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