THE **GREEN CONSTRUCTION BOARD**

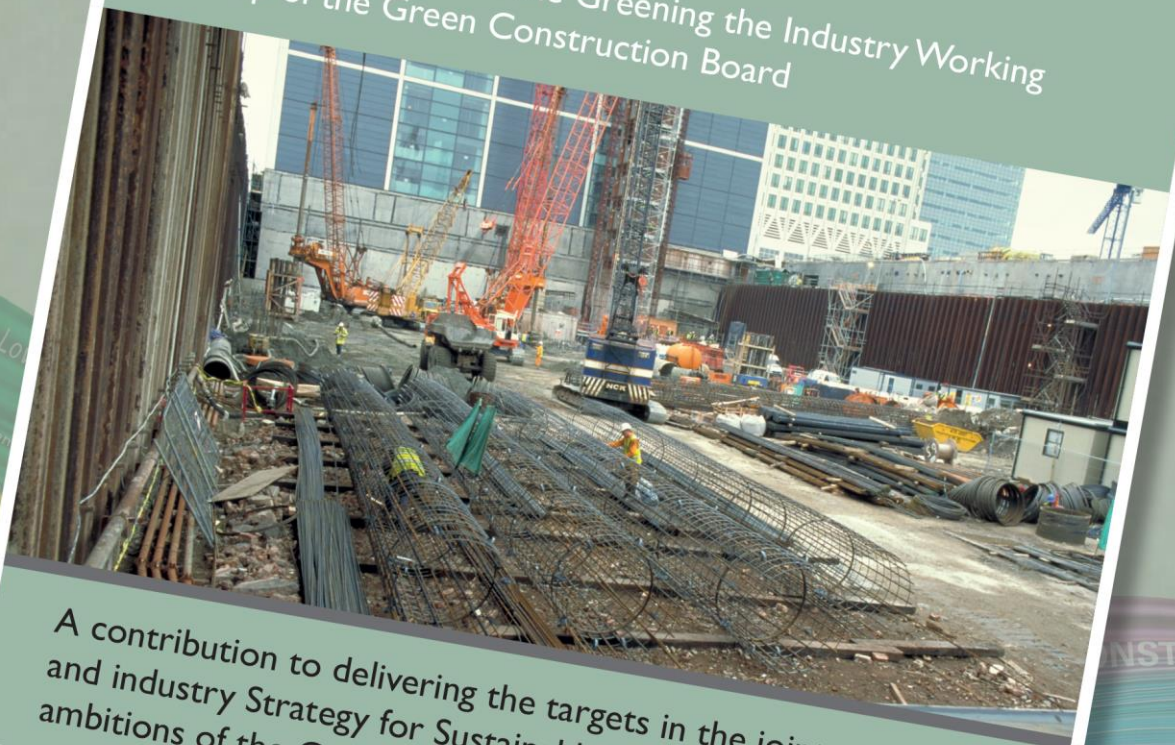
REPORT 024

CARBON:
Reducing the footprint of construction processes

2014

THE 2012 ASSESSMENT FIGURES AND PROJECT OVERVIEW

Prepared on behalf of the Greening the Industry Working Group of the Green Construction Board



A contribution to delivering the targets in the joint government and industry Strategy for Sustainable Construction and the ambitions of the Green Construction Board

wrap Working together for a world without waste

GREEN CONSTRUCTION BOARD

CARBON:
By 2012, a 15% reduction in carbon emissions from construction processes and associated transport compared to 2008

This report is the final waste focussed output in a series aimed at supporting the delivery of the targets within the Strategy for Sustainable Construction, a joint industry and government strategy published in June 2008, as well as the ambitions of the Green Construction Board.

More information about the strategy can be found at
http://webarchive.nationalarchives.gov.uk/+/www.bis.gov.uk/policies/business-sectors/construction/sustainableconstruction/strategy-for-sustainable-construction

This progress report was prepared by the Carbon Subgroup of the Green Construction Board's Greening the Industry Working Group (formerly a Subgroup of the Strategic Forum for Construction's (SFfC) Sustainable Construction Task Group (SCTG)).

www.strategicforum.org.uk
www.greenconstructionboard.org/

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Funding for the secretariat and preparation of this report was provided by WRAP (Waste & Resources Action Programme). Gareth Brown represented WRAP as project manager.

WRAP is backed by government funding and aims to help business and individuals to reap the benefit of reducing waste, develop sustainable products and use resources in an efficient way.
www.wrap.org.uk

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Contents

Executive Summary

Project background. In June 2008, the UK Government and the Strategic Forum for Construction (SFfC) jointly published the Strategy for Sustainable Construction. One of the many targets included was by 2012 to reduce the carbon emissions from construction processes (i.e. on site) and associated transport by 15% compared to 2008 levels. A subgroup made up of construction contractors was established to look at how to take this target forward. The subgroup was established under the Strategic Forum for Construction's Sustainable Construction Task Group (SCTG). Project funding was sought and initially came from the Carbon Trust; this provided the financial support to hire an expert secretariat to assist the Carbon Subgroup in its work. Arup won the contract to run the secretariat. The initial work of the Subgroup was to decide what the target meant, i.e. what was its scope to be. This led to the first output from the group – the decision that the target was to be applicable to England only and would apply to both absolute emissions (tonnes CO_2e/annum) and emissions relative to contractor's output (tonnes CO_2e/£ million/annum). The agreed scope of the target included coverage of the transport, enabling works, assembly, office activities, installation and disassembly activities necessary for delivery of construction services.

This project was not about reducing carbon during other aspects of the construction life cycle – i.e. design, manufacturing, operational or at end of life. These other aspects of reducing carbon are the aim of other policies, regulations and activities such as Part L of Building Regulations, the Carbon Reduction Commitment, Zero Carbon Homes, the Code for Sustainable Homes, the Emissions Trading System, the Climate Change levy etc.

This paper presents the results of the carbon assessment for 2012, a recalculated baseline for 2008 and a commentary on the progress the project made over the five year period. The project has now concluded.

The recalculated 2008 baseline for England is 5,568,000 tonnes CO_2e, which is 10.3% greater than reported in the 'Baseline carbon assessment for 2008' paper. The baseline was recalculated to account for updated greenhouse gas emission factors published by Defra/DECC for road freight, updated data on 2008 construction output and changes from CO_2 to CO_2e.

The 2012 result for England was 5,222,000 tonnes CO_2e, a **6% reduction** from 2008. However, this is less than the reduction in contractors' output[1] which fell by 9% for the same period. In broad terms therefore, this means that the carbon efficiency (emissions per £ spend) of construction activity has **increased by 2%** between 2008 and 2012. Table ES1 summarises the changes for each construction process covered by the scope of this assessment. The 2012 target would be considered met if both absolute emissions (tonnes CO_2e/annum) and emissions relative to contractors' output (tonnes CO_2e/£ million/annum) had reduced by at least 15%. Therefore, the target, based on the data provided, has not been met.

[1] Contractors' output is defined in the ONS *Construction Statistics Annual* as output by contractors, including estimates of unrecorded output by small firms and self-employed workers, classified to construction (Division 45) in the 2003 revised Standard Industrial Classification. For further detail please refer to the Construction carbon 15% target by 2012 – data and methodology paper (http://www.strategicforum.org.uk/carbon.shtml).

Table ES1: Emissions per construction process for England in 2008 and 2012 with likely cause of any change

Construction process	Emissions (tCO_2e)		Change from 2008	Likely reasons for % change in figures
	2008	2012		
On-site construction	1,944,000	2,191,000	13%	Mostly due to increase in emissions for refurbishment and maintenance and new infrastructure projects. Very dependent on quality of data received from construction companies, which was poor in 2012.
Freight transport	1,738,000	1,439,000	-17%	Due to a 19% reduction in road freight transportation (tonne km) between 2008 and 2012 and updated emission factors published by Defra/DECC.
Waste removal	542,000	537,000	-1%	Although CD&E waste transported to waste facilities increased by 3% between 2008 and 2012, transport emission factors were lower.
Off-site assembly	246,000	212,000	-14%	Likely to be due to a combination of a lack of data in 2012 and a reduction in the construction output, rather than a reflection of changes in operation since 2008.
Corporate office	265,000	281,000	6%	Due to a large increase in site emissions. Office emissions are calculated as a ratio of office to site emissions, therefore are affected by the increases in site emissions.
Business travel	834,000	562,000	-33%	Due to a reduction in the transport to site emissions ratio, a bigger data sample in 2012 and ongoing progress towards more efficient vehicles and efficient driving behaviour.
TOTAL	**5,568,000**	**5,222,000**	**-6%**	
Emissions (tCO_2e) per 2005 £ million contractor output	**58**	**59**	**2%**	

The number of data points available for each element of the assessment has changed between 2008 and 2012.

There are a number of sources of uncertainty in the baseline assessment and subsequent annual assessments and this paper provides a summary of: the main data quality issues, their likely effect on the baseline and subsequent assessments, the level of uncertainty and recommended options for future assessments.

A key issue is the lack of data available from individual companies, specifically for individual projects. Although there has been an improvement in corporate reporting in terms of emissions from offices and business travel since the 2008 baseline assessment, reporting for individual projects does not seem to have improved. In order to ensure the assessment provides an accurate representation of the construction sector there needs to be a

representative sample of emissions from a range of projects. Both the amount and quality of data received has decreased since 2008 creating a potential source of error in the progress over the five year period.

Although the assessment indicates that the 15% reduction target was not achieved, on the positive side much has been put in place to facilitate future progress. When the journey to identify what needed to be done began in 2008, with the industry setting itself a target of trying to reduce carbon emissions from construction processes on site by 15% by 2012, nothing existed. There was no methodology to measure emissions in such a scope, there was no data gathering from companies, there was no baseline from which to measure progress, it was unknown where the carbon emissions were greatest, there was no action plan of what to do and no specific guidance available. All that has now changed. Through the hard work, usually above and beyond the requirements of their jobs, many people across the industry have collaborated and worked together to better understand the challenge they were facing to deliver this target and to initiate necessary actions.

We now have in place an established methodology for measuring carbon emissions on construction sites, we have defined the scope of what we mean by the construction phase, we have a 2008 baseline both absolute and relative to annual construction output, we have an action plan published in 2010 identifying the key areas where carbon might be able to be reduced, and we have published a number of practical guidance posters for use on construction sites. In that famous phrase – If you cannot measure it you cannot manage it – we have come a long way and are now in a much better position to make progress.

However, reducing greenhouse gas emissions from the construction phase has proved more difficult and more challenging than expected, not helped by the downturn in construction during the recession and the great movement of people in and out of companies during that time. Certainly in this project the governance and administrative challenges of changing funding bodies, changing secretariats, changing representative bodies, changing employment circumstances of key individuals and even a change in the name of the appropriate government department have all proved major challenges. To have even achieved some forward momentum is a result. Indeed, there is evidence that the contractors are making progress towards reducing carbon emissions from construction processes on site. Indeed some of the recorded increases in project on-site emissions may in fact be due to improved monitoring, and this in itself tends to result in efficiencies.

Moving forward, the results of this analysis indicate areas where additional efforts would be beneficial; specifically the level of carbon emissions from on-site activities, recorded at project level and project type. It may be that improved emissions monitoring is already occurring; however without accurate data this is not evident in the 2012 assessment.

What Next? This project contributes to the wider activity of reducing the construction industry's carbon emissions. This project was about the target included in the 2008 Strategy for Sustainable Construction; the focus was the narrow strand of work to examine how to reduce carbon emissions on construction sites; it related to work that only contractors can take responsibility for. Ideally it should continue; much has been put in place and a good substrate now exists from which to continue. As it is only within the remit of the contractors to deliver on site reductions then the "ownership" and governance of any future work – be it continued work on attempting to reach this target or any revised new target needs to rest with the contractors and therefore with the representative bodies for construction contractors. Currently the UK Contractors Group represents the large contractors and the Construction Alliance represents small contractors. The challenge will

be leadership of the work and the acquisition of funds to pay for long term measuring and reporting systems.

Clearly, this strand of work is only one of a myriad of activities required across all parts of the construction industry to reduce carbon emissions and improve resource efficiency. The built environment as a whole is a major contributor to carbon and other greenhouse gas emissions with carbon emissions emitted throughout the construction life cycle - from the extraction of raw materials through manufacturing of construction products, the onsite construction phase of a project, the operational use of a building and at demolition and end of life. The Green Construction Board's Low Carbon Route Map for the Built Environment[2] published in 2013 sets out the wide range of actions required if the UK is to meet the 80% reduction in carbon emissions by 2050 set out in the UK Climate Change Act. *Construction 2025* published in 2014 includes an interim target of 50% reduction in carbon by 2025.[3]

To address climate change all parts of the construction supply chain will need to play their part – from architects, designers and engineers through manufacturers of materials and products, contractors both large and small, specialist contractors and demolition and end of life professionals. On some tasks different parts of the supply chain will have to take the principal responsibility, though to achieve the greatest reduction all parts of the construction life cycle will need to act and work together.

[2] http://www.greenconstructionboard.org/index.php/resources/routemap

[3] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/210099/bis-13-955-construction-2025-industrial-strategy.pdf

Introduction

1.1 Project background

In June 2008, the United Kingdom (UK) Government and the Strategic Forum for Construction (SFfC) representing industry, jointly published the Strategy for Sustainable Construction. The strategy included many ambitions and targets as well as actions and deliverables.

For the Strategy's climate change mitigation theme, one of eight actions and deliverables listed was: *a 15% reduction in carbon emissions from construction processes and associated transport compared to 2008 levels*. This target was but one of numerous strands of action across the wide construction industry to focus on how to reduce carbon.

To take the target forward, the Strategic Forum for Construction established in 2008/9 a Carbon Subgroup made up largely of individuals from contracting companies giving their time voluntarily, as well as government officials and those from statutory agencies. Their task was to identify and put in place the necessary actions to deliver this target. To assist the Subgroup in its deliberations and to provide the necessary expertise and secretariat support, funds were sought and a successful project bid was made to the Carbon Trust; Arup was the successful bidder and provided the secretariat support for the first few years of the project. Subsequently, project funding was sought from, and provided by, WRAP (Waste & Resources Action Programme) and the secretariat changed to URS. In addition, in 2011, the Strategic Forum's Sustainable Construction Task Group (SCTG) which coordinated this work and to which the Carbon Subgroup reported became a working group of the newly established Green Construction Board. Much change was therefore experienced throughout the duration of the project.

Since its inception the project has:

- Defined the scope, - the boundaries – of its work
- Established a methodology for measuring carbon emissions related to processes on a construction site
- Declared a 2008 baseline, both absolute and relative to annual construction output
- Measured annual performance against the 2008 baseline:
- Published an Action Plan for reducing carbon on construction sites
- Focused on six tasks in the action plan for greater implementation
- Produced three *How to Posters* for :
    - Reducing carbon emissions on construction sites
    - Save money and CO_2 emissions through effective logistics
    - Save money and CO_2 emissions through smarter business travel

This report is the 2012 annual performance assessment of progress against the target.

The scope of the target was defined by the Carbon Subgroup early in its deliberations, both in terms of processes and geographic applicability. The target is deemed applicable to England and is the focus of this carbon assessment. In addition, this paper provides data for other regions of the UK as useful contextual information.

The agreed scope for 'construction processes' includes the transport, enabling works, assembly, office activities, installation and disassembly activities necessary to deliver the service of construction.

The Carbon Subgroup decided that the target shall be considered met if by 2012:

a) absolute emissions (tonnes CO_2e/annum) in the target scope are reduced by at least 15% by 2012; and

b) emissions relative to contractors' output (tonnes CO_2e/£ million/annum) in the target scope are reduced by at least 15% by 2012.

1.2 About this paper

This paper presents the results of the 2012 carbon assessment and presents a re-calculation for the 2008 baseline. To aid the reader's understanding, this paper may be read in conjunction with the previously published reports on this project:

- Scoping study (2009) – Defines the processes to be covered by the target
- Data and methods study (2010) – Documents the methodology for calculating annual emissions
- 2008 baseline assessment (2010) – Applies the calculation method to determine the emissions for the 2008 baseline year; and
- Action plan (2010) – Provides a sector-level summary of recommended actions to reduce construction process emissions in England by 15% by 2012.

These studies are all available from the Green Construction Board website, http://www.greenconstructionboard.org/index.php/working-groups/greening-the-industry/carbon.

Section 2 provides details of the recalculated 2008 baseline, which has been updated according to the recalculation policy in the data and methods study.

Section 3 reports the results of the 2012 assessment.

Section 4 sets out future considerations

Section 5 sets out the key conclusions

Appendix A documents the data sources and their quality.

Appendix B lists the contributors to this project.

1.3 Acknowledgements

This project has been made possible with the input of many individuals and organisations, throughout its five year life, these are listed in Appendix B.

For the 2012 carbon assessment, the following companies provided direct data assistance.

Balfour Beatty
BAM Construct
BAM Nuttall
CECA
Costain
The Environment Agency
Galliford Try
Interserve
Kier Group
Laing O'Rourke
Lend Lease
Mace
Sir Robert McAlpine
McNicholas Construction
Miller Construction
Skanska
Volker Wessels
Willmott Dixon

2 Recalculation of 2008 baseline

2.1 Recalculation policy

The 15% reduction target is measured from a 2008 baseline. The baseline was calculated and published in March 2010 as 5,050,000 tonnes CO_2. The baseline figure was recalculated in the 2012 carbon assessments as 5,568,000 tonnes CO_2e respectively; in accordance with the recalculation policy set out in the March 2010 'Data and methods' paper. This policy is reproduced below.

Recalculation policy from 'data and methods paper'

The baseline shall be recalculated if:

- the user has access to new site emissions and project value data for 2008;
- significant errors are detected;
- stakeholders agree to changes in the target scope;
- there are changes to calculation methods; and
- Defra/DECC publishes improved, more accurate emissions factors.

For example, where Defra/DECC grid electricity emissions factors are used, it will be necessary to update these historically, as per Defra/DECC's guidance in the introduction to the 2009 Guidelines to Defra/DECC's GHG Conversion Factors for Company Reporting. Electricity emissions factors lag by two years. This is due to ongoing improvements in the calculation methodology or UK GHG inventory datasets that the factors are based upon.

... Any recalculations should be clearly identified in the public reporting of metrics with an explanation of the reasons for the recalculations.

2.2 Reasons for 2008 recalculation and main changes

Overall, the 2008 absolute baseline for England has increased by 10.2%, equivalent to 518,000 tonnes CO_2e. This section describes the reasons that triggered the baseline recalculation and how these changes affected the result. The changes for each construction process are shown in Table 1. Table 1 acounts for recalculations made during this assessment due to:

- Changes to Defra/DECC emissions factors for freight transport;
- Changes in the emission factors used for electricity and generator use from diesel and gas oil;
- Revisions to the contractors output for Great Britain and by country; and
- Changes from CO_2 only to CO_2e, which includes other greenhouse gasses in addition to CO_2.

Table 1: Summary changes of original versus recalculated England 2008 baseline

	Original (tonnes CO_2)	Recalculated (tonnes CO_2e)	Change (%)
On-site construction	1,710,000	1,944,000	13.7
Freight transport	1,620,000	1,738,000	7.3
Waste removal	525,000	542,000	3.2
Off-site assembly	232,000	246,000	6.0
Corporate office	233,000	265,000	13.7
Business travel	732,000	834,000	13.9
TOTAL	**5,050,000**	**5,568,000**	**10.2**
Emissions per 2005£ million contractors' output	50	58	16

Defra/DECC publish updated emissions factors regularly so the correct emissions factors were applied for the 2008 freight transport data, as outlined in the recalculation policy. Defra/DECC guidance states that, in general, greenhouse gas emissions calculations should be updated for two years.

ONS construction sector output statistics are also updated and revised as more accurate data is collected. The data is also provided in current prices which are used to ensure consistency between the 2008 and 2012 data.

3 Results of 2012 assessment

3.1 Summary of 2012 emissions

Table 2 shows the results of the 2012 emission assessment, overall progress towards the 15% reduction target. These results are based on the recalculated 2008 baseline shown in Section 2. Note that the target applies to England only and results for other UK regions are provided for context.

Table 2: 2012 greenhouse gas emissions for construction processes and associated transport, and percentage change from 2008 baseline

	England	Wales	Scotland	Northern Ireland	Great Britain	UK
Absolute emissions (tonnes CO_2e)	5,222,000	225,000	501,000	135,000	5,921,000	6,084,000
% change from 2008	**-6**	**-17**	**-18**	**-24**	**-8**	**-8**
Relative emissions (tonnes CO_2e) per 2005£ million contractors' output[4]	59	64	60	70	60	60
% change from 2008	**2**	**0**	**-2**	**9**	**2**	**2**

In 2012, contractors' output in England was almost 9% lower than in 2008, a reduction of 4% compared to 2011 and on par with 2010, in constant value terms. Absolute emissions reduced by around 6% in 2012 compared to 2008. However, there has been a 2% increase in tonnes CO_2e per 2005 £million contractors' output for England between 2008 and 2012.

The change in carbon emissions from 2008 to 2012 can be viewed as a sum of those construction processes which showed a decrease in carbon emissions and those which showed an increase. Of the processes which decreased, 49% of this reduction is due to changes in freight transport emissions which fell by 17% compared to the recalculated 2008 baseline. A further 45% was due to a reduction in business travel related emissions, which reduced by 33% compared to 2008. The remaining savings were from off-site assembly and waste removal with 6% and 1% of the total reductions respectively.

Of the processes which were responsible for emission increases the majority was due to a 13% increase in on-site emissions from 2008 to 2012. The only other process with an emissions increase was corporate offices, increasing by 6% from 2008 to 2012.

The increase in emissions from on-site activities is largely due to a near doubling in the site emissions associated with refurbishment and maintenance projects in 2012 compared to 2008; in addition to an increase in emissions from infrastructure projects. As a significant proportion of all construction works, an increase in the average site emissions for refurbishment and maintenance projects has a large effect on the estimate of the total emissions.

[4] Emissions relative to contractors' output are reported in constant prices (purchasing power in 2005) in order to remove the influence of inflation.

Table 3 Shows the change in emissions for each scope category and provides a short explanation for likely reasons for the change in emissions. Uncertainties are documented in greater detail in Section 3.4.2.

Table 3: Emissions per construction process for England in 2008 and 2012 with likely cause of any change

Construction process	Emissions (tCO_2e)		Change from 2008	Likely reasons for % change in figures
	2008	2012		
On-site construction	1,944,000	2,191,000	13%	Mostly due to increase in emissions for refurbishment and maintenance and new infrastructure projects. Very dependent on quality of data received from construction companies, which was poor in 2012.
Freight transport	1,738,000	1,439,000	-17%	Due to a 19% reduction in road freight transportation (tonne km) between 2008 and 2012 and updated emission factors published by Defra/DECC.
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Business travel	834,000	562,000	-33%	Due to a reduction in the transport to site emissions ratio, a bigger data sample in 2012 and ongoing progress towards more efficient vehicles and efficient driving behaviour.
TOTAL	**5,568,000**	**5,222,000**	**-6%**	
Emissions (tCO_2e) per 2005 £ million contractor output	**58**	**59**	**2%**	

The number of data points available for each element of the assessment has changed between 2008 and 2012, as summarised in Table 4.

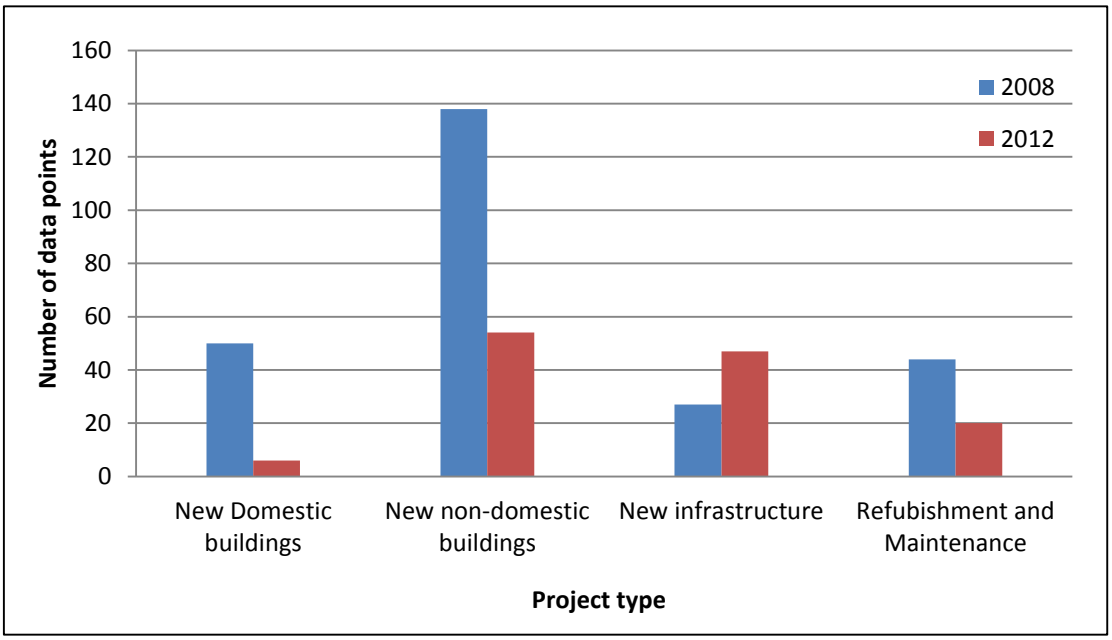
Table 4: Number of individual data points available for assessment

Assessment year	2008 baseline	2009	2010	2011	2012
Number of data points for project-specific emissions	259	301	172	358	129
Number of data points for off-site construction emissions	2	1	3	2	7
Number of data points for corporate office emissions	4	4	13	12	14
Number of data points for business travel emissions	4	3	8	11	14

The number of data points for project specific emissions has varied over the years; unfortunately the amount of data available for individual projects in 2012 is much lower than in previous years. Furthermore, as shown in Figure 1, the number of data points is significantly lower for all but new infrastructure projects. This means the projects for which there is data will have a proportionally larger effect on the average value for that project type. If the project data supplied is not representative of the industry as a whole, they may affect the overall result.

The number and quality of corporate data regarding office and business travel emissions has improved since 2008 with 14 data points for each in 2012, possibly reflecting an improvement in carbon accounting within the industry. See section 3.4 for further discussion of data uncertainties.

Figure 1: Breakdown of the number of construction project data points per construction project type for 2008 and 2012



3.2 Analysis over the 5 years: 2008-12

Table 5 summarises results by construction process and region. All results shown in this section should be reviewed with reference to the key uncertainties due to variability in reporting and data quality, as described in Section 3.4. Data sources used for the assessment are listed in Appendix A.

Figure 2 shows that emissions from on-site activities have increased significantly since 2008. Waste removal, off-site assembly and corporate office emissions have remained relatively static from 2008 to 2012. However, emissions from freight transport and business travel have shown a steady and continual decrease. The changes in construction activity emissions could be due to the following reasons:

- As carbon measurement and reporting methods and techniques improve, the accuracy and the number of factors measured increases, this is especially true for on-site activities due to the variety and scale of different carbon sources on-site. Therefore the 2012 data may be a more accurate representation of actual emissions compared to 2008 which may have underestimated emissions.
- The lower number of data points for the different project types available for the 2012 assessment may be affecting the results as each individual project will have a greater effect on the average result for the process.
- Lower construction output requires fewer materials and associated freight transport.
- A combination of more efficient vehicles and the low cost of behaviour change may explain the drop in transport and travel emissions.
- Increases in transport fuel costs may have provided an incentive to businesses to reduce mileage and vehicle use may explain the particularly large reduction in emissions from freight transport and business travel.

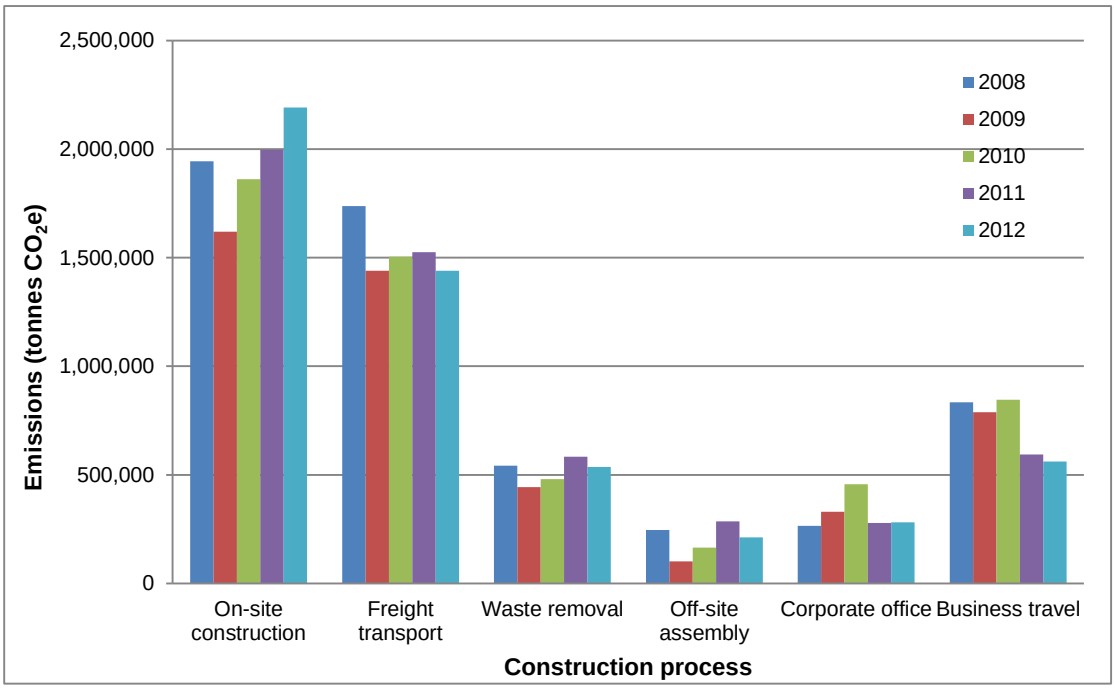


Figure 2: Breakdown of absolute emissions from construction processes in England for 2008, 2009[5], 2010, 2011 and 2012

[5] Note the 2009 analysis was undertaken by a different consultant and, as a result, source data has not been available for this analysis. Therefore, 2009 data has been directly taken from the 2009 report but has not been checked or recalculated in line with the 2008, 2010 and 2011 assessment data.

Table 5: Summary of results by construction process and region for the calendar year 2012

	England[6]	Wales	Scotland	N. Ireland	Great Britain[7]	UK[8]
Contractors' output (£ million)	102,275	4,090	9,698	2,282	116,060	118,342
Contractors' output (2005£ million)	87,862	3,514	8,331	1,947	99,704	101,664
Site activities (tonnes CO_2e, % of regional emissions total)	2,191,334	93,734	210,668		2,476,806	
Freight transport (tonnes CO_2e, % of regional emissions total)	1,439,322	63,251	137,859		1,640,433	
Waste removals (tonnes CO_2e, % of regional emissions total)	537,363	22,551	51,469		611,383	
Off-site assembly (tonnes CO_2e, % of regional emissions total)	211,589	9,298	20,266		240,108	
Off-site offices (tonnes CO_2e, % of regional emissions total)	280,741	12,009	26,990		317,314	
Business travel (tonnes CO_2e, % of regional emissions total)	562,137	24,045	54,042		635,369	
Total absolute emissions (tonnes CO_2e, % of regional emissions total)	5,222,487	224,889	501,294	135,497	5,921,413	6,084,168
Emissions per £ mil contractors' output (tonnes CO_2e/£ mil)	51	55	52	59	51	51

[6] Note that the 15% reduction target applies to England only.

[7] Sum of England, Wales and Scotland. Data is taken from a separate data set so discrepancies may exist.

[8] Sum of England, Wales, Scotland and Northern Ireland data

Emissions per £ mil contractors' output (tonnes CO_2e/2005£ mil)	59	64	60	70	59	60

3.3 Results for on-site activities

As with the 2008 assessment, on-site activities are responsible for over a third of emissions in the 2012 assessment. Table 6 shows a detailed breakdown of emissions by project type. Due to the availability of data, the detailed breakdown for new non-domestic projects (shops, offices, education, health and other non-domestic) is only available for Great Britain.

Table 6: Site activities emissions by project type for Great Britain for the calendar year 2012 compared to 2008

		Relative emissions - tonnes CO_2e per £ million (data range provided in parentheses)		**Total emissions in Great Britain (tonnes CO_2e)**	
Site activity		**2008**	**2012**	**2008**	**2012**
	New domestic	29 (0.16 - 759)	12 (0.07 - 34)	593,000	242,000
	New infrastructure	26 (4.74 - 103)	32 (0.38 - 83)	203,000	457,000
New non-domestic	New shops	11 (0.06 - 29)	11 (0.01 - 29)	54,000	49,000
New non-domestic	New office	17 (0.01 - 80)	9 (0.16 - 52)	164,000	58,000
New non-domestic	New education	10 (0.48 - 27)	23 (1.53 - 57)	93,000	192,000
New non-domestic	New health	12 (0.05 - 48)	20 (4.46 - 46)	59,000	62,000
New non-domestic	New other non-domestic	21 (0.38 - 111)	14 (2.20 - 37)	252,000	201,000
	Refurbishment & maintenance	13 (0.06 - 87)	27 (4.03 - 62)	756,000	1,215,000
	Total			**2,175,000**	**2,477,000**

There were significant changes in emissions intensity for different project types from 2008 to 2012, with rises in emission intensity especially evident in new education and refurbishment and maintenance construction, as shown in Figure 3. Figure 3 also shows a reduction in emissions in new domestic, new shops, new office and new other non-domestic.

Across the construction sector carbon emissions for different construction project types would not be expected to show large positive and negative changes in emission intensity due to changing practices. It is therefore likely that the variation observed between the 2008 and 2012 data is due to the influence of individual projects in the data samples provided, especially in 2012 where the data sample size is smaller and therefore more easily influenced by individual project data sets.

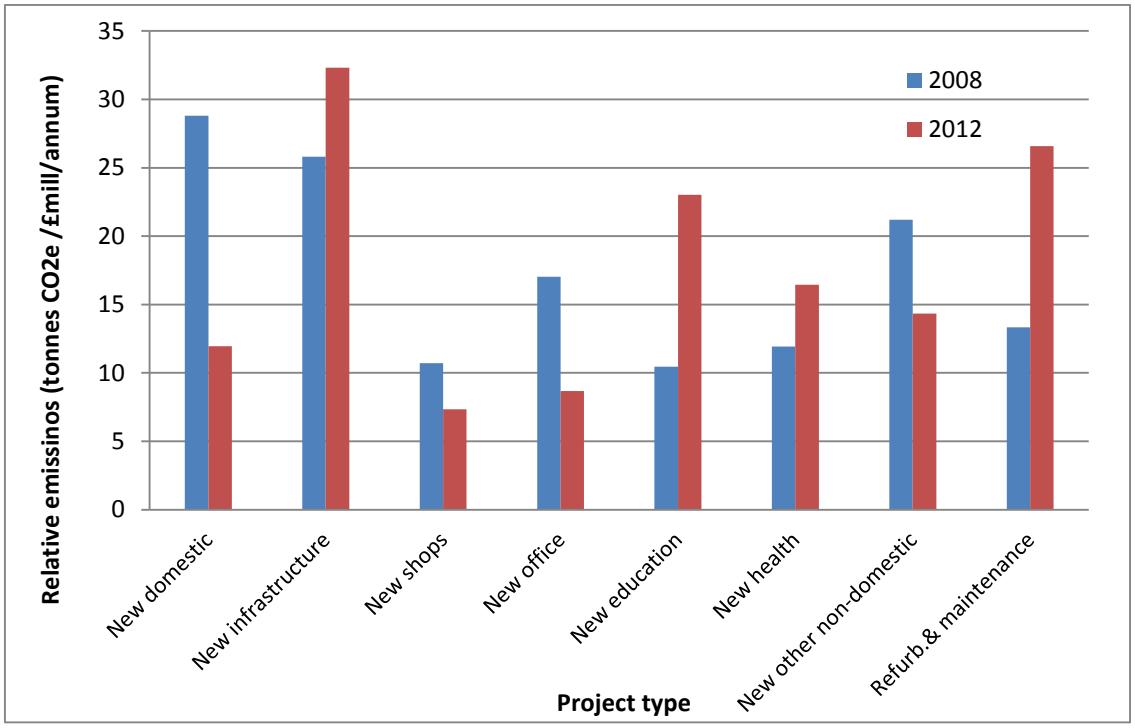


Figure 3 Breakdown of on-site emission intensity in Great Britain by project type for 2008 and 2012

Of the on-site construction activity, the proportion of emissions from different project types changed considerably between the 2008 to 2012 analysis, see Figure 4. This may reflect a change in construction activity due to the implications of the financial recession. Alternatively it may be an artefact of the reduction in the quantity of individual project data sets available for 2012.

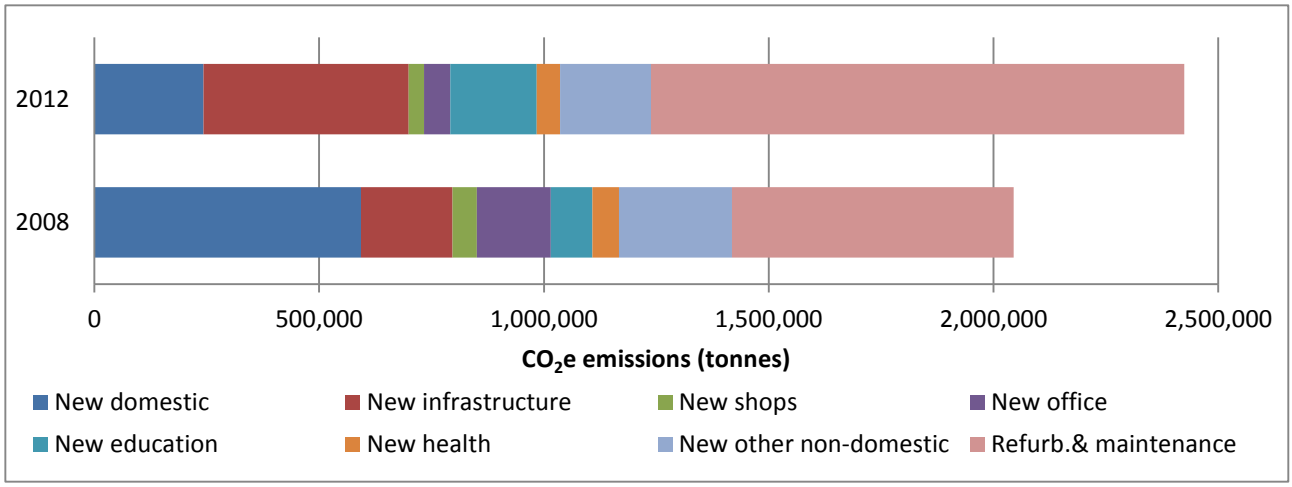


Figure 4: Total on-site emissions in Great Britain for each project type in 2008 and 2012

There was a marked difference in on-site emissions between large (>£5m) and small (<£5m) construction projects in 2012. Mean emissions per £m project value for large projects was 15.5 tonnes CO_2e /£m project value, and mean emissions for smaller projects were 33.7 tonnes CO_2e /£m project. This indicates that specific focus going forwards should be placed on improving the on-site energy efficiency of smaller projects.

Conversely, the mean emissions per £m project value for 2008 did not show a marked difference between small and large projects, mean values of 15 and 18 tonnes CO_2e /£m project value respectively. This indicates either: an increase in emission intensity for smaller projects; an artefact of the data available for the assessment; or that carbon reduction efforts are being focused on larger projects where the greatest savings can be achieved, while improved recording methods mean smaller projects report higher emissions as more factors are included.

3.4 Key uncertainties

3.4.1 Uncertainties in sector data

For the assessment, the major source of uncertainty remains whether or not it is valid to assume that project values reported by contractors closely correlate with overall sector emissions. This assumption is the basis for the calculation methodology for site emissions. For a more specific discussion of data uncertainties in construction processes refer to Table 8 in Section 3.4.2.

A further key issue is the lack of data available from individual companies, specifically for individual projects. Although there has been an improvement in corporate reporting in terms of office and business travel emissions since the 2008 baseline assessment, the availability of data for individual projects seems to have declined in 2012. In order to ensure the assessment provides an accurate representation of the construction sector, there needs to be sufficient quality and quantity of project data to provide a representative sample of the industry as a whole.

Throughout the assessments there has been very little accurate up-to-date data on the overall level of off-site construction and project specific data on emissions from off-site assembly. This meant that the analysis has relied on old data which may not represent any year-on-year changes. The amount of company and project specific emission data available each year was very low. In 2012 there was no off-site assembly project data available, therefore a combination of previous year's data had to be used, introducing further uncertainty. Further discussion of the effects of this can be found in Table 8 below.

Another area of uncertainty arises from a lack of up-to-date data on construction freight road transport. This data is compiled by the DfT, however the most recent data produced was for 2011. The 2012 data is unlikely to be produced until autumn 2014. With no other source of appropriate data available, an estimate developed using data from previous years was used for the 2012 assessment. This estimate relied upon the assumption that the quantity of construction material required, and transported by road freight, scales with total contractors' output. Previous years' construction freight transport totals per vehicle type were graphed against the contractors' output that year, which gave very strong correlations (R^2 values from 0.92-0.98 and a statistical significance p value of <0.05). From which the 2012 construction freight values were estimated using the 2012 contractors' output for each construction material. The proportion of the average total for each vehicle type was then used to estimate the breakdown of the 2012 values by size of construction vehicle. See Table 8 for assessment of the uncertainty in this method and Appendix A2 for a more detailed description of the method used.

Appendix A shows the relationship between project value and emissions. The R correlation coefficient value indicates how strong this relationship is and therefore the validity of the methodology. Results are likely to be more reliable where R^2 value is 0.7 or greater. Table

7 summarises the correlations, for comparison, the same statistics are shown for the 2008 sample.

Table 7: Strength of correlation between project value and emissions

Project type	2012 assessment		2008 baseline	
	Correlation coefficient	Strength of correlation	Correlation coefficient	Strength of correlation
New domestic buildings	0.89	Strong	0.04	Low
New non-domestic buildings	0.41	Low to moderate	0.80	Strong
New infrastructure	0.41	Low to moderate	0.49	Low to moderate
Refurbishment and maintenance	0.60	Moderate	0.62	Moderate

From the summary statistics in Table 7, the 2012 data set is of a similar consistency and range to the data used for the 2008 baseline assessment and overall has a moderate strength of correlation. There has, however, been a significant reduction in the strength of correlation for new non-domestic buildings and an increase in strength of correlation for new domestic buildings, although the number of data points for new domestic buildings is significantly lower.

The key implication is that over the course of the five annual assessments (2008 to 2012), there may be significant real or data-driven fluctuations in site emissions. These fluctuations may obscure any real progress towards the 15% target. All construction activities apart from on-site emissions have shown at least a steady or downward trend in carbon emissions but any reductions achieved are being outweighed by the consistent increase in site emissions, which is heavily influenced by the data supplied.

3.4.2 Uncertainties across whole scope of the target

As discussed in Section 3.4.1, there are a number of sources of uncertainty in the baseline assessment and the subsequent assessments. Table 8 lists the data quality issues, their likely effect on the assessments, the level of uncertainty, and recommended options for managing uncertainties.

Table 8: Effects of data quality issues and uncertainties for the 2012 calendar year

Construction process	Issue	Number of data points	Potential effect on 2012 assessment	Potential effect on change from baseline	Uncertainty associated with issue and recommendation
i. Site activities – new domestic	Major decrease in number of data points between 2008 and 2012 and proportion of total on-site emissions.	6	Unknown effect. Actual emissions may be higher or lower than calculated. Difference between calculated and actual may be large.	Results may be due to data collection, rather than actual changes in emissions.	Uncertainty: **High** Emissions from on-site activities for new domestic buildings accounted for around 18% of total GB construction output in 2012. Using 6 projects to estimate the total emissions from this project type is not a representative sample. The decrease in emissions per £m project value may be a real reflection of changing types of domestic construction or it may reflect differences in sampling.
ii. Site activities- new non-domestic	High variability in data set (refer to Appendix B)	54	Actual emissions may be higher or lower than calculated. Difference between calculated and actual may be small or large.	Results may be influenced by the variability of the data rather than changes in carbon emissions.	Uncertainty: **Minor** New non-domestic emissions represent 37% of the 2008 and 23% of the 2012 GB total for emissions from on-site construction activities. The high degree of variation in the data set may be due to real variety in project types (e.g. hospitals, schools, warehouses). The scale and variability of the data is relatively consistent between the two assessments and the sample is reasonably sized, so it is likely to represent real variability.
iii. Site activities – new education	Large increase in emissions intensity between 2008 and 2012.	15	Actual emissions may be lower than the calculated. Difference between calculated and actual may be small or large.	This level of emissions intensity is much greater than 2008, the 2012 figure maybe an artefact of the low number of data points.	Uncertainty: **Moderate** Although new education project emissions have increased in absolute terms, proportionally it only represents 8% of the 2012 total for emissions from on-site construction activity GB total. The increase in emissions per £m project value may be a reflection of the lower sample size with a few large projects skewing the average.

Construction process	Issue	Number of data points	Potential effect on 2012 assessment	Potential effect on change from baseline	Uncertainty associated with issue and recommendation
iv. Site activities – refurbishment & maintenance	Reduction in the number of data points and a major increase in absolute emissions and emissions intensity between 2008 and 2012.	20	Unknown effect. Actual emissions may be higher or lower than the calculated. Difference between calculated and actual may be small or large.	Given the significance of refurbishment and maintenance (38% of construction contractors' output in 2012), changes in the site activities emissions (and consequently, the total emissions) may be unduly driven by variations in the data sample.	Uncertainty: **High** Emissions from on-site activities to refurbish and repair buildings and infrastructure account for 49% of the total emissions from on-site construction activities in 2012, up from 30% in 2008. Therefore, comparison between the baseline is likely to be affected by changes in data collection for refurbishment and repair. The low number of samples may mean the figure is not a true representation of the actual scale of emissions from this sector of the construction industry.
v. Freight transport – building materials moved by road freight	No data on number of million tonne-km of building materials moved by road by vehicle size	0	Unknown effect, actual emissions may be lower than reported as any change to more efficient use of road freight is not represented. Output is based upon previous year's data.	Until DfT release the 2012 data any changes in freight transport during 2012 is not represented	Uncertainty: **High** Freight transport accounts for 27% of the 2012 footprint. Any reduction in the amount of materials moved by road freight or improvements in the efficiency of transporting building materials is not represented in the 2012 total. Most likely a small overestimate of emissions. Updating the road freight statistics will give a more accurate representation of the associated carbon emissions. However there is only a limited carbon reduction potential.
vi. Freight transport – utilisation (% weight laden)	No data on utilisation of freight transport, therefore average emissions factors for road and rail have been adopted.	0	Actual emissions may be lower than the calculated, as anecdotally construction freight is limited by tonnage rather than volume.	Improvements in freight utilisation (e.g. through the use of consolidation centres) will not be reflected in the annual assessment.	Uncertainty: **High** Small changes in utilisation have the potential for major changes in total emissions, as freight emissions account for 27% of the 2012 footprint.

Construction process	Issue	Number of data points	Potential effect on 2012 assessment	Potential effect on change from baseline	Uncertainty associated with issue and recommendation
vii. Freight transport – import/export balance	No data on the proportion of GB freight movements that are related to domestic or foreign construction activity. Emissions should be calculated only for freight movements related to domestic construction activity.	0	Unknown effect. If the export of construction materials and products account for a significant proportion of freight movements, then total emissions will be lower.	As long as the proportion of export-related freight movements stays relatively constant, then annual emissions will be comparable.	Uncertainty: **Minor** The change in exports is not significantly different to the change in domestic contractors' output. The total amount of imported and exported construction materials is similar between 2008 and 2012.
viii. Freight transport – water freight	No data on water freight movements for construction materials and products.	0	Likely to increase both the 2008 and the 2012 result. Unknown if this increase is small or large, as there is no data on how much water freight is used for construction materials and products.	As long as water freight is consistently excluded in reporting, then annual emissions will be comparable. If there has been a large shift from road/rail freight to water freight, then it will be necessary to include water freight in calculations.	Uncertainty: **Minor** If a shift towards water freight is to be implemented as an industry-wide carbon reduction measure, then a calculation of the emissions savings due to modal shift would be needed and the methodological approach outlined in Section 6.7.2 of the data and methods paper will need to be adopted. However, there is no evidence this has occurred on any significant scale.

Construction process	Issue	Number of data points	Potential effect on 2012 assessment	Potential effect on change from baseline	Uncertainty associated with issue and recommendation
ix. Waste removal – tonnages	CD&E waste received by waste facilities is likely to be double-counted, as waste is moved between facilities.	2	Acceptable effect. Although CD&E waste may be counted multiple times due to movement between facilities, there are transport emissions associated with these movements, and these could be reasonably attributed to the construction sector.	None, as long as data source is consistent each year.	Uncertainty: **Minor** One sector-level figure for each of England and Wales. In 2012 Scotland and Northern Ireland are based upon new sector-level from 2010 this does not affect the England only target but does affect any comparisons.
x. Waste removal – distances	Not enough data available on transport distances between construction sites and waste treatment locations.	0	Unknown effect. It may be an accurate estimate, if the sample is representative of most sites in 2012.	It may be that waste removal distances do not change in the short term (between 2008 and 2012) and therefore, reasonable assumptions for distances are acceptable as an unvarying parameter. Annual results would be comparable.	Uncertainty: **Moderate** Waste removal is a significant emissions source (around 10% of Great Britain emissions). The environment agency consistently uses the same average distances based on industrial opinion. If there was a change to reduce emissions by optimising distance (e.g. by agreeing to use the waste treatment sites closest to a construction site), then this is not being captured in the calculation.

Construction process	Issue	Number of data points	Potential effect on 2012 assessment	Potential effect on change from baseline	Uncertainty associated with issue and recommendation
xi. Waste removal – utilisation (% weight laden)	No data on utilisation of waste removal trucks, therefore average emissions factors for road freight have been adopted.	0	Unknown effect. Actual emissions may be higher or lower than the calculated. Anecdotally, waste removal vehicles are full on leaving the site but arrive empty. Small changes in utilisation have the potential for changes in total emissions, as waste removal emissions account for 10% of the 2012 total.	Unless data is collected, improvements in truck utilisation will not be reflected in the annual assessment.	Uncertainty: **Moderate** It is unknown whether year-to-year the average freight utilisation figures are appropriate for the removal of CD&E waste. This may mean carbon emission reductions since 2008 have not been captured however without accurate data any change is unknown.
xii. Off-site assembly – industry output	Non-transparent and out-dated (2007) data used to make assumptions on the industry output.	Studies from 2000, 2001 and 2005.	If the use of off-site assembly has increased since 2007, then emissions may be greater than reported in the 2012 assessment.	Data is not collected regularly. Assessment will index off-site assembly output to contractors' output. If the proportion of construction activity due to off-site assembly changes, this will not be reflected in annual results.	Uncertainty: **Minor** Off-site assembly output is 4% of the 2012 emissions footprint, which is relatively small. Other uncertainties are likely to be more significant. There is little evidence of a shift towards off-site manufacturing being implemented as an industry-wide carbon reduction measure, however some increased use may have occurred which has not been captured.

Construction process	Issue	Number of data points	Potential effect on 2012 assessment	Potential effect on change from baseline	Uncertainty associated with issue and recommendation
xiii. Off-site assembly – emission intensity	Not enough data for reliable characterisation of emissions intensity of off-site assembly.	7	Unknown effect. Actual emissions may be higher or lower than calculated. Difference between calculated and actual may be small or large.	Annual results may fluctuate due to data collection, rather than actual changes in emissions. In 2012 an average of previous years had to be used.	Uncertainty: **Moderate** In 2008, off-site assembly emissions accounted for 4% of the 2008 GB footprint, the same as in 2012. The lack of good quality data may affect the quality of the results.
xiv. Off site (corporate) offices – emissions	Low number of data points for reliable characterisation of the relationship between emissions from off-site office activity and site activity.	14	Unknown effect. Actual emissions may be higher or lower than the calculated. Difference between calculated and actual may be small or large.	Results may fluctuate due to data collection, rather than actual changes in emissions.	Uncertainty: **Moderate** In 2012, emissions from corporate offices accounted for around 5% of GB emissions. Although an increase in the quantity of data for corporate offices, the estimate is reliant upon the estimation of emissions from site activities which has high uncertainty.
xv. Business travel – emissions	Low number of data points for reliable characterisation of the relationship between emissions from off-site office activity and site activity. Not enough detail in data samples to exclude non-domestic travel.	14	Unknown effect. Actual emissions may be higher or lower than the calculated. Difference between calculated and actual may be small or large.	Results may fluctuate due to data collection, rather than actual changes in emissions.	Uncertainty: **Moderate** In 2012, business travel accounted for around 10% of GB emissions. Although an increase in the quantity of data for business travel in 2012, the estimate is reliant upon the estimation of emissions from site activities which has high uncertainty.

4 Activities / Achievements of the Carbon Subgroup

Although the 15% reduction target was not achieved based on the data provided, much has been put in place to facilitate future reporting and progress. When the journey to identify what needed to be done began back in 2008, with the industry setting itself a target of trying to reduce carbon emissions during the construction process on sites by 15% by 2012, nothing existed. There was no methodology to measure emissions in such a scope, there was no data gathering from companies, there was no baseline from which to measure progress, it was unknown where the carbon emissions were greatest, there was no action plan of what to do and no specific guidance available. All that has now changed. Through the hard work, usually above and beyond the requirements of their jobs, many people across the industry have collaborated and worked together to better understand the challenge the companies face to deliver this target and to initiate necessary actions.

We now have in place an established methodology for measuring carbon emissions from construction processes on site, we have defined the scope of what we mean by the construction phase, we have a 2008 baseline both absolute and relative to annual construction output, we have an action plan published in 2010 identifying the key areas where carbon might be able to be reduced, and we have published a number of practical guidance posters for use on construction sites. In that famous phrase – if you cannot measure it you cannot manage it – we have come a long way and are now in a much better position to make progress.

Specifically, since its inception the project has:

- Defined the scope, - the boundaries – of its work (2009)
- Established a methodology for measuring carbon emissions related to processes on a construction site (2010)
- Declared a 2008 baseline, both absolute and relative to annual construction output (2010)
- Measured annual performance against the 2008 baseline
- Published an Action Plan for reducing carbon on construction sites (2010)
- Focused on six tasks in the action plan for greater implementation
- Produced three *How to Posters* for :
    - Reducing carbon emissions on construction sites
    - Save money and CO_2 emissions through effective logistics
    - Save money and CO_2 emissions through smarter business travel

There is much still to do.

5 Future considerations

5.1 Improving reporting

Reducing greenhouse gas emissions from the construction phase has proved more difficult and more challenging than expected, not helped by the downturn in construction during the recession and the great movement of people in and out of companies during that time, making long term monitoring and reporting commitments more difficult to follow up. However, there is evidence that the contractors are making progress towards reducing carbon emissions from construction processes on site. Indeed some of the recorded increases in project on-site emissions may be due to improved monitoring. For the future, the results of this analysis do indicate areas where additional efforts should be focused; specifically the level of carbon emissions from on-site activities, recorded at project level and project type. It may be that improved emissions monitoring is already occurring; however without accurate data this is not evident in the 2012 assessment

Some construction companies are measuring project level carbon emissions and publicly reporting reductions annually. Table 9 summarises reported carbon targets and achieved savings from a selection of companies involved in the 2012 assessment. Similar savings may be occurring across the sector. However, due to the data sample size, the assessment may not be reflecting these savings. The assessment does show that some reductions are occurring, especially in freight transport and business travel. It may be that these are the areas where carbon savings are most easily achieved or financially beneficial.

Table 9: Summary of individual company carbon reduction targets and achievements up to 2012

Construction company	Carbon reduction target	Target year (baseline)	Achieved savings by 2012	Notes supplied by construction companies
BAM	25%	2015 (2008)	36% absolute 19% normalised	Emissions did increase in 2012 from 2011.
Galliford Try	15% of Scope 1&2 emissions	2013 (2008)	Achieved by 2012	Largest savings were from transport and travel
Laing O'Rourke			27% absolute savings 13% normalised	
MACE	20%	2015 (2012)		Targets part of a three year plan
McNicholas	2% 10% 20%	2012 (2008) 2015 (2008) 2020 (2008)	22% absolute achieved by 2012	Significant savings were achieved through travel
Skanska			20% normalised	

If future carbon measurement from construction processes is going to be more meaningful, accurate and useful for measuring progress against industry or company-specific targets, then additional effort will need to focus on project level recording and reporting of carbon emissions. For all assessment years in this project and for 2012 in particular, there has been a lack of emissions data for individual projects. Whether the quality of measurement and reporting is a consequence or a driver of carbon reductions is unknown; either way

accurately understanding the sources of carbon is vital to developing and monitoring reduction initiatives.

Moving forward, many construction companies are beginning to measure their direct carbon emissions, however the methods and scope varies between companies and it would be beneficial to standardise the carbon measurement and reporting. Such consistency would allow for direct comparison between companies and projects; creating a more reliable metric of carbon emissions as well as the opportunity for sharing knowledge and good practice.

WRAP has been working on an updated Reporting Portal (expanded from its Halving Waste to Landfill Commitment measurement and reporting tool), enabling carbon data to be reported at project or business level. WRAP hopes that this reporting method will become widely accepted and utilised across the industry, either directly or through adoption of the reporting methods and measurements. The inclusion in the joint government and industry *Construction 2025* strategy of an action for construction businesses to commit to voluntary resource efficiency agreements including reducing carbon will, it is hoped, prompt more businesses to submit their data to such a Reporting Portal.

Industry-wide use of WRAP's Reporting Portal would provide a much greater source of comparable data for any future assessments, both sector wide and individual company targets and would facilitate project level emission benchmarks for distinct project types. Unlike an industry wide reduction target, project specific benchmarking would be more practical and allow greater flexibility to create a measured and consistent change and help drive change and innovation.

Going forward, major contractors, especially those which are members of the UK Contractors Group (UKCG), as part of their renewed commitment to delivering the low carbon, resource efficient built environment actioned in *Construction 2025* have pledged to renew their efforts on reducing carbon. They are now in a much better position to deliver such a commitment.

5.2 Wider context of carbon reduction

The built environment is a major contributor to carbon and other greenhouse gas emissions (hereafter referred to as Carbon emissions). Carbon emissions are emitted throughout the construction life cycle - from the extraction of raw materials through manufacturing of construction products, the onsite construction phase, the operational use of a building and at demolition and end of life. To address climate change and to reach the 80% reduction in carbon emissions by 2050, as set out in the UK Climate Change Act, as well as the 50% reduction by 2025 target set out in *Construction 2025*, all parts of the construction supply chain must play their part – from architects, designers and engineers through manufacturers of materials and products, contractors both large and small, specialist contractors and demolition and end of life professionals. If the country is to achieve the target of reducing carbon by 80% by 2050 then the broad range of activities across the entire construction industry must continue and indeed accelerate. The Green Construction Board published in 2013 *The Low Carbon Routemap* for the *Built Environment* which sets out in great detail the myriad of actions needed to achieve the 2050 goal.

The focus of this project - reducing carbon emissions from construction process on site and associated transport by 15% by 2012, is one narrow strand in the overall big picture of reducing carbon emissions from the built environment. There are already many regulations, policies, initiatives by both government and industry aimed at improving energy efficiency

and reducing carbon, for instance Building Regulations Part L which seeks to drive up energy efficiency in buildings and lower operational carbon, ECO and the Green Deal aimed at providing incentives for improving energy efficiency, the EU Emissions Trading System, the Climate Change Levy, Climate Change Agreements, the Carbon Reduction Commitment, the Code for Sustainable Homes, the 2016 Zero Carbon Homes target, BREEAM schemes etc and a host of self-imposed industry and company targets. Understanding the combined impact of all such policies is a very complex challenge and the Low Carbon Routemap made a first attempt at doing so.

To date most of the focus of action to decrease carbon and other greenhouse gas emissions has been on reducing the operational carbon emitted as part of the everyday use of energy. As this decreases the carbon embodied within the materials and products used to construct buildings and infrastructure will become more significant. This is the carbon emitted during the extraction and manufacturing phase and in the Low Carbon Routemap is referred to as *capital carbon*. Standardised methodologies for measuring this carbon now exist in European standards (BS EN 15804 for producing Environmental Product Declarations and BS EN 15978: Assessment of environmental performance of buildings, both within the CEN 350 suite of standards). Tools are beginning to emerge, such as IMPACT, which can use this information to enable architects and designers to consider embodied carbon and other embodied impacts at the start of the design process. The introduction of BIM (Building Information Modelling) will also help facilitate design and procurement choices involving embodied carbon and other embodied impacts. Opportunities for reuse of materials and products or the avoided emissions through retrofitting and refurbishing also represent opportunities for lowering carbon.

Clearly there is much already available to the wider construction industry to make better choices and build more resource efficient, low carbon buildings and other construction works, but there is still an enormous amount to achieve.

6 Conclusions

This paper has presented the results of a project looking at reducing carbon emissions from on site construction process and associated transport. It provides the carbon assessment for 2012 and reports a recalculated baseline for 2008.

The recalculated 2008 baseline for England is 5,568,000 tonnes CO_2e, which is 10.2% greater than reported in the 'Baseline carbon assessment for 2008' (March 2010) paper. The baseline was recalculated to make use of updated greenhouse gas (GHG) emissions factors published by Defra/DECC for road freight and incorporated the baseline data from the 2010 carbon assessment, as well as revised construction output data in current prices.

Between 2008 and 2012, contractors' output in England fell by almost 9% in constant value terms, however based on the data available, **only a 6% reduction in absolute emissions** was realised**.** The **carbon efficiency** (emissions per 2005 £m spend) of construction activity therefore **increased by 2%.**

At the start of the project, it was decided that the 15% reduction target would be applicable for both absolute and relative carbon emissions. Based on the 2012 assessment, the construction sector:

a) **Made some progress** towards the target for absolute emissions (tonnes CO_2e/annum), though did not reach the 15% carbon reduction; and

b) **Made no progress** towards meeting the target for emissions relative to contractors' output (tonnes CO_2e/£ 2005 million/annum), with an increase of 2%.

The result is of course disappointing and needs to be considered and take into account the sources of uncertainty in the baseline assessment and in the subsequent annual assessments. It may be that we have progressed from a baseline stab in the dark about what is happening re carbon emissions from construction processes on site to a just a slightly better or worse stab in the dark. A key issue is the lack of data available from individual companies, specifically for individual projects. Although there has been an improvement in corporate reporting in terms of emission from offices and business travel since 2008, reporting for individual projects did not improve. In order to ensure any future assessments provide an accurate representation of the sector, individual project data collected and reported by organisations will need to be of an appropriate quantity and quality to be representative of the industry as a whole.

All of the construction processes measured were approximately either equal or lower in the 2012 assessment compared to the 2008 assessment, with the exception of the on-site construction activity. On-site construction is the area most influenced by the availability of construction project data, which in 2012 was a much smaller sample than in 2008. The large rise in on-site construction emissions calculated could be due to: an actual increase in on-site carbon emissions, artefacts of the project data supplied (either underestimated in 2008 or overestimated in 2012); or due to improvements in recording of emissions in 2012, providing a more accurate but higher figure for individual projects.

The sector as a whole launched an approach to meeting the target in July 2010 with the aim of accelerating both absolute and relative emission reductions. While various contracting firms and transport providers are individually implementing strategies to reduce their emissions. further carbon reductions, in both absolute and relative terms, could be expected to occur if recommendations from the action plan are implemented by the industry. The rate of adoption may have been too slow to achieve the 15% target within the timeframe (2012) set within the Strategy for Sustainable Construction (2008).

From this 2012 assessment and 5 year review it can be concluded that the construction industry has made some progress towards reducing their carbon emissions fro construction processes on site, especially regarding transport and travel. Although the 15% reduction target was not achieved, there are several uncertainties with the data, particularly regarding the small project data sample size in the 2012 assessment, which may mean the assessment is not truly representative of the actual carbon emissions emanating from these construction processes.

This project, initiated in 2008 to deliver a specific 2012 target within the joint industry and government Strategy for Sustainable Construction (2008) has now concluded.

Going forward, ideally this activity of contractors measuring and reporting carbon emissions from the on site construction processes should continue. This will depend on a number of factors;

- Encouraging more contractors to measure and report annual carbon emissions data.
- The continued existence of a reporting process, a reporting portal, to which contractors can submit data and for that data to be analysed. During this project that activity has been funded on an ad hoc project basis with the driving force for identifying and securing project funds coming from industry (i.e. by the SCTG Task Group/ Greening the Industry Group Secretariat and Chairs identifying potential funding bodies and writing project proposals to seek their support). Such pursuit of project funds will now need to be led by the contractors; they will need either to fund the reporting process and subsequent analysis activity directly or seek third party project funds.
- Embracing an industry wide standard of carbon emission reporting at the project level to a central repository, such as WRAP's Reporting Portal, would help to provide the opportunity for direct comparisons and benchmarking.

This activity of reducing carbon emissions during the construction process on site is one narrow strand in the overall picture of reducing carbon emissions from the built environment. If the country is to achieve the target of reducing carbon by 80% by 2050 (50% by 2025) then the broad range of activities across the entire construction industry as identified in the 2013 Green Construction Board's *Low Carbon Routemap for the Built Environment* must continue and indeed accelerate.

Major construction contractors, especially those belonging to the UK Contractors Group, have made a renewed commitment to delivering a low carbon, resource efficient built environment as their contribution to delivering the actions identified in *Construction 2025*. As a result of this project they are now in a much better position to understand, measure and reduce carbon emissions in one aspect of their activities

Appendix A

Data sources and quality assessment

A1 Data for site emissions by project type

A1.1 New domestic buildings

For Great Britain in 2012, new domestic construction was over 17% of all contractors' output (in £ million). Figure A1.1 below shows that there were only 6 data points (individual construction projects) for which site activity data were available. The R^2 correlation coefficient of 0.89 indicates a strong correlation between project value and emissions. Although there is a strong correlation suggesting a good estimation of emissions per total construction output, this data should be treated with caution as it could be a poor representation of the actual figure due to the small sample size. .

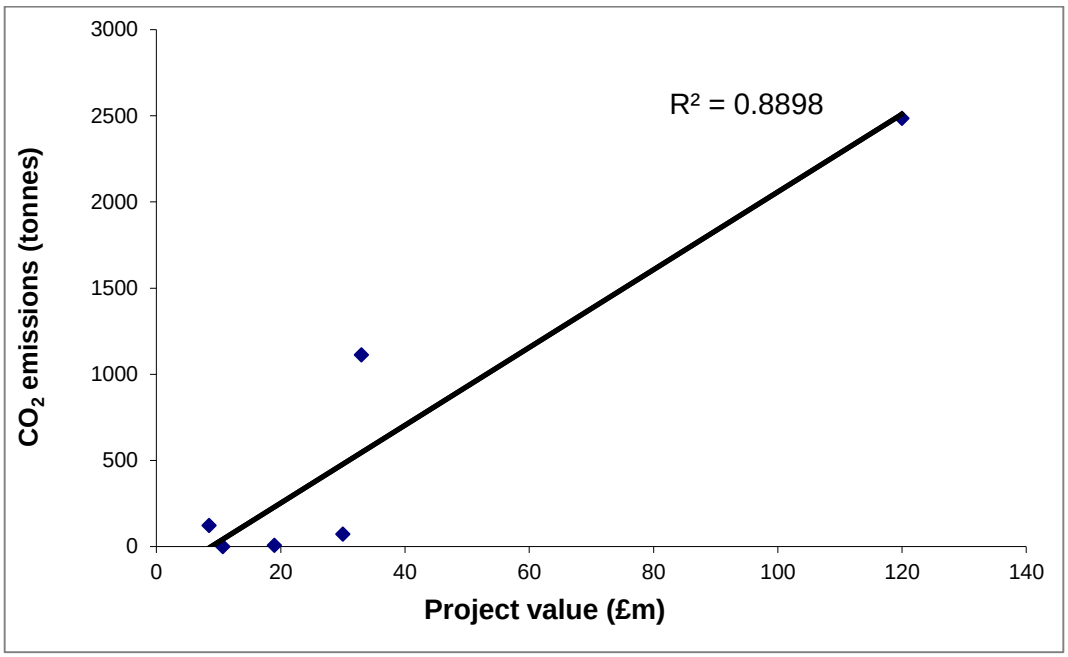


Figure A1.1: New domestic site emissions, correlation between project value and emissions for the calendar year 2012

A1.2 New non-domestic buildings

For Great Britain in 2012, new non-domestic buildings construction was 32% of all contractors' output (in £ million). Figure A1.2 shows that for new non-domestic building construction, there were 56 data points (individual construction projects) for which site activity data were available. This is a medium sample, which shows a low correlation (R^2 correlation coefficient of 0.41) between project value and emissions. This suggests a degree of uncertainty and potential effect on the total emissions driven by changes in data.

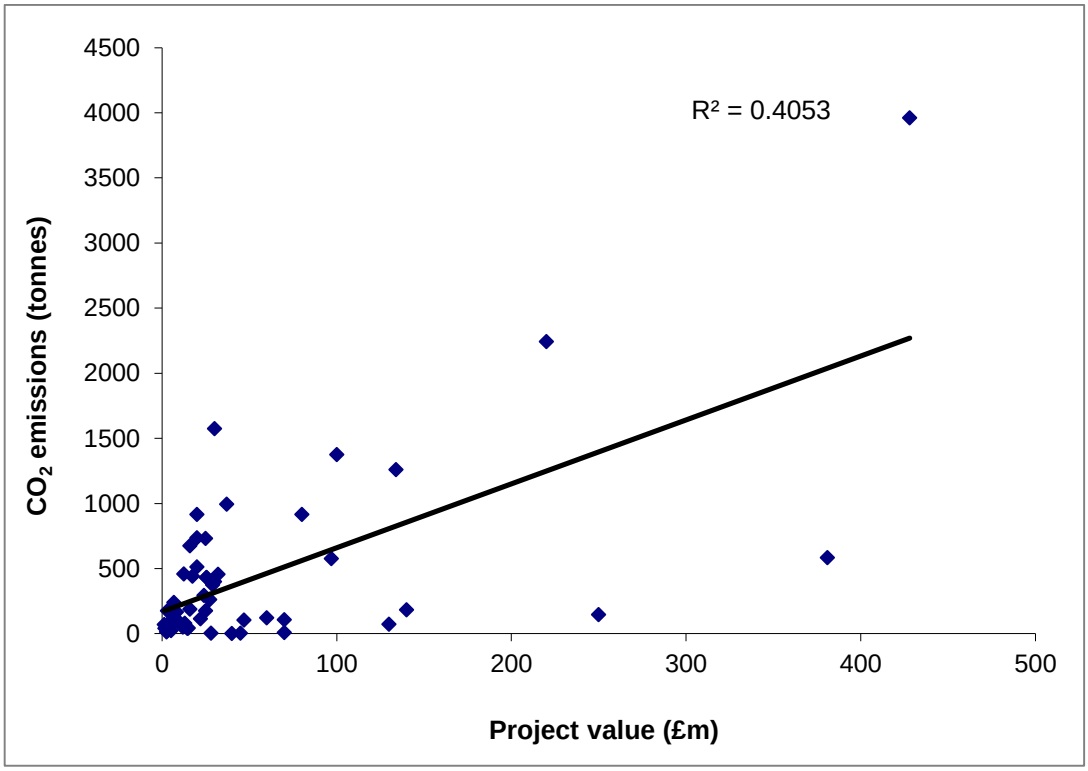


Figure B1.2: New non-domestic site emissions, correlation between project value and emissions for the calendar year 2012

A1.3 New infrastructure

For Great Britain in 2012, new infrastructure was 12% of all contractors' output (in £ million). Figure A1.3 shows that for new infrastructure construction, there were 42 data points (individual construction projects) for which site activity data were available from a variety of data sources. Figure A1.3 shows that there is a poor correlation (R^2 correlation coefficient of 0.41) between project value and emissions. This indicates that the estimate for new infrastructure emissions is potentially unreliable and could be a source of error in the estimation.

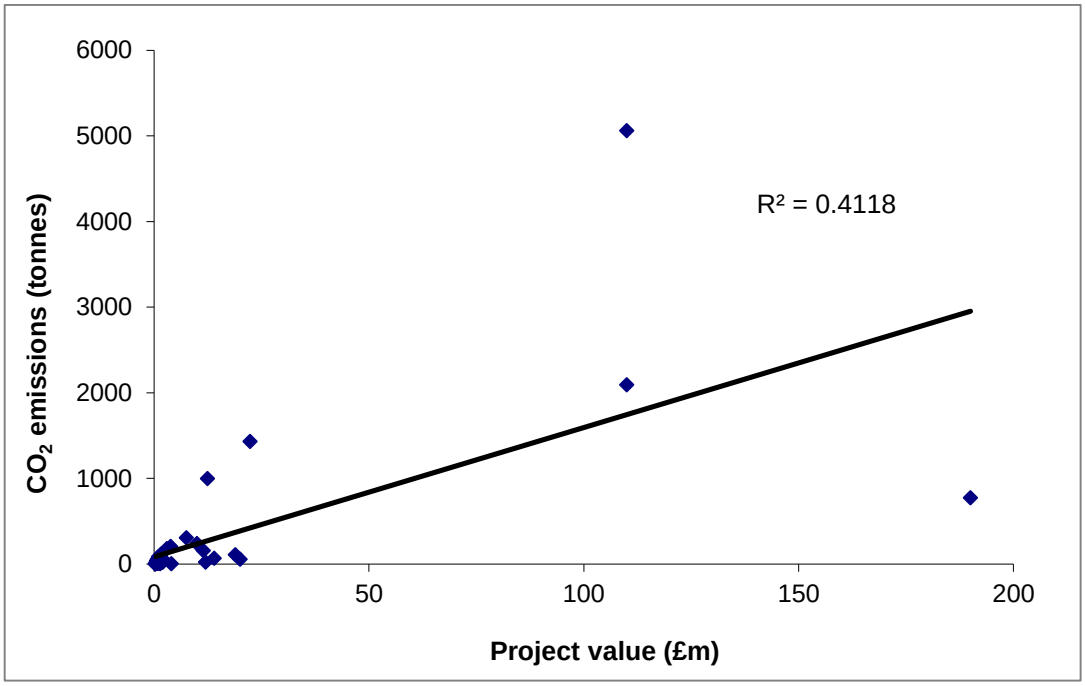


Figure A1.3: New infrastructure site emissions, correlation between project value and emissions for the calendar year 2012

A1.4 Refurbishment and maintenance

For Great Britain in 2012, refurbishment and maintenance was 38% of all contractors' output (in £ million). Figure A1.4 shows that for refurbishment and maintenance, there were 20 data points (individual construction projects) for which site activity data were available from a variety of data sources. The R^2 correlation coefficient of 0.60 shows a moderate correlation between project value and emissions.

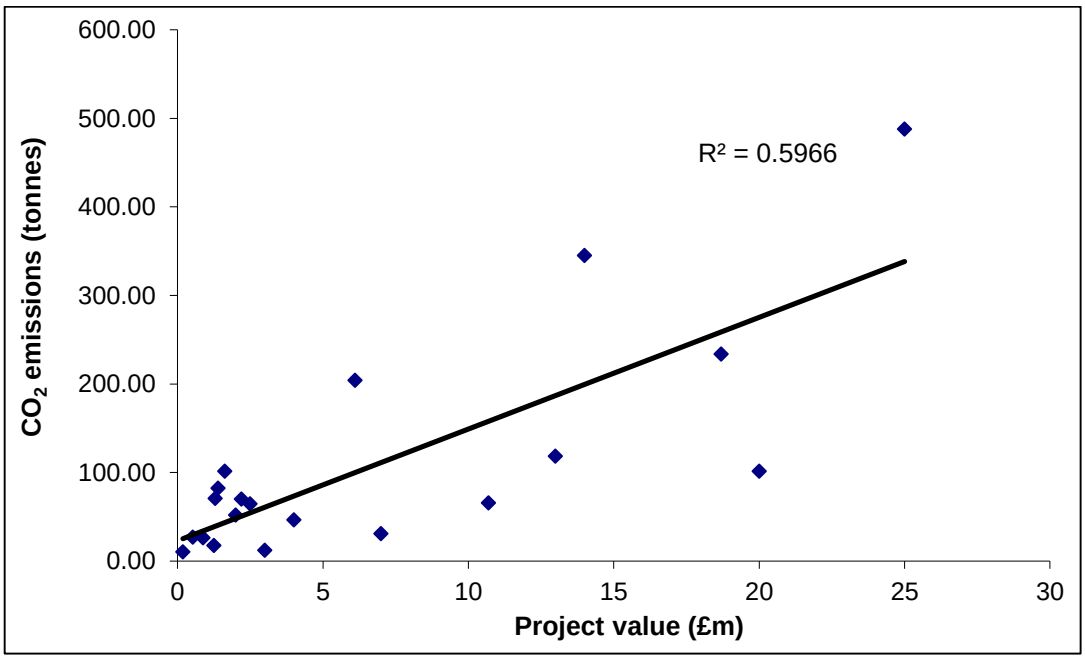


Figure A1.4: Refurbishment & maintenance site emissions, correlation between project value and emissions for the calendar year 2012

A2 Road freight calculations

As there was no DfT road freight data available in 2012, the quantity of different construction commodities moved by road freight was calculated using previous years' road freight and construction output data.

The annual total road freight for each construction commodity for Great Britain, in million tonne km, was plotted against the contractors' construction output for that year to give a linear correlation relationship between the two. The correlation coefficient values for each were very strong (Table 10) giving confidence in the relationship.

Using the linear correlation equation and the construction output for 2012 a total value for each construction commodity for 2012 was estimated. A t-test was done to test the significance of the observed relationship with a resulting p value of <0.05 indicating a strong and significant relationship between road freight and construction output.

The average proportion of each commodity moved by different vehicle type and size from previous years was then applied to the total to estimate the million tonne km for each construction commodity and vehicle type.

Table 10: Construction commodity and the strength of the correlation between the annual road freight and total construction output.

Commodity	R^2 value
Sand gravel and clay	0.98
Cements	0.93
Other building materials	0.96
Total	0.99

Overall there is confidence that this method means the values used to calculate the freight emissions in 2012 are at least comparable with previous years. Although it does mean any changes to improve efficiency of freight transport are not represented in the assessment.

A3 Data quality assessment

Data source	Data set	Data quality	Acceptable	Gaps	Comment
Emissions factors					
Defra (2012), *Guidelines to Defra / DECC's Greenhouse Gas Conversion Factors for Company Reporting* [9]	Emission factors for fuel use, electricity and transport	Relevant			Emission factors apply to the UK, although some simplification of construction processes was needed to use the factors (e.g. average rail freight emission factors without distinguishing between electric and diesel trains).
		Complete			Covers the range of activities (fuel use, electricity use, transport modes) considered in this assessment.
		Consistent			Factors align with Kyoto Protocol inventory methods. Indirect emissions (Scope 3) are provided and this assessment has consistently not applied them, using instead only direct emissions.
		Transparent			Defra/DECC publishes the methodology paper for emissions factors each year.
		Accurate			These are sector or regional averages (secondary data) not specific to sites, projects or processes. However, given the sector and regional scale of the project, this level of accuracy is acceptable.
Site activities (plant, equipment and site offices)					
Contractors' output Office for National Statistics (ONS) (2013), *Construction*	Sector-level site activity	Relevant			Largely relevant as the core services of contractors are in scope.
		Complete			Contractors are required to provide data so the statistics are complete for contractors' output. However, does not cover the revenue/turnover of non-contracting organisations involved in construction processes. It is assumed that the revenue of other organisations will change in proportion to changes in contractors' output. As long as this indicator is consistently

[9] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69554/pb13773-ghg-conversion-factors-2012.pdf

Data source	Data set	Data quality	Acceptable	Gaps	Comment
Statistics Annual [10]					measured and used for each year's calculation, this assumption is acceptable.
		Consistent			Is consistently reported for Great Britain, England, Wales and Scotland each year. Northern Ireland data is not consistent or complete compared to the other regions. Calculation methodology for output has changed in 2010 – this has been addressed in this assessment (through baseline recalculation)
		Transparent			Data sources documented by the Office of National Statistics.
		Accurate			The data set is the most precise available.
Project carbon footprints and project value, provided by individual companies listed in Section 1.3	Emissions intensity (tCO_2 / £100k project value)	Relevant			A sample of projects has been collected directly from companies, covering different project types, new construction and refurbishment.
		Complete			Samples will always be incomplete relative to all live projects and contractors.
		Consistent			As the project data was collated by multiple people, there is a risk that each used different methodologies.
		Transparent			Data is generally provided as litres of fuel and kWh of electricity at project level so it is straightforward to check for data quality.
		Accurate			The correlation between project value and carbon emissions was generally weak to moderate.
Transport – freight					
Department for Transport (2011), *Road Freight Statistics* annual[11]	Road freight movements (tonne-kilometres) for construction	Relevant			Largely relevant, covering a range of construction materials and products. However, does not distinguish between imported and exported materials. It is assumed that the majority of construction materials road freighted in Great Britain are for Great Britain projects.

[10] http://www.ons.gov.uk/ons/publications/all-releases.html?definition=tcm%3A77-211472

[11] http://www.dft.gov.uk/statistics/releases/road-freight-statistics-2010

Data source	Data set	Data quality	Acceptable	Gaps	Comment
	products and materials	Complete			Complete for Great Britain. No data for Northern Ireland.
		Inconsistent			Although a standard methodology to collect and report data for previous years, no data was available for 2012. Previous year's data was used to estimate 2012 using relationship between transport and construction output.
		Transparent			Breakdown of construction materials is suitably detailed, although no breakdown of data between England, Wales and Scotland. To attribute freight between the regions, assumptions were made. Data set also provides break down of types of vehicles used.
		Accurate			The data set is the most precise available up to and including Q1 2011, however complete data for 2012 not yet released.
ORR (2012), *National Rail Trends Data Portal*[12]	Rail freight movements (tonne-kilometres) for construction products and materials	Relevant			Largely relevant, covering the movement of construction commodities by rail in Great Britain. However, does not distinguish between imported and exported materials. It is assumed that the majority of construction materials road freighted in Great Britain are for Great Britain projects.
		Complete			Complete for Great Britain. No data for Northern Ireland.
		Consistent			Standard methodology to collect data for each quarter.
		Transparent			Single figure provided each year with no detail. 'Construction' commodities not defined.
		Accurate			The data set is the most precise available.
Transport – waste removals					
Environment Agency (2012), *Waste Data*	Amount of construction, demolition and excavation waste received by waste facilities	Relevant			CD&E waste for England is relevant to construction processes.
		Complete			Complete for England and Wales, although not available for Scotland and Northern Ireland.
		Consistent			Methodology is consistent and is based on operator site returns. The definition of CD&E waste is consistent with the

[12] https://dataportal.orr.gov.uk/displayreport/report/html/79c33859-004c-486b-b752-cd485b1dba96

Data source	Data set	Data quality	Acceptable	Gaps	Comment
Interrogator 2012[13]	(tonnes per annum)				Sustainable Construction Task Group Waste Sub-Group (i.e. the same waste codes have been used).
		Transparent			Detailed breakdown of waste types is provided.
		Accurate			Although this data set is consistent and replicable each year, there is likely to be double counting, as CD&E waste is moved between facilities.
Off site assembly					
Mtech Group (2007), *Offsite Construction Industry Survey 2006*, Buildoffsite	Value of off-site manufacturing	Relevant			Covers the use of off-site construction in all project types.
		Complete			31% response rate to survey.
		Consistent			One off study knowledge gap for recent trends
		Transparent			Survey methodology is clearly documented.
		Accurate			Sample size is reasonable.
Pan W., Gibb A, Dainty A., (2005), *Offsite Modern Methods of Construction in Housebuilding: Perspectives and Practices of Leading UK Housebuilders*	Value of off-site manufacturing as a proportion of construction output	Relevant			Covers the use of OSM techniques in house building, which is within the target scope.
		Complete			Covers only house building and not the use of OSM for non-domestic buildings and infrastructure.
		Consistent			One off study knowledge gap for recent trends
		Transparent			Data is stated without source and methodology details.
		Accurate			The data is out-dated.
WRAP (2007), *Current Practices and Future Potential in*	Value of off-site manufacturing products as proportion of building materials and products	Relevant			Relates to products, rather than the assembly/installation processes.
		Complete			Addresses OSM products for all construction.
		Consistent			One off study knowledge gap for recent trends
		Transparent			Data is stated without source and methodology details.

[13] http://publications.environment-agency.gov.uk/epages/eapublications.storefront

Data source	Data set	Data quality	Acceptable	Gaps	Comment
Modern Methods of Construction[14]		Accurate			The data is out-dated.
Project and company OSM factory data, project value and/or company revenue, provided by individual companies listed in Section 1.3	Emissions intensity (tCO2 / £ million project value or revenue)	Relevant			Relevant where the factory processes produce construction products. Where possible, assembly processes shall be included and manufacturing processes excluded.
		Complete			No current samples were available; a combination of previous years' data had to be used. This does not reflect the most current use of off-site manufacture; neither does it cover the full range of off-site products available.
		Consistent			Data was collated by multiple people so there is a risk that each will use different methodologies. There are potential inconsistencies in combining project-based data and data from a permanent off-site facility.
		Transparent			Carbon footprints were not provided with details of data sources and assumptions.
		Accurate			The data samples came from a variety different off-site processes and varied greatly. Accuracy and precision limited by lack of data. Data is out of date.
Off-site / corporate offices					
Company off-site office emissions and project site emissions, provided by individual companies listed in Section 1.3	Ratio between office and project site emissions	Relevant			The assessment only made use of data from companies and divisions whose core business is in construction processes. The assessment excluded data from companies with non-construction businesses, where only a proportion of their off-site emissions is relevant.
		Complete			Fourteen companies provided suitable data, more data would provide a better sample of the industry.
		Consistent			As organisational data was collated by multiple people, there is a risk that each has used different methodologies.

[14] http://www.wrap.org.uk/document.rm?id=3663

Data source	Data set	Data quality	Acceptable	Gaps	Comment
		Transparent			Carbon footprints were not always provided with details of data sources and assumptions.
		Accurate			Accuracy and precision limited by lack of data samples.
Business travel					
Company business travel emissions and project site emissions, provided by individual companies listed in Section 1.3	Ratio between business travel and project site emissions	Relevant			The assessment only made use of data from companies and divisions whose core business is in construction processes. The assessment excluded data from companies with non-construction businesses, where only a proportion of their off-site emissions is relevant. Only domestic travel related to construction projects should be included. However, in practice some companies report travel emissions that include non-domestic travel and travel related to non-construction functions. It was difficult to separate these out.
		Complete			Fourteen companies provided suitable data more data would provide a better sample of the industry.
		Consistent			As organisational data was collated by multiple people, there is a risk that each has used different methodologies.
		Transparent			Companies identified the data sources (e.g. fuel cards, depot inventories, mileage).
		Accurate			Accuracy and precision limited by lack of data samples.

Appendix B

Contributors to the Construction Carbon Project

Project Contributors 2008-2012

Advante

Aggregate Industries Europe

Argent Group

Balfour Beatty

BAM Construct

BAM Nuttall

Barhale Construction

Barratt Developments

Blue Planet Buildings

Bovis Lend Lease

BRE Global

British Property Federation

Carbon Clear

Carbon Trust

Carillion

CECA

CEEQUAL Ltd

Central Networks

Centrica

CIRIA

Civil Engineering Contractors Association

Clancy Group

Clugston Construction

Colas

Confederation of British Industry

Constructing Excellence

Construction Industry Council

Construction Products Association

Construction Skills

Costain

Davis Langdon

Department for Transport

Department of Business, Innovation and Skills

Department of Environment, Food & Rural Affairs (Defra)

Dorton Group

EDF Energy

Electrical Contractors' Association

Elliott Group

Energy Saving Trust

Enigma Vehicle Systems plc

Environment Agency

Galliford Try

GenQuip

Glenigan

Hall Construction Services

Hewden

Highways Agency

Hoile Associates

Hydrock

Interserve

JCB

Kier Group

Kotuku CIC

Lafarge

Laing O'Rourke

Land Securities

Leadbitter

Lend Lease

Mace

McLaughlin & Harvey Ltd

McNicholas Construction

Miller Construction

Mineral Products Association

Modular and Portable Building Association

NG Bailey

Ofwat

Osbourne

Parsons Brinckerhoff

Portable Offices (Hires)

Portakabin

Premier Waste

Road Haulage Association

Select Plant

Shepherd

Sir Robert McAlpine

Skanska

Skills for Logistics

Speedy Hire

Springfield

SummitSkills

Techrete

UK Contractors Group

Vinci Construction

Volka Vessels

Waste & Resources Action Programme

Wates

Wernick Group

Willmott Dixon

Wilson James

Wolsley

WSP

WRAP