Carbon Accounting Framework

HA Carbon Accounting Tool – Explanatory Report V1

Working Draft

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This report has been prepared as part of the Climate Change Portfolio of Projects being undertaken by the PB-WSP consortium on behalf of the Highways Agency.

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EXECUTIVE SUMMARY

Following from targets within the Highways Agency's (HA) Sustainable Development Action Plan in June 2007, the HA is seeking to develop a Carbon Accounting Tool, in order to quantify the volumes of Carbon Dioxide (CO_2) and other Greenhouse Gas (GHG) emissions emitted in relation to its construction, maintenance and internal activities. It is envisaged that the Accounting Tool will enable the HA to identify and collect the data required to establish an emissions baseline, from which areas in which reductions and savings can be made would be identified, and meaningful emission reduction targets be sets. The three key objectives of the Accounting Tool are summarised as follows:

- To develop a cost-effective and efficient means of collecting data on GHG's generated from all construction, maintenance and internal operational activities;
- To collect the initial information to allow the establishment of a GHG "footprint"; and
- To supply a method and reporting mechanism for ongoing calculation and management of GHG generation, allowing meaningful targets for emission reduction, and to measure future progress towards these targets.

The need for a cost-effective and efficient accounting methodology is recognised to be of particular importance, given the significant levels of data and information that are likely to be required from the HA's supply chain.

The Accounting Tool is to be developed with reference to existing carbon accounting methodologies, and has drawn upon recognised best practice. As such, it was agreed that the GHG Protocol Corporate Standard would form the basis for evolving the Accounting Tool, which is an internationally recognised standard for emissions reporting.

To date, the Accounting Tool has been developed around the following Reporting Areas: (i) HA Internal Operations; (ii) HA Network Operations; (iii) HA Major Projects; (iv) HA Managing Area Contractors; (v) HA Design-Build-Finance-Operate Contracts; and (vi) Tolling Stations. The assumed reporting boundaries for the above are detailed within this Explanatory Report. The overall scope of the Accounting Tool is to cover all operations and activities over which the HA has control, which is defined in terms of financial or contractual commitments for which the HA is ultimately responsible. This includes the responsibility of its supply chain.

A range of GHG's are commonly included within GHG Inventories, with each having a differing capacity to cause global warming. The Accounting Tool has been extended to include those GHG's covered by the Kyoto Protocol. Therefore, the use of the term CO_2 is taken to include both emissions of carbon dioxide, and other GHG's expressed as Carbon Dioxide Equivalents (CO_2e). Carbon emissions and emission sources have been categorised in terms of the following main emission categories: energy, materials, transport, and waste removal. Emissions are to be calculated or estimated based upon published emission factors, which converts a given measure of activity (e.g. distance driven in a car) into a volume of GHG emissions. Where necessary, certain conversion factors have been utilised in order to convert measures in activities into appropriate units (e.g. from cubic metres to tonnes), so that emission factors can be applied.

It is recognised that certain assumptions and uncertainty are both an inherent part of this approach to Carbon Accounting, and certain data limitations will persists. However, the adopted 'tiered' approach to the Accounting Tool will allow future developments and clarifications as deemed necessary. Assumptions regarding the data collection model have been made, in terms of the sourcing and supply of relevant data to feed up into the Accounting Tool. There is likely to be a degree of administrative burden, and associated financial cost, associated with the implementation and operation of the Accounting Tool, and new areas of data collection are likely to be required and pose particular issues – with the key challenge being identified as adequately sourcing data from the supply chain. Such issues require due consideration, so that the implemented Accounting Tool is not overly cumbersome, but at the same time is not limited in achieving its purpose.

As part of the Accounting Tool development process to date, a number of issues and areas for future refinement and development have been identified in terms of tool clarifications and enhancements, the tool implementation phase, and areas of further research. A key aspect is recognised to be the development of a Carbon Management Strategy (CMS), so that the Accounting Tool can be fully utilised as a management and decision-making tool, and through enhanced efficiencies, to realise both financial and emission reduction benefits.

INTRODUCTION

1.1 TERMS OF REFERENCE

Parsons Brinckerhoff Ltd (PB) has been commissioned by the Highways Agency (HA) to develop a Carbon Accounting Tool (hereafter referred to as the 'Accounting Tool'), in order to quantify the volumes of Carbon Dioxide (CO_2) and other Greenhouse Gas (GHG) emissions emitted in relation to the HA's construction, maintenance and internal activities. This Commission forms part of the Research and Development SSR Framework, and the Climate Change Portfolio.

In June 2007, the HA published its first Sustainable Development Action Plan (SDAP), which established the target to investigate the Agency's GHG / Carbon Footprint. Moreover, the HA also set objectives to identify potential future actions for reduction. As part of this Commission, the HA has therefore requested a methodology to allow the development of a Carbon Accounting Tool for the Agency's operational, construction and maintenance activities. Details of the organisational and operational boundaries adopted within the Accounting Tool are included within Section 3 (Tool Development) of this Explanatory Report. An accompanying Accounting Tool Instruction Manual has been produced in order to facilitate the use of the Accounting Tool by the User.

Within the Task Specification, separate Accounting Tools for the 'Operational' and 'Construction and Maintenance' components were envisaged. However, following discussions during initial Consortia Progress Meetings it was determined that, due to the inherent overlap between the two, these components would be integrated as part of a single Accounting Tool.

The Accounting Tool will enable the HA to identify and collect the data required to establish an emissions baseline, from which the Agency can begin to identify areas in which reductions and savings can be made, and meaningful targets may be set. As such, the three objectives of the Accounting Tool are summarised as follows:

- To develop a cost-effective and efficient means of collecting data on GHG's generated from all construction, maintenance and internal operational activities;
- To collect the initial information to allow the establishment of a GHG "footprint"; and
- To supply a method and reporting mechanism for ongoing calculation and management of GHG generation, allowing meaningful targets for emission reduction, and to measure future progress towards these targets.

The need for a cost-effective and efficient accounting methodology is recognised to be of particular importance, given the significant levels of data and information that are likely to be required from the HA's supply chain. Consequently, it will be necessary to implement an Accounting Tool that has been designed in a user-friendly manner; that covers the wide range of operations and activities; and reduces the administrative burden to a workable minimum.

In adopting a Carbon Accounting Tool, the HA is seeking to actively reduce its direct and indirect emissions, in terms of establishing targets for reductions both internally and from within its supply chain. It is envisaged that financial and emission benefits within the HA's operation will be obtained through the promotion of Carbon Management practices, both internally, and through the supply chain with enhanced efficiencies in the operation of the HA's Managing Area Contractors (MACs) other and subcontractors.

A list of abbreviations used throughout this Report is included within Annex 1, and a glossary of terms within Annex 2. A reference list is included within Annex 3.

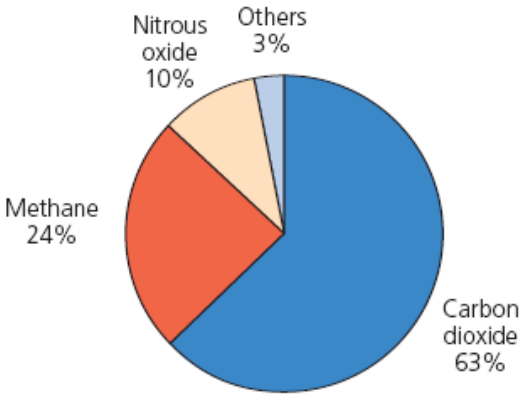
1.2 PROJECT RATIONALE AND NEED

1.2.1 UK Climate Change Programme

Since the Kyoto Protocol entered into force in February 2005, the UK Government has set plans to deliver its target to cut GHG emissions by 12.5%, and move towards a domestic goal to cut CO_2 emissions by 20% below 1990 levels by 2010. The Government estimates that the proposals in the 2006 UK Climate Change Programme could reduce the UK's GHG emissions to approximately 23-25% below 1990 levels by 2010, and comfortably beyond the UK's Kyoto target. The Government has since introduced a Climate Change Bill, which puts into statute targets to reduce CO_2 emissions by at least 60% by 2050, and by 26-32% by 2020, relative to a 1990 baseline. The Bill was introduced into the House of Lords in November 2007, with the aim to receive Royal Assent by early summer 2008.

CO_2 is recognised to be the most important anthropogenic GHG, with annual global emissions having grown by 80% between 1970 and 2004, from 21 to 38 giga-tonnes. In 2004, CO_2 reportedly constituted 77% of total anthropogenic GHG emissions[1]. Figure 1.1 illustrates the relative importance of specific GHGs in terms of their anticipated contribution to global warming within the next Century.

Figure 1.1 Relative Contribution to Global Warming of Current Emissions of GHGs within the Next Century (Source: HM Government (2006). Climate Change – The UK Programme 2006).



1.2.2 Role of the HA

The HA's SDAP recognises that the HA's activities and operations have important implications for GHG emissions and for sustainability. As such, it is stated that "…o*ur construction and maintenance programmes use resources, aggregates, energy and water. We produce emissions to air and water as well as waste of which we need to dispose. Our network goes through towns, cities and rural areas where residents, fauna and flora are affected by noise and other emissions*". The key sustainability issues in relation to the HA's business, in relation to the national context, are identified within Figure 1.2, with climate change and energy constituting a key area of concern.

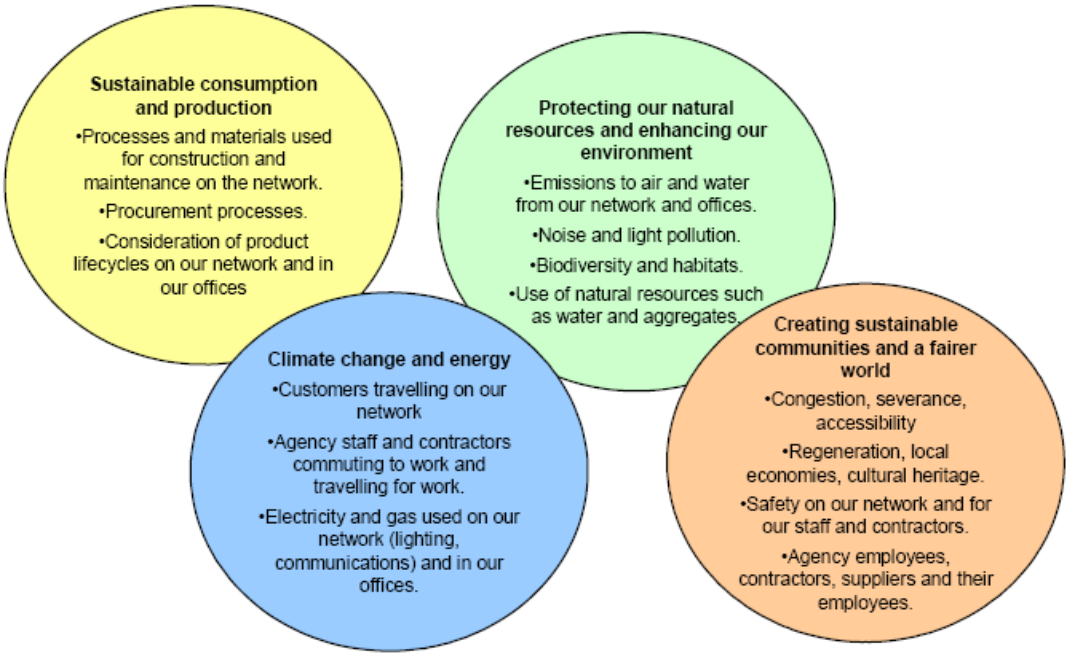
Furthermore, within the 2006 UK Climate Change Programme the public sector is considered to be "…*in a key position to lead on carbon emissions reduction by setting a behavioural and strategic example to the private sector*". As such, in June 2006, the Prime Minister launched challenging new targets for sustainable operations on the Government estate, which in relation to carbon emissions require the following:

- A reduction in office carbon emissions by 12.5% by 2010-11, relative to 1999/2000 levels;
- A reduction in office carbon emissions by 30% by 2020, relative to 1999/2000 levels;
- Reduce carbon emissions from road vehicles used for Government administrative operations by 15% by 2010/11, relative to 2005/2006 levels;
- Central Government's office estate to be carbon neutral by 2012;
- Departments to increase their energy efficiency per m^2 by 15% by 2010, relative to 1999/2000 levels; and
- Departments to increase their energy efficiency per m^2 by 30% by 2020, relative to 1999/2000 levels.

[1] IPCC (2007). Fourth Assessment Report – Climate Change 2007: Synthesis Report.

As a Government Agency, the HA is therefore committed to contributing to the Government's targets for GHG emissions reductions. However, before the HA can set about implementing measures to reduce its emissions, it is first necessary to establish and quantify current levels through an emission baselining process.

Figure 1.2 HA's Key Sustainability Impacts against UK Priorities (Source: HA (2007). Achieving Sustainability – The Highways Agency's Sustainable Development Action Plan 2007-08).



1.2.3 Carbon Management

Carbon Management, by its inherent nature, requires a comprehensive approach that can impact positively upon all areas of an organisations operation. With regard to the HA, this refers to not only the internal operations, but also from within the supply chain. Improvements in business performance are often driven by financial factors such as rising energy costs, and the Climate Change Levy (CCL). The adoption of a Carbon Management Strategy can not only provide financial benefits, for example through reducing the burden of the above, but can simultaneously provide emissions reductions and reduce environmental impacts.

Adopting a GHG emission reduction target is often the logical follow-up to the Carbon Accounting process, since this target can essentially drive moves towards emissions reductions, raise awareness, and ensure that the issues remains upon the business agenda. Key drivers for Carbon Management and adopted emission targets include the following[2]:

- To minimise and manage GHG risks from climate change;
- Achieve cost-savings and stimulate innovation and resource efficiency;
- Assist preparation for future GHG regulation;
- Demonstrate leadership and corporate responsibility; and

[2] See World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD). (2004). *The Greenhouse Gas Protocol –A Corporate Accounting and Reporting Standard.*

- Facilitate participation in voluntary GHG programmes.

The development of a Carbon Management Strategy (CMS) is discussed further within Section 6.4 (Carbon Management Strategy). In developing a CMS, the role and responsibility of the HA would require due consideration in relation to the Department for Transport (DfT), and consultations would therefore be required.

2 EXISTING AND ADOPTD ACCOUNTING METHODOLOGIES

2.1 INTRODUCTION

As detailed within the Task Specification, the Accounting Tool has been developed with reference to existing carbon accounting methodologies, and has drawn upon recognised best practice. A wide variety of methodologies are available, either publicly or through data purchase. To date, the development of the HA's Accounting Tool has focused upon information and methodologies that are publicly available, and therefore no supplementary data or information has been acquired. Such methodologies range from Government-led initiatives, to academic research tools, and carbon calculators developed by the private sector. An initial review of existing guidance documents, data and information has been undertaken in order to establish the nature of current best practice to which the HA's Accounting Tool should conform. A summary of the key information reviewed is provided below.

2.2 EXISTING GUIDANCE AND DATA SOURCES

2.2.1 GHG Protocol – Corporate and Project Accounting and Reporting Standards

Originally published in 2001 and revised in 2004, the Standards were prepared jointly by the World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI), and are reportedly the most widely used international Accounting Tool[3]. The Standards consist of the following products:

- *The GHG Protocol Corporate Standard*; and
- *The GHG Protocol for Project Accounting.*

The Standards are globally recognised tools, and are based upon step-by-step approaches to carbon accounting at the corporate and project level. These tools are taken to represent current best practice and as such have been selected as the basis of the HA's Accounting Tool. Further details are provided within Section 3.3 below. The guidance document are complemented by a number of cross-sector and sector-specific calculation tools that are consistent with those proposed by the Intergovernmental Panel on Climate Change (IPCC).

2.2.2 BS ISO 14064-1 – Specification with Guidance at the Organization Level for Quantification and Reporting of Greenhouse Gas Emissions and Removals

This part of ISO14064 details principles and requirements for designing, developing, managing, and reporting for organisation level GHG inventories. This standard incorporates many key concepts and requirements of the GHG Protocol above and is therefore consistent.

2.2.3 DEFRA's Environmental Key Performance Indicators

Guidance is provided within DEFRA's 'Environmental Key Performance Indicators (KPI) - Reporting Guidelines for UK Business' (2006) regarding how to report the 22 KPI considered to be significant to UK businesses – under the following key areas: emissions to air, emissions to water, emissions to land, and resource use. The Guidance also highlights the importance of supply chains and products. GHGs feature as a key KPI under emissions to air, and as such various emission factors are published annually to provide guidance for company reporting. Current factors for 2007 that are utilised within the Accounting Tool are detailed within Annex 6. A revised Annex to the DEFRA guidance is published annually, including revised and updated factors from previous years, in addition to new emission factors following new areas of research.

2.2.4 Carbon Trust Guidance

The Carbon Trust approach to carbon footprinting makes direct reference to the GHG Protocol and ISO14064, and is based upon the following five main steps: (i) define the methodology; (ii) specify the boundary and scope of coverage; (iii) collect emissions data and calculate the footprint; (iv); verify results (optional); and (v) disclose the footprint (optional). The guidance document 'Energy and Carbon Conversations', provides details to calculate energy consumption in common units, and to work out CO_2 emissions associated with energy use. The document is however currently out of date following subsequent revisions by DEFRA to emission factors.

[3] The Tools and associated guidance are available from www.ghgprotcol.org

2.2.5 Waste Resources Action Programme (WRAP) and AggRegain

The WRAP provides information on recycling and sustainability across various sectors including: construction, composting, retail, manufacturing, local authorities, businesses, and home, garden, schools and communities. AggRegain is a sustainable aggregates information service provided by the WRAP Aggregates Programme, and includes a CO_2 emissions calculator specifically designed for the construction industry[4]. The tool assesses the output of emissions from four types of construction application: bitumen bound, concrete, hydraulically bound and unbound. The output is an "estimate of the savings in CO_2 realised by selecting sustainable construction techniques and recycled/secondary materials. Users can also access the background calculations, where the carbon dioxide arising from different processes (e.g. embodied energies, transport, construction techniques) are estimated, and the data used" (WRAP 2007).

2.2.6 Environment Agency (EA) Carbon Calculator for Construction Activities

The EA's Calculator was launched in November 2007[5], in order to force considerations of resource efficiency and sustainable construction and has been specifically designed to consider carbon emissions from the construction of flood and coastal defences, including embodied CO_2 of materials and their transportation. The tool excludes carbon emissions derived through EA operations, and its largely based upon CO_2 emission factors from the Inventory of Carbon and Energy, provided by the University of Bath (see below).

The tool has been designed for use mainly at the pre and feasibility stages, outline and detailed design stages, with a focus on incorporating sustainable construction at the design stage. The main emissions sources incorporated by the tool are those associated with travel, transportation, site activities and waste management. Carbon volumes are expressed as tonne of carbon per tonne of material (t/CO_2). The calculator was developed on the assumption that those using it would have a Bill of Quantities (EA 2007; CIWEM 2007).

2.2.7 Inventory of Carbon & Energy (ICE)

The Inventory of Carbon & Energy Version 1.5a Beta (hereafter referred to as the 'Bath Inventory') was developed by Bath University in November 2006. The Bath Inventory was joint funded under the *Carbon Visions Buildings* program by the Carbon Trust and Engineering and Physical Research Council. The aim of the project was to create an inventory of building materials with values of embodied energy and carbon coefficients. The data in the inventory was compiled using secondary data resources. As such, the boundaries for data reporting vary between the materials listed in the Inventory, and wide margins of error and uncertainty are reported. The Bath Inventory however represents an important reference document for emission factors for construction materials, and is commonly referred to within Accounting Tools.

2.2.8 Publicly Available Specification (PAS) 2050 – Specification for the Measurement of the Embodied Greenhouse Gas Emissions in Products and Services

British Standards Institution (BSI) is currently being co-sponsored by DEFRA and the Carbon Trust to develop a PAS for the measurement of the embodied GHG emissions of products and services. The aim of PAS 2050 is to provide a method for measuring embodied GHG emissions of products and services for organisations e.g. business, to effectively measure the climate change related impacts of their products and services with a view to using this information to improve the climate change related performance of these.

PAS 2050 also contributes to benchmarking ongoing business programmes aimed at reducing GHG emissions, and provides a common basis from which GHG emissions assessments can be reported and communicated to stakeholders and consumers. PAS 2050 is still in its draft stage and currently undergoing stakeholder review and consultation.

2.3 ADOPTED METHODOLOGY

2.3.1 GHG Protocol Corporate Standard

Following from the above, it was determined during a Consortia Progress Meeting on 4th December 2007 to adopt the GHG Protocol Corporate Standard as the basis for evolving the Accounting Tool. As indicated

[4] See http://www.aggregain.org.uk/sustainability/try_a_sustainability_tool/co2_emissions.html

[5] See http://www.environment-agency.gov.uk/business/444304/502508/1506471/1506565/1508048/1883907/?lang=_e

above, this particular methodology is an internationally recognised standard for emissions reporting, and as such has been designed with the following objectives in mind:

- To help organisations prepare a GHG inventory that represents a true and fair account of their emissions, through the use of standardised approaches and principles;
- To simplify and reduce the costs of compiling a GHG inventory;
- To provide information that can be used to build an effective strategy to manage and reduce GHG emissions;
- To provide information that facilitates participation in voluntary and mandatory GHG programs; and
- To increase consistency and transparency in GHG accounting and reporting among organisations and GHG programs.

The Corporate Standard establishes the following five accounting principles, which set an implicit standard for the faithful representation of an organisations GHG emission through its technical, accounting, and reporting efforts:

1. *Relevance* – Ensuring that GHG Accounts appropriately reflect the emissions of the organisation and serves the decision-making needs of users;
2. *Completeness* – Accounting for and reporting all GHG emission sources and activities within the chosen inventory boundary, whilst disclosing and justifying any specific exclusions;
3. *Consistency* – Ensuring the use of consistent methodologies to allow for meaningful comparisons of emissions over time, and to transparently disclose any changes to data, inventory boundaries, methods, or any other relevant factors in the time series;
4. *Transparency* – Addressing all relevant issues in a factual and coherent manner, based on a clear auditable trail. Disclose any relevant assumptions and make appropriate references to the accounting and calculation methodologies and data sources used; and
5. *Accuracy* – Ensuring that the quantification of GHG emissions is systematically neither over nor under actual emissions, as far as can be judged, and that uncertainties are reduced as far as practicable. Achieve sufficient accuracy to enable users to make decisions with reasonable assurance as to the integrity of the reported information.

2.3.2 Conformance with BS ISO 14064-1

In addition to the Corporate Standard, as a quality check and cross-reference, it has been determined to develop the Accounting Tool in accordance with the provisions of BS ISO 14064-1. Following a review, the principles of both methodologies are very similar, and there exist few differences[6]. The Accounting Tool will therefore be consistent with both the Corporate Standard and BS ISO 14064-1 requirements. It should be noted however that at this stage, certain requirements, procedures and processes outlined within the above remain unfulfilled, in relation to the categorisation of emission into direct and indirect sources (as detailed further below), and whereby aspects of the Standard have not yet been encountered as part of this Commission.

2.3.3 Direct and Indirect Emissions

Within the Corporate Standard, emissions are separated into three categories:

- Scope 1 – Direct GHG Emissions;
- Scope 2 – Electricity Indirect GHG Emissions; and
- Scope 3 – Other Indirect GHG Emissions.

Direct GHG emissions are defined as those which occur from sources either owned or controlled by the reporting organisation. Whereas indirect emissions occur as a consequence of the activities of the reporting organisation, although at sources owned or controlled by another organisation / company. This distinction therefore recognises that not all emissions will be directly attributable to an organisation, but are however relevant. For example, emissions may be emitted at a location other than one under the control

[6] See http://www.ecologia.org/ems/ghg/news/cop9/comparison.html for further details.

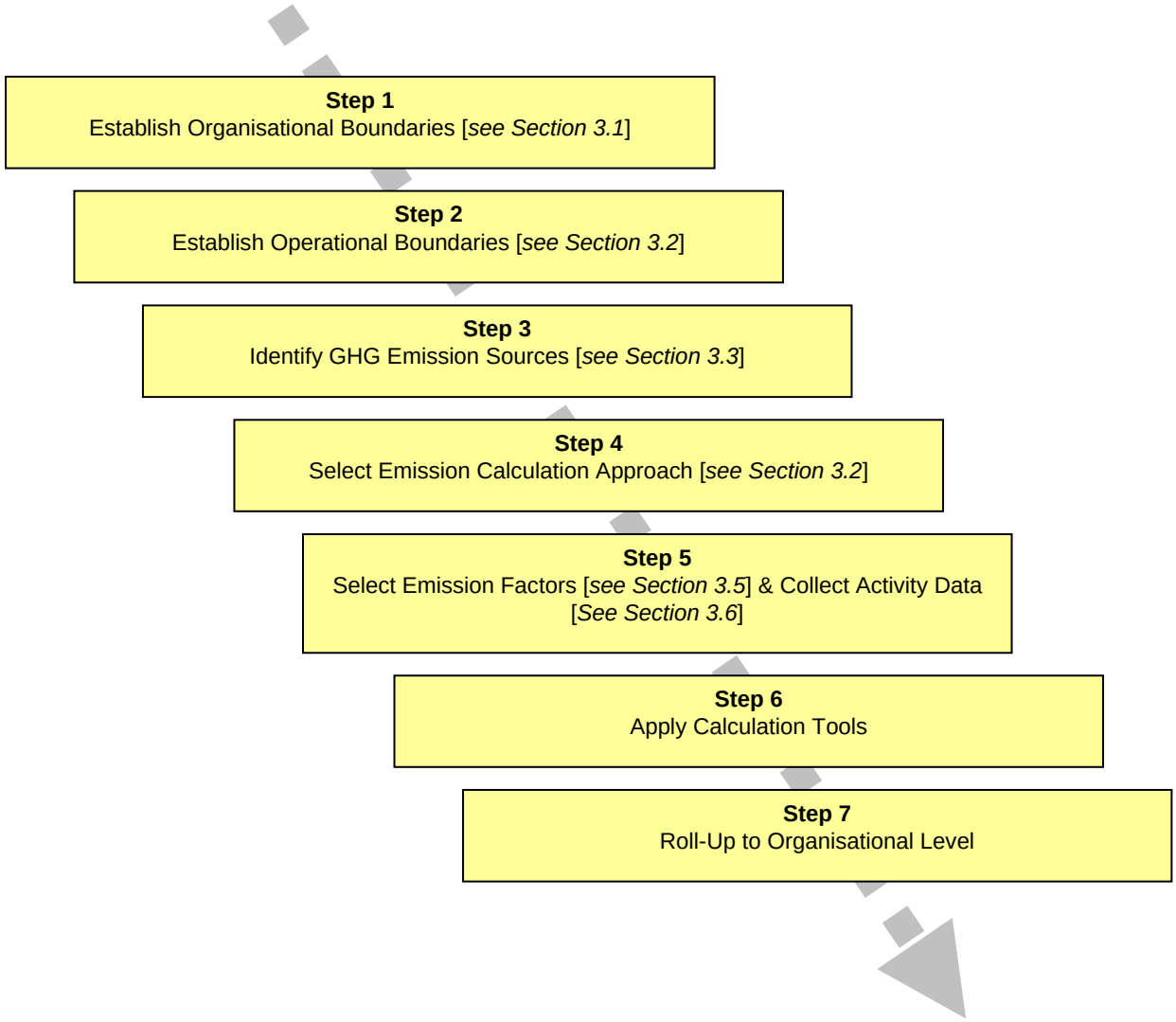
of the HA, such as at power stations that supply the HA's electricity demands. The classification of emissions may also depend upon the determined organisational boundaries (see Section 3.1).

[**Note**: *Within the Accounting Tool, given that the organisational boundaries require finalisation following the initial review process, the classification of emissions as direct or indirect has not been included at this stage. This should however be developed as part of any future works following detailed consultations with the HA. These should establish which emissions, particularly indirect emissions, are likely to be of particular significance with the HA-wide context*]

2.3.4 Corporate Accounting Process

The Corporate Standard outlines the general process illustrated within Figure 2.1 below, which is to be followed when creating a GHG Inventory. The relevant steps within the process are elaborated further within Sections of this Report as indicated.

Figure 2.1 GHG Protocol Corporate Accounting Process



3 TOOL DEVELOPMENT

The Accounting Tool is at present a Microsoft Excel application, comprising the following seven workbooks:

- HA Carbon Account;
- HA Carbon Accounting Tool for Internal Operations;
- HA Carbon Accounting Tool for Network Operations;
- HA Carbon Accounting Tool for Major Projects;
- HA Carbon Accounting Tool for Managing Area Contractors (MACs);
- HA Design-Build-Finance-Operate (DBFO) Contracts; and
- Tolling Stations.

To minimise complexity, the above workbooks are not linked through macros or other formulae, and as such can be used independently of one another. Each workbook contains multiple worksheets for data entry.

3.1 STEP 1 – SETTING ORGANISATIONAL BOUNDARIES

With regard to the nature of the HA's operations, it is recognised that both the construction and maintenance activities are undertaken either internally by the HA itself, and externally on behalf of the HA by its Managing Agent Contractors (MACs) or other sub-consultants / contractors. It is therefore necessary to firmly establish the reporting boundaries of the HA Account, and give due consideration to the inclusion / exclusion of given 'direct' and 'indirect' emission sources (see Section 3.3).

With regard to setting the organisational boundaries for Reporting, in terms of where the responsibility for particular emissions might lie, the GHG Protocol specifies the following two approaches:

- under the *equity share approach*, an organisation accounts for GHG emissions from operations according to its share of equity in (business) operations; whereas
- under the *control approach*, an organisation accounts for 100% of the GHG emissions from operations over which it has control. Organisations do not account for GHG emissions from operations in which it owns an interest, but has no control of. 'Control' can be defined in either financial or operational terms.

The need to specify a particular method arises due to variations in legal and organisational structures of organisations, as certain activities may be wholly owned operations in themselves, incorporated and non-incorporated joint ventures, or subsidiary operations for example.

Within the context of the HA, the scope of the Accounting Tool has been determined to extend across all operations and activities over which it reasonably has control. As indicated above, control is defined or equated to financial or contractual commitments for which the HA is ultimately responsible, including its supply chain. It is recognised that in allocating supply chain GHG emissions within the HA's control, should suppliers be reporting GHG emissions of their own activities as a separate exercise, the such those emissions in relation to HA contractual obligations may be double counted. Since the HA's emission reporting will not contribute to a higher level of reporting[7], such as a national emissions inventory, such potential for double-counting is not considered to be of significance at this stage. Furthermore, the methodology outlined within the GHG Protocol Corporate Standard – in terms of distinguishing between Scope 1 and Scope 2 emissions (see Section 2.3.1) and the optional reporting of Scope 3 – ensures that two or more companies / organisations would account for emissions in the same scope.

It should be noted that the operational boundary of the Accounting Tool **does not** extend to include emissions associated with the use of the road network by drivers. During Consortia Progress Meetings, the inclusion of emissions related to changes in traffic flows as a result of traffic management measures was discussed. Given the relative complexity in calculating robust emission estimates in relation to this, this particular aspect has not been included within the operational boundary of the Accounting Tool at this

[7] Although it will contribute to the Government's Sustainable Operations on the Government Estate (SOGE) reporting process which includes emissions reporting.

stage. However, this issue is discussed further within Section 6 (Tool Development), in terms of its relevance

3.2 STEP 2 – SETTING OPERATIONAL BOUNDARIES

At the outset of the Commission, the HA proposed that two separate Carbon Accounting Tools be developed, in order to cover: (i) operational activities; and (ii) construction and maintenance activities undertaken by the Agency (or on behalf of the Agency). Although the focus and application of the Accounting Tools may differ between these activities, due to the similarities of the data to be recorded, interrogated and interpreted, it was agreed that the development and application of both Accounting Tools should be carried out concurrently.

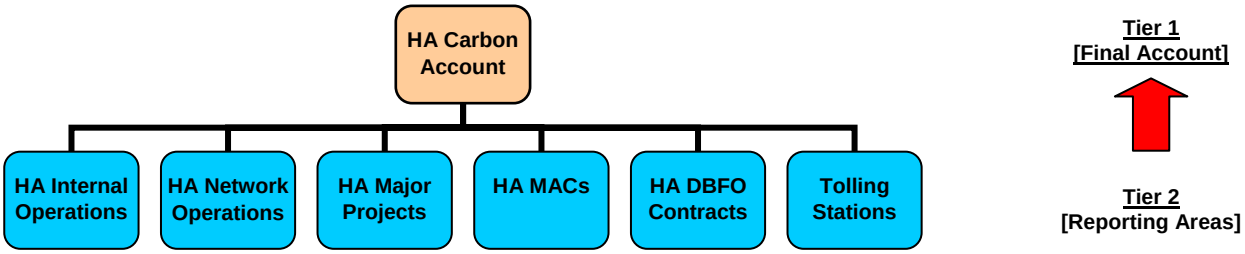
During the Consortia Progress Meeting held on 4th December 2007, the general approach to the Carbon Accounting process was determined. It was agreed that the Accounting Tool should evolve around a modular approach to enable clear identification of the broad business areas of the HA. Given the Commission's timescales, it was recognised that Version 1 of the Accounting Tool would not consist of a final methodology, but would rather define the key areas of GHG emissions of the HA, and establish the initial methodology to enable their relative quantification and reporting. As such, certain aspects included within the presented Accounting Tool are recognised to be areas pf future clarification and development, so that the Tool can be developed to fully meet the HA's requirements with regard to the objectives outlined within Section 1.1 (Terms of Reference).

The Accounting Tool has been developed around the following six key operational areas:

- *HA Internal Operations;*
- *HA Network Operations;*
- *HA Major Projects;*
- *HA Managing Area Contractors;*
- *HA DBFO Contracts; and*
- *Tolling Stations.*

These key areas form the second reporting tier of the Accounting Tool, referred to as 'Reporting Areas'. The reporting structure of the Accounting Tool is illustrated within Figure 3.1, and the initial first two 'Tiers' of the HA Carbon Account.

Figure 3.1 HA Carbon Account Reporting Areas



The tiered approach to the Accounting Tool will allow respective layers of data / information to feed up into the next level of Reporting and, importantly, allow progressive development and refinement into the future. As such, once data has been compiled for all Reporting Areas, these will be "rolled up" to the final HA Carbon Account. This will provide the HA will a holistic illustration of the total emissions the HA are responsible for, either directly or indirectly, and subsequently deliver its 'Carbon Footprint'.

The assumed operational boundaries within each Reporting Area (i.e. those facilities / offices which will report up to each Reporting Area) are defined within Table 3.1 below.

Table 3.1 Operational Boundaries for Reporting Areas

Reporting Area	Operational Boundaries
HA Internal Operations	Reporting to cover: ➢ HA Offices – Bedford, Birmingham, Bristol, Dorking, Exeter, Hemel Hempstead, Leeds, London, and Manchester. ➢ National Traffic Control Centre – Understood to be a shared facility with the Police, and therefore only the HA's proportion should ultimately be accounted for. ➢ Regional Control Centres (including 31 Outstations) – East, East Midlands, North East, North West, South East, South West, and West Midlands.
HA Network Operations	Reporting to cover emissions in relation to electricity consumption for network lighting, ITS Communication System and Vehicle Restraint Systems. Embodied carbon is to be included for network operation fixtures, and maintenance in relation to these fixtures only. At present it has been agreed to present the HA Network Operations as a separate Reporting Area. However, it is however recognised that there may exist a degree of overlap particularly in relation to the HA MAC Account. This issue will therefore require clarification. This aspect has been developed based upon the Capita Symonds Carbon Footprint of Motorway Electrical Equipment (January 2008).
HA Major Projects	Reporting to cover all on-going major projects within the defined reporting period. Such projects typically include those of > £5million (this represents a total scheme cost, and not costs incurred during the reporting period). It has been agreed that emissions are to be accounted for at the point of purchase, rather than across the lifespan of an asset.
HA MACs	Reporting to cover: ➢ MAC Areas – (1) Cornwall & Devon; (2) Somerset, Avon, Wilts, Gloucs, Devon; (3) Berks, Bucks, Dorset, Hants, Surrey & Oxon; (4) Kent, Surrey, East Sussex & West Sussex; (5) Berks, Bucks, Essex, Herts, Kent & Surrey (M25); (6) Essex, Cambs, Suffolk & Norfolk; (7) Leics, Notts, Lincs & Derbyshire; (8) Bucks, Herts, Beds, Essex, Cambs & Northants; (9) Gloucester, Worcester, West Midlands, Warwickshire, Staffordshire; (10) Cheshire, Merseyside, Greater Manchester, South Lancashire; (11) Northants, Warwicks, Leics, Staffs, Shropshire; (12) Cumbria & North Lancashire; (13) Yorkshire & North Lincolnshire; and (14) Northumberland, Tyne & Wear, Durham & North Yorkshire. This boundary is inclusive of MAC offices, compounds, salt barns, and any other operational depots contributing to HA financed / contracted activities.
HA DBFO Contracts	Reporting to cover all on-going HA DBFO Contracts. It has been agreed that emissions are to be accounted for at the point of purchase, rather than across the lifespan of an asset. It is recognised that there may exist a degree of overlap particularly in relation to the HA MAC Accounts and works undertaken as Major Projects. This issue will therefore require clarification.
Tolling Stations	Reporting to cover any maintenance and construction activities pertaining to existing Tolling Stations owned and operated by the HA. Construction of any future Tolling Stations will also be included within the reporting as appropriate. It is recognised that there may exist a degree of over lap in relation to other construction activities of the HA, particularly in relation to Major Projects. This issue will therefore require further clarification.

The GHG Protocol advises that "…*setting operational boundaries that are comprehensive…..will help a company better manage the full spectrum of GHG risks and opportunities that exist along its value chain*". Therefore, in establishing the scope of the HA's operational boundaries, from the outset an inclusive approach has been adopted.

Given the nature of the HA's operations and its organisational structure, it is envisaged that indirect emissions will form a significant component of the HA Carbon Account – given the range of operations that are conducted on its behalf by MACs or other sub-contractors for example. Each of the six Reporting Areas will therefore be required to collate relevant data from various sources, including supply chain data. The potential issues and difficulties in relation to data collection are however fully recognised and discussed further within Section 5 (Uncertainty and Risks).

Reviewer Question 1:

Are the Reporting Areas and Operational Boundaries outlined above considered to be sufficient to capture all emission arising's and data from the HA's operations?

Does there exist overlap between the HA MACs, DBFO and Tolling Station Reporting Areas, and how might this be overcome?

3.3 STEP 3 – IDENTIFYING EMISSION SOURCES

3.3.1 GHG Coverage

A range of GHG's are commonly included within GHG Inventories. GHGs have a differing capacity to cause global warming – dependent upon radiative properties, molecular weights, and atmospheric residence times. The index of Global Warming Potentials (GWP), as published by the IPCC, can be used to assess the relative global warming effect of the emissions of different gases over a defined time period. This period is usually taken to be one hundred years, and is calculated relative to the emission of an equal mass of CO_2. The GWP of each GHG may therefore be expressed in CO_2 equivalents (CO_2e), and indicates that for those gases with a high GWP, a relatively small emission can still have a considerable relative impact. The use of CO_2e and other conversion calculations for GHG's other than carbon and CO_2 incorporates an inherent degree of scientific uncertainty (for further details see Section 5.1 – Uncertainty).

The six GHGs covered by the Kyoto Protocol[8], and commonly reported on, are summarised within Table 3.2 in terms of their relative GWP. In accordance with the GHG Protocol Corporate Standard, other GHG emissions that are not covered by the Kyoto Protocol such as Chlorofluorocarbons (CFCs) or Nitrogen Oxides (NOx), can be reported separately if desired. These have not been included within the HA Accounting Tool to date.

Table 3.2 GWP of Kyoto Gases (Source – DEFRA Emission Factors, 2007)

Kyoto Protocol Gas	GWP over 100 Years
Carbon Dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous Oxide (N_2O)	310
Sulphur Hexafluoride (SF_6)	23,900
Perfluorocarbons (PFCs)	6,500-9,200
Hydrofluorocarbons (HFCs)	140-11,700

Within the Accounting Tool, the use of the term 'CO_2' has been taken to include both emissions of carbon dioxide, and other GHG's expressed as CO_2e. As such, certain emission factors which have been used calculate emissions of CO_2 only, whereas other emission factors are expressed in CO_2e. Best practice recommends that different units should be reported separately; given the relative scientific uncertainly surrounding the application of CO_2e (see Section 5.1 - Uncertainty). As present, these are currently calculated and reported together, and it is recognised that future refinements would be required. Such

[8] See Annex A of United Nations (1998). Kyoto Protocol to the United Nations Framework Convention on Climate Change.

clarification includes the investigation of reference data sources such as the Bath Inventory, in terms of its GHG coverage, as this forms a key reference source for emission factors as detailed further within Section 3.5 (Step 5 – Selecting Emission Factors).

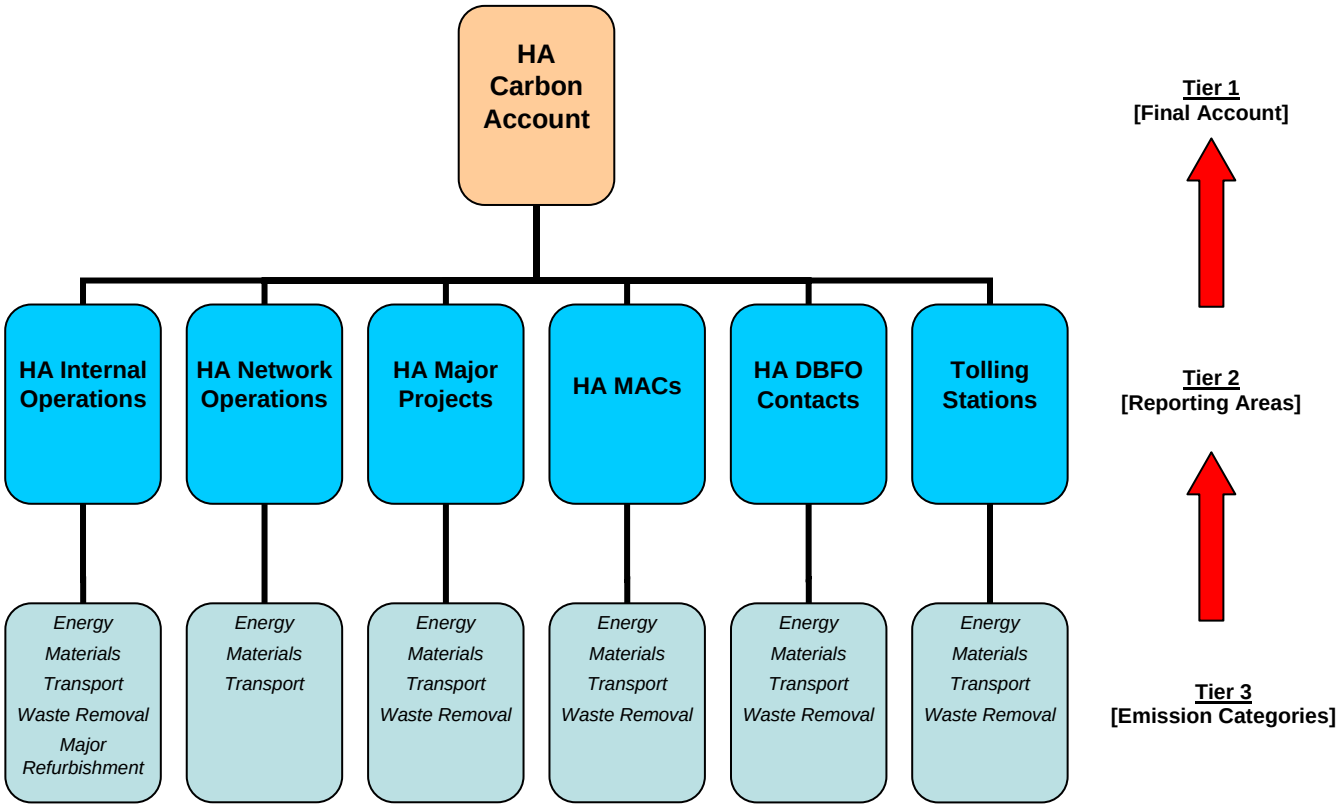
3.3.2 Tier 3 - Emission Categories

Once the organisational and operational boundaries above were established, the likely emissions associated with the HA's operation and maintenance activities as a whole were identified. Initial key emission sources for the Tier 2 Reporting Areas have been established, subsequently classified under the following Emission Categories, which form 'Tier 3' of the Accounting Tool:

- *Energy;*
- *Materials* (Note: a distinction has been made within the HA Internal Operations Account between typical office materials that may be consumed, and those potentially used as part of major office build / refurbishment works. A further category '*Major Refurbishment*' has therefore been included within this particular Account);
- *Transport; and*
- *Waste Removal.*

The Emission Categories outlined above are considered to sufficiently capture the relevant emissions that are likely to arise from the HA's operations. Furthermore, the Categories will facilitate emissions being correctly identified and attributed to an appropriate part of the HA's business, and also to reduce the potential for emissions double-counting (see Section 5 – Uncertainty and Risks). The structures of the Tier 3 Emission Categories are identified within Figure 3.2 below.

Figure 3.2 HA Emissions Accounting Structure



3.3.3 Tier 4 - Emission Sources

From the Tier 3 Emission Categories, the key emission sources of the HA's operations and activities have been identified. In summary, this includes the relevant types of energy usage and consumption, typical types of transport that would be utilised and typical construction materials. Individual emission calculators

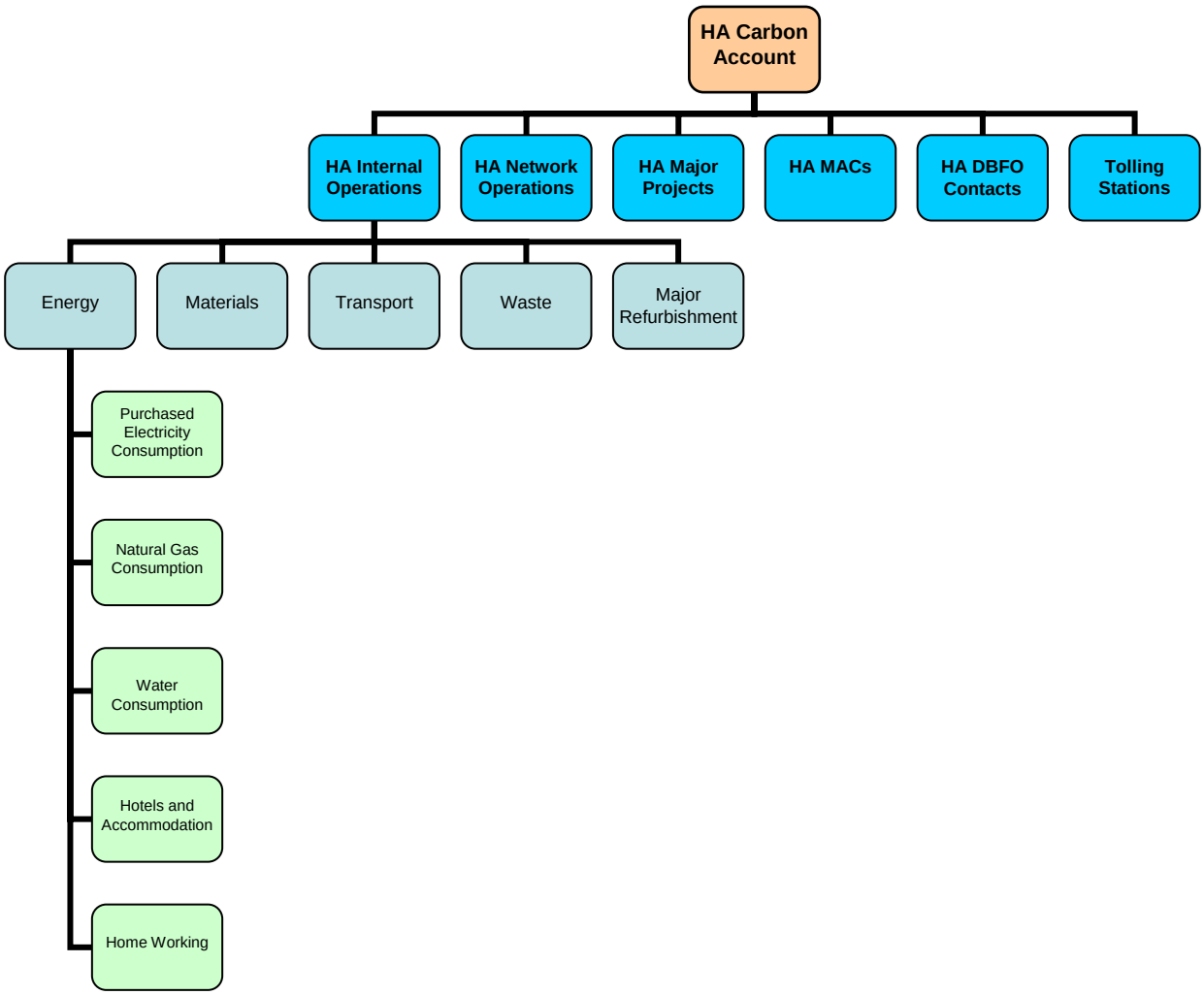
have been produced for specific activities. For example, under the 'Energy Emission Category' (Tier 3) for the HA Internal Operations Reporting Area (Tier 4), the aspects illustrated within Figure 3.3 have been included.

The identification of Tier 4 Emission Sources and the development of an GHG Source Inventory, as illustrated within Annex 4, has been based upon available information to PB, and following initial reviews within the Project Team. A detailed appraisal by HA staff has not been undertaken to date, and as such forms part of the first Panel Review (see Reviewer Question 2 below). The full range of Emissions Sources identified from HA activities have been categories within the relevant Tier 3 Emission Categories.

Reviewer Question 2:

Are the Emission Sources outlined within the GHG Source Inventory in Annex 4 considered to be sufficient to capture all emission arising's and data from the HA's operations?

Figure 3.3 Example of Tier 4 Emission Sources



Due to the inherent variability, in terms of availability and reliability, of both the input data required to complete the Tool and of the CO_2 emission factors, it has been necessary to draw some assumptions within specific emission calculations. This is in terms of the type of data to be included within the Tier 4

Emission Sources, and in terms of how such data is to be collected. These general assumptions relating to data coverage of particular Tier 4 Emission Sources are outlined within Tables 3.2 – 3.7.

Specific assumptions in relation to the calculation methods and the technical data incorporated within the Accounting Tool are detailed separately within Annex 5.

Table 3.2 Data Coverage – HA Internal Operations

Emission Category	Coverage
Energy	This category relates to emissions associated with the electricity, gas and water which has been consumed within in HA Offices, the National Traffic Control Centre (NTCC), Regional Control Centres (RCCs) & associated Outstations (which at this stage are to be reported under the relevant RCC totals). It also includes domestic energy and water consumption by staff working from home, and energy used by staff staying in hotels on HA business. Data is assumed to be available in the following units: ➢ Electricity – kilowatt hours (kWh); ➢ Gas – kWh; ➢ Water – Cubic metres (m^3); ➢ Hotel Stays – Number of nights per reporting period; and ➢ Home Working – Number of full-time and part-time home based staff. Where data is not available for electricity, gas, and water, Consumption Estimators based upon floor areas (m^2) or number of employees (for water) have been developed to enable some data capture.
Materials	This category estimates the volume of embodied CO_2 in a selection of materials commonly used throughout HA Offices. Materials have been broadly sorted into two categories: ➢ Office Equipment and Other; and ➢ General Refurbishment. As this stage, the materials included within these Calculators are indicative materials only and are those for which emission factors are readily available. In the future, it will be necessary to establish which key materials, considering both HA usage and associated emission within the HA context, should be included and also to obtain the relevant calculation data. Some cross-over with the 'Major Refurbishment' worksheet is anticipated and this will similarly require future refinement to ensure appropriate coverage of data capture. This Category also provides a methodology for calculating emissions produced during the transportation of materials from suppliers to HA offices / facilities. This has been simplified to a selection of either 'Local' or 'Regional' supplies, which are based upon arbitrary transport distances. This section does not include: ➢ Materials used in any other construction projects e.g. Major Projects or projects managed by MACs; or ➢ Materials used during 'Major Refurbishment' (see below).
Transport	This category estimates the volume of emissions produced by HA staff using vehicles in relation to HA business (limited to office-related business and does not include site-based activities). This scope has been extended to include staff commuting, taxi journey, and temporary hire cars. It also includes an indicative estimation of indirect emissions associated with a limited number of supply chain services – these mainly purport to services related directly to HA office activities (i.e. couriers, HA building contractors and catering suppliers).
Waste Removal	The waste removal category accounts for the removal of waste in terms of the following types: ➢ Standard office waste; ➢ Indicative Recycled Office Waste At this stage is assumed that recyclable materials are segregated from standard office waste, and stored separately. It is recognised that this may however not be the case, since certain waste contractors do offer sorting services after collection to segregate recyclables. This would not affect the transport emission calculation at this stage, since waste could simply be recorded and accounted for as Standard Office Waste. The Indicative Recycled Office Waste only includes selected office materials for which standard density / weight assumptions are available and considered to be robust. Other materials can be

Emission Category	Coverage
	included and developed in due course. Despite the relatively minor contributions of the transportation of an individual office's recycled waste to the HA's emissions total, when the activity is scaled up across the HA operations as a whole, the cumulative total of recycled waste transportation could potentially be of significance. This aspect will therefore require clarification.
Major Refurbishment	This category estimates the volume of emissions embodied in materials used in refurbishment / construction projects undertaken in relation to HA offices only. The range of materials included is derived from the EA's 'Carbon Calculator for Construction Activities'. It is therefore recognised that such materials may therefore require future refinement and additions as necessary and that certain data entry units (either tonnes or cubic metres), may not presently be in the most user-friendly form.

Table 3.3 Data Coverage – HA Network Operations

Emission Category	Coverage
Energy	This category relates to the energy requirements of motorway electrical equipment, specifically the lighting and communications systems. Data for this section has been extrapolated from Capita Symonds (2008) *Carbon Footprint of Motorway Electrical Equipment v 4.* Within the Capita Symonds model, only two broad categories of road are investigated, Rural D3M and Rural ATM. Each of these roads has then been categorised by the type of lighting required, either 'passively safe columns, standard columns, or unlit'. Therefore, these types of road have been assumed to be typical of the HA. The expansion of this section to include a greater variety of road types and associated electrical requirements, at this stage necessitates further discussion
Materials	This category relates to the materials used to construct and operate motorway electrical equipment. Data for this section has been extrapolated from Capita Symonds (2008) *Carbon Footprint of Motorway Electrical Equipment v 4.* The embodied tCO_2/unit of equipment has been estimated using data provided in the above document. Volumes of material per unit (e.g. lighting column) have been assumed by summing the individual components listed within each item of equipment. CO_2 conversion factors are derived from the Bath Inventory. Conversion into relevant units has been based upon typical weight / density estimates from various sources, with the exception of the figure for "electrical components", which is a rough estimate from Capita Symonds (2008). These data are typical of the UK market, and take into account the element of recycling that occurs for each material. New installations as part of Major Projects should be accounted for under Major Projects. Furthermore, waste removal has not been included within the Accounting Tool, and this aspect will require further clarification in terms of the most suitable Accounting line.
Transport	At the present time, the Accounting Tool incorporates an assumption that maintenance operations, and hence maintenance-related transport and emissions, can be separated from other MAC operations. However, in practice, this may not be achievable in future versions of the Accounting Tool this aspect would require relocation under the appropriate Reporting Area.

Table 3.4 Data Coverage – HA Major Projects

Emission Category	Coverage
Energy	This category covers the energy consumption from site offices, fixed plant, and mobile plant. Mobile plant is distinguished from transport below given that its primary purpose is for construction, rather than as a mode of transportation *per se*.
Materials	This category estimates the volume of emissions embodied in materials used in maintenance and construction projects undertaken by the HA (and its contractors, excluding projects managed by MACs). The range of materials is derived from the EA's 'Carbon Calculator for Construction Activities', and as such is recognised that materials may require future refinement, with additional materials incorporated as necessary. Furthermore, some data entry units (e.g. tonnes or cubic metres), may not presently be in the most user-friendly form and may also require updating.

Emission Category	Coverage
Transport	This category estimates the volume of emissions produced by Major Project staff in relation to Major Project-related business only. This extends to include all HA and contractor staff as appropriate. With regard to HA staff, there exists the potential for business journeys to be double-counted if appearing under HA Internal Operations above. This distinction in the reporting lines will therefore have to be maintained. This scope has been extended to include staff commuting to Major Project sites, taxi journey, and temporary hire cars.
Waste Removal	The waste removal category accounts for the removal of waste in terms of the following types: ➢ Standard site office waste; ➢ Indicative Recycled Office Waste; and ➢ Construction waste. It is assumed that standard and recycled site office waste will be segregated from construction waste, and as such information will be readily available. Volumes of construction site waste are to be recorded separately.

Table 3.5 Data Coverage – HA MACs

Emission Category	Coverage
Energy	This category relates to emissions associated with the electricity, gas and water which has been consumed by the MACs in relation to works undertaken on behalf of the HA, both within MAC offices and onsite. It also includes domestic energy and water consumption by staff working from home, and various forms of plant. For mobile plant, whereby data is unavailable an 'estimator tool' has been included based upon the duration of use. Data is assumed to be available in the following units: ➢ Electricity – kilowatt hours (kWh); ➢ Gas – kWh; ➢ Water – Cubic metres (m^3); ➢ Hotel Stays – Number of nights per reporting period; ➢ Home Working – Number of full-time and part-time home based staff; and ➢ Plant fuel consumption (litres per fuel type). For MAC office facilities only, where data is not available for electricity, gas, and water, consumption estimators based upon floor areas (m^2) or No. of employees (for water) have been developed to enable some data capture.
Materials	This category estimates the volume of emissions embodied in materials used in maintenance and construction projects undertaken by MACs (and its sub-contractors, excluding projects managed by the HA or Major Projects) The range of materials is derived from the EA's 'Carbon Calculator for Construction Activities', and as such is recognised that materials may require future refinement, with additional materials incorporated as necessary. Furthermore, some data entry units (e.g. tonnes or cubic metres), may not presently be in the most user-friendly form and may also require updating.
Transport	This category estimates the volume of emissions produced by MAC staff using vehicles in relation to HA / MAC business. A distinction is made between office-related business and site-based activities, which are recorded separately. This scope has been extended to include MAC staff commuting, taxi journey, and temporary hire cars. The scope does not include an estimation of indirect emissions associated with a limited number of supply chain services (e.g. use of couriers), since it is assumed that such information is unlikely to be obtainable from MACs and would not constitute a significant emission source.

Emission Category	Coverage
Waste Removal	The waste removal category accounts for the removal of waste in terms of the following types: ➢ Standard MAC office waste; ➢ Indicative Recycled Office Waste; and ➢ Construction waste. At this stage, it is assumed that recyclable materials are segregated from standard office waste, and stored separately. It is recognised that this may however not be the case, since certain waste contractors do offer sorting services after collection to segregate recyclables. This would not affect the transport emission calculation at this stage, since waste could simply be recorded and accounted for as Standard Office Waste. As indicated within Table 3.2, the Indicative Recycled Office Waste only includes selected office materials for which standard density / weight assumptions are available and considered to be robust. It is to be established whether information on recyclable waste from MAC offices and other facilities is obtainable, and if so, whether the volumes generated will constitute a 'significant' emission source within the context of the wider HA Account. This aspect has therefore been included at this stage, for future consideration and development.

Table 3.6 Data Coverage – HA DBFO Contracts

Emission Category	Coverage
Energy	This category relates to emissions associated with the electricity, gas and water which has been consumed by projects under HA DBFO contracts in relation to works undertaken on behalf of the HA, both within DBFO offices and onsite. It also includes domestic energy and water consumption by staff working from home, and various forms of plant. For mobile plant, whereby data is unavailable an 'estimator tool' has been included based upon the duration of use. Data is assumed to be available in the following units: ➢ Electricity – kilowatt hours (kWh); ➢ Gas – kWh; ➢ Water – Cubic metres (m^3); ➢ Hotel Stays – Number of nights per reporting period; ➢ Home Working – Number of full-time and part-time home based staff; and ➢ Plant fuel consumption (litres per fuel type). For DBFO office facilities only, where data is not available for electricity, gas, and water, consumption estimators based upon floor areas (m^2) or No. of employees (for water) have been developed to enable some data capture.
Materials	This category estimates the volume of emissions embodied in materials used in maintenance and construction projects undertaken through DBFO contracts (and its sub-contractors, excluding Major Projects and projects managed by MACs) The range of materials is derived from the EA's 'Carbon Calculator for Construction Activities', and as such is recognised that materials may require future refinement, with additional materials incorporated as necessary. Furthermore, some data entry units (e.g. tonnes or cubic metres), may not presently be in the most user-friendly form and may also require updating.
Transport	This category estimates the volume of emissions produced by staff working under a HA DBFO contract using vehicles in relation to HA business. A distinction is made between office-related business and site-based activities, which are recorded separately. This scope has been extended to include Tolling Station staff commuting, taxi journey, and temporary hire cars. The scope does not include an estimation of indirect emissions associated with a limited number of supply chain services (e.g. use of couriers), since it is assumed that such information is unlikely to be obtainable from DBFOs and would not constitute a significant emission source.

Emission Category	Coverage
Waste Removal	The waste removal category accounts for the removal of waste in terms of the following types: ➢ Standard DBFO office waste; ➢ Indicative Recycled Office Waste; and ➢ Construction waste. At this stage, it is assumed that recyclable materials are segregated from standard office waste, and stored separately. It is recognised that this may however not be the case, since certain waste contractors do offer sorting services after collection to segregate recyclables. This would not affect the transport emission calculation at this stage, since waste could simply be recorded and accounted for as Standard Office Waste. As indicated within Table 3.2, the Indicative Recycled Office Waste only includes selected office materials for which standard density / weight assumptions are available and considered to be robust. It is to be established whether information on recyclable waste from Tolling Station offices and other facilities is obtainable, and if so, whether the volumes generated will constitute a 'significant' emission source within the context of the wider HA Account. This aspect has therefore been included at this stage, for future consideration and development.

Table 3.7 Data Coverage – Tolling Stations

Emission Category	Coverage
Energy	This category relates to emissions associated with the electricity, gas and water which has been consumed by Tolling Station projects in relation to works undertaken on behalf of the HA, both within Tolling Station associated offices and onsite. It also includes domestic energy and water consumption by staff working from home, and various forms of plant. For mobile plant, whereby data is unavailable an 'estimator tool' has been included based upon the duration of use. Data is assumed to be available in the following units: ➢ Electricity – kilowatt hours (kWh); ➢ Gas – kWh; ➢ Water – Cubic metres (m^3); ➢ Hotel Stays – Number of nights per reporting period; ➢ Home Working – Number of full-time and part-time home based staff; and ➢ Plant fuel consumption (litres per fuel type). For Tolling Station office facilities only, where data is not available for electricity, gas, and water, consumption estimators based upon floor areas (m^2) or No. of employees (for water) have been developed to enable some data capture.
Materials	This Category estimates the volume of emissions embodied in materials used in maintenance and construction projects of Tolling Stations (and its sub-contractors, excluding Major Projects and projects managed by MACs) The range of materials is derived from the EA's 'Carbon Calculator for Construction Activities', and as such is recognised that materials may require future refinement, with additional materials incorporated as necessary. Furthermore, some data entry units (e.g. tonnes or cubic metres), may not presently be in the most user-friendly form and may also require updating.
Transport	This category estimates the volume of emissions produced by staff working at Tolling Stations using vehicles in relation to HA business. A distinction is made between office-related business and site-based activities, which are recorded separately. This scope has been extended to include Tolling Station staff commuting, taxi journey, and temporary hire cars. The scope does not include an estimation of indirect emissions associated with a limited number of supply chain services (e.g. use of couriers), since it is assumed that such information is unlikely to be obtainable from Tolling Stations and would not constitute a significant emission source.

Emission Category	Coverage
Waste Removal	The waste removal category accounts for the removal of waste in terms of the following types: ➢ Standard Tolling Station office waste; ➢ Indicative Recycled Office Waste; and ➢ Construction waste. At this stage, it is assumed that recyclable materials are segregated from standard office waste, and stored separately. It is recognised that this may however not be the case, since certain waste contractors do offer sorting services after collection to segregate recyclables. This would not affect the transport emission calculation at this stage, since waste could simply be recorded and accounted for as Standard Office Waste. As indicated within Table 3.2, the Indicative Recycled Office Waste only includes selected office materials for which standard density / weight assumptions are available and considered to be robust. It is to be established whether information on recyclable waste from Tolling Station offices and other facilities is obtainable, and if so, whether the volumes generated will constitute a 'significant' emission source within the context of the wider HA Account. This aspect has therefore been included at this stage, for future consideration and development.

3.3.4 Additional Calculations

Additional features within the Accounting Tool include the calculation of emission savings or avoidance due to certain supply-based or 'behavioural' actions. These additional calculations include the following:

- Installed Onsite Renewables Generation;
- Renewable Energy Tariffs;
- Indicative Recycled (Office) Waste; and
- Recycled Construction Material Purchasing.

In principle, the supply of renewable energy can be assumed to displace or reduce the relative proportion of emissions that would have otherwise be released as a result of conventional generation. Within the Accounting Tool, the use of a renewable energy supply would be reflected by a decrease in the overall level of kWh supply and therefore the associated emissions. In order to determine this, a provision to calculate any 'displaced' emissions has been included within the Accounting Tool. The displaced emissions are based upon the assumption that 1kWh of renewables supply will displace the emissions equivalent of 1kWh of standard supply.

This approach may represent an oversimplification, and certain issues persist in terms of claiming emission offsets in this way, particularly with regard to renewable energy supply tariffs. Under current guidance, renewable energy inputs can only qualify for a zero emission factor when organisations have entered into a renewables source contract with an energy supplier which has itself acquired Climate Change Levy Exemption Certificates (LECs) for the electricity supplied as a non-domestic electricity consumer. The Office of Gas and Electricity Markets (OFGEM), DEFRA and the Energy Saving Trust (EST) are currently running consultations to revised guidelines on green supply tariffs, and to develop third party accreditation. Revised emission factors will follow the outcome of these processes. Until this time, DEFRA advises to include renewables factors detailed within 2005 Emission Factors data. This assumes that certified renewables account for zero carbon emissions and this assumption is therefore made here. It is important to note that such calculations therefore do not constitute an 'offset' of emissions within the context of the Tool, and are not subtracted from the HA's total Carbon Account and the renewable energy benefits are included for information only. As stated previously, such benefits are captured through the decrease in measured standard supply kWh demand.

Similarly, with regard to waste management options – which to date has only been developed for selected office recyclables for which robust CO_2(e) saving values are available – there exist feasible emission benefits through the method of waste disposal (i.e. recycling in preference of landfill). Indicative office-based materials have been included at the stage, so that the benefits of selecting one waste management option over another can be identified in terms of volumes of emissions produced. However, this aspect of the Accounting Tool is still in development, and at this stage is acknowledged to be relatively crude and simplistic. It has been included to provide an illustration of an area of work for future development (see Section 6 – Tool Development).

The final calculation included within the Accounting Tool helps to establish the volumes of emissions avoided through the purchasing and specification of recycled products / materials in preference of virgin products / materials. Where recycled materials (or proportions of these) have been selected, an automatic calculation is performed which compares the emissions output of the recycled element and its non-recycled equivalent, using appropriate emission factors and assuming a like-for-like emissions substitution. As above, these emissions volumes are presented as a separate figure in the appropriate section of each Workbook and does not constitute and offset.

3.4 STEP 4 – SELECTING EMISSIONS CALCULATION APPROACH

GHG emissions can be calculated through a variety of methods. The direct measurement of emissions, through monitoring or flow rates is not common and more often emissions are calculated based upon a mass balance basis specific to facilities or processes. Such methods are also of greater relevance to industrial operations. Alternatively, the most common approach for calculating emissions is through the application of documented emission factors, and thus is the approach which has been adopted within the HA Accounting Tool.

Documented emission factors are represented using a calculated ratio that converts a measure of activity from an emissions source into a volume of GHG emissions. For example, a vehicle's CO_2 emissions per litre of fuel consumed. An example calculation is included below[9]:

Measure of Activity	X	Emission Factor	=	Emission Estimate
A car consumes 1000 litres of petrol	X	2.315kg CO_2 per litre	=	**2.315 Tonnes CO_2** ([1000 x 2.315]/1000)

3.5 STEP 5 – SELECTING EMISSION FACTORS

3.5.1 Key Data Sources

In order to calculate the emissions produced by the various processes, activities and materials accounted for within the Accounting Tool, it is essential that reliable emission/ conversion factors are sourced. Such factors underpin the workings of any Accounting Tool, and as such it is essential that they are sufficiently reliable, robust and transparent.

> An important distinction is made within this Report between the term 'emission factor' and 'conversion factor', as the two are not considered to be synonymous:
>
> *Emission Factor = a numerical value to enable a conversion from an input measure of energy consumption to a volume of associated CO_2 / CO_2e emissions.*
>
> *Conversion Factor = a numerical value to enable a conversion from a unit of activity / consumption (e.g. consumption of aggregate in cubic metres) into an appropriate unit so that an emission factor can be applied (e.g. conversion from cubic metres into tonnes).*

The adopted approach has been to set out as clearly as possible the conversion factors utilised and any assumptions made. In addition, it has been essential to recognise that alternative, more appropriate emissions values may be identified during further development of the Accounting Tool, which would require updating as appropriate. The relevant emission factors are incorporated within the calculations embedded in the Accounting Tool, and detailed within Annex 6.

Identified below are the key published data sources which have been referred to, provide the majority of emission factors:

- Guidelines to DEFRA's GHG Conversion Factors for Company Reporting – Annexes, Department of Environment, Food and Rural Affairs, 2007[10].

[9] The emission factor of 2.315kg CO_2 per litre is based upon the current DEFRA Conversion Factors from 2008.

- Inventory of Carbon and Energy (ICE). University of Bath, 2006 (referred to as the 'Bath Inventory').
- Carbon Calculator for Construction Activities. Environment Agency, 2007.

3.5.2 Emission Factor Issues

It is acknowledged that emission factors inherently contain certain assumptions within the applied values. For example, the DEFRA emission values for vehicle emissions produced per kilometre driven do not account for the impact of different UK average driving speeds, and to an extent the impacts of vehicle age. They also take no account of further 'real-world' effects, such use of accessories (air conditioning, lights, heaters etc), vehicle payload (only the driver +25kg is considered and vehicles assume no passengers or further luggage), poor maintenance (e.g. tyre under inflation), gradients, weather conditions, aggressive driving style, and other such variables. A further difference is that car and motorcycle transport emission factors are based upon vehicle-kilometres emissions, whereas public transport and air transport are based upon factors for passenger-kilometres.

Such issues can to a degree be overcome so that more accurate emission estimates are generated. In the example of car emissions, calculations based upon volumes of fuel consumption (e.g. litres or petrol or diesel) rather than a distance-based method will improve accuracy and should therefore be used in preference. It is recognised that this may not always be possible and the 'best estimate' for one reporting line may differ from the next. Consequently, the degree of certainty / confidence within emission estimates the Accounting Tool's calculations will vary from calculation to calculation, and as such the resolution of emission reporting will invariably differ across the application of the Accounting Tool.

The GHG Protocol recommends that an organisation should use the most accurate calculation and appropriate approach available to the reporting context.

For some materials included in the Bath Inventory, it has been recognised that the data regarding the embodied energy of that material is incomplete. This is due to an incomplete set of data boundaries. The majority of data collated has been provided using a 'cradle to gate' boundary, which represents the efficiency of a product / service until it is produced or delivered. However, due to data limitations, the 'cradle to gate' boundary conditions were unable to be applied throughout the entire inventory.

The ideal boundary for this study would be 'cradle to grave', that is from manufacture through to the point of disposal. To assist in implementing these boundary conditions, various additional conversion factors have been applied to existing data in order to convert select materials (or consumption data) from the Bath Inventory into relative CO_2 emissions. For example, emissions data within the Bath Inventory is presented as tonnes CO_2 per tonne of material. Therefore, it has been necessary to draw certain assumptions relating to material density to enable materials measured in alternative units (such as metres and litres) to be converted into tonnages (e.g. lengths in metres of drainage pipes).

Published emission factors will be regularly updated, in some cases annually, and as such the assumptions included within the Accounting Tool should also incorporate such updates as required. Consequently, changes in emission factors between reporting periods will essentially comprise a change in assumptions, and will presumably be reflective of improvements in data accuracy with time. Through reporting year on year, such changes will require consideration in terms of changing baselines and the comparison of 'like-for-like' (as discussed further below).

For example, standard electricity generation values are anticipated to change in time given the development of the UK's energy generation mix. The Renewables Obligation (RO) has been developed as an incentive to encourage new renewables generation in the UK, and currently sets a mandatory target for electricity supply from eligible renewable generation capacity. This target is currently increasing to 15% by 2015. As such, the corresponding emission factors are anticipated to evolve and be reflective of such market changes.

[10] The current DEFRA Emission Factors for 2007 are due to be updated shortly. Draft revised factors are indicated within the following document – DEFRA (2008). *Draft Code of Best Practice for Carbon Offset Providers – Accreditation Requirements and Procedures*. These factors are yet to be confirmed by DEFRA, however it was agreed that the Accounting Tool be updated using the relevant factors where applicable. The Draft Code document indicates that new emission factors will be published in certain areas following recent research, which should therefore be incorporated within the HA Accounting Tool as applicable, in due course.

3.6 EMISSIONS BASELINE

Part of the Accounting process involves tracking the changes in emissions over time. In order to allow meaningful and consistent comparisons of emissions, a common approach is to set a performance datum with which to compare current emissions. This performance datum is referred to as the 'Base Year', for which verifiable emissions data should be available. In setting and tracking progress towards a GHG target, it is referred to as a 'Target Base Year'.

Organisations typically select a single year to represent the base year, although there is a potential risk that this year's data is unrepresentative of the organisations typical annual emissions profile. To overcome this issue, it is recommended that an average of emissions over several consecutive years is adopted, so that any unusual fluctuations in emissions occurring within individual years are removed.

For consistent tracking, the base year emissions may need to be recalculated should an organisation undergo significant structural change, due to changes in calculation methodology or improvements in the accuracy of emission factors / activity data, or should significant errors be identified. Should recalculations be required, base year emissions are essentially retrospectively recalculated to reflect the changes that would otherwise compromise the consistency and relevance of the reported GHG emissions. Given the likely updates of emission factors detailed previously (see Section 3.5.2 – Emission Factor Issues), re-baselining upon this basis would be required.

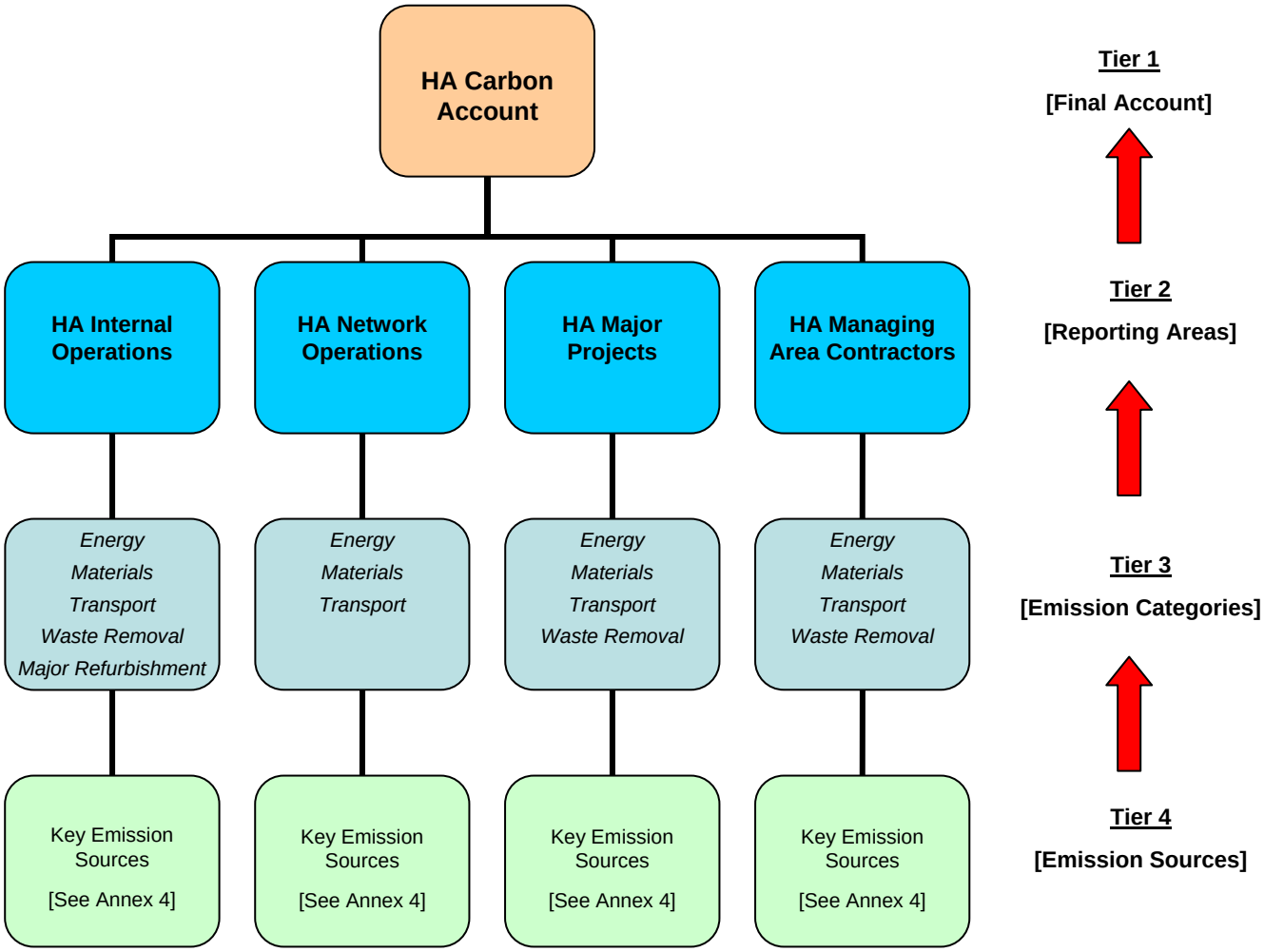
Within the HA context, significant changes may occur due to the number, scale and type of major projects within a reporting period for example. The baseline would therefore be anticipated to significantly change from year to year, due to operational differences between reporting periods. It is therefore considered that to enable emissions comparison's which allow for such operational changes, an appropriate 'like for like' approach will be required. For example, this may include project emissions being calculated upon a financial basis (e.g. tonnes of CO_2 per £-spend), or internally on an employee basis (e.g. tonnes of CO_2 per employee). Such an approach would allow a standarised methodology of comparison to reporting and facilitate target setting (see Section 6 - Future Developments for further information). This aspect would therefore require discussion with the HA to establish the most suitable approach.

4 OVERALL TOOL STRUCTURE AND FUNCTION

4.1 STRUCTURE

Following from Section 3, the overall structure of the HA Accounting Tool is illustrated within Figure 4.1 below, which demonstrates the tiered approach to data collection, and the relative contribution to the HA's Carbon Account.

Figure 4.1 HA Carbon Account Structure



4.2 DATA COLLECTION STRATEGY

4.2.1 Generic Model Selection

During the application of the Accounting Tool, the HA will be required to gather (and in some cases processes and analyse) data from various sources and locations from within its own operations and supply chain. It is therefore important that this process is carefully defined, to ensure that the administrative burden is minimised, to reduce the risk of data collection error, and to ensure that information is collated in a consistent and applicable manner.

In application, the data collection model should seek to become integrated within the HA's existing reporting tools and processes, and to make use of all existing data provisions. However, as emissions data improves, it is recognised that the prescribed Accounting Tool is likely to require new areas of data collection to be established, and that the methods to achieve this will need to be developed as part of future work.

As such, it should be recognised that the methodology contained within the Accounting Tool V1 is not intended to be prescriptive, in the sense that any components can be further modified and tailored to better suit the HA's future requirements. Rather, the Accounting Tool has been developed thus far, upon the assumption that the 'best available' data would be supplied, which, in the future, may however prove not to be the case. As an inherent part of its design, the tiered approach of the Accounting Tool lends itself to such progressive future development and refinement that the current assumptions can themselves be refined, and the resolution of the emissions inventory be increased.

In terms of gathering data for an organisation-wide Account, the GHG Protocol Corporate Standard identifies two basic approaches, as follows:

- *Centralised* – whereby individual facilities report activity / fuel data to the organisational level, where GHG emissions are calculated. This approach is noted to be particularly suitable for office-based organisations, whereby emissions can be calculated in a straightforward manner and would be standard across a number of facilities; and
- *Decentralised* – whereby individual facilities collect activity /fuel data, directly calculate their GHG emission using approved methods, and report this to organisational level. It is suitable to where calculation methods would vary across facilities. This approach may help increase the awareness and understanding of the issue at the facility level, however may require increased training, an increase in calculation errors, and a greater need for auditing of calculations.

To date the overall data collection approach has not been explicitly defined, and the development of the Accounting Tool has been limited by this. Consequently, where necessary certain assumptions have been made to enable the Accounting Tool to be developed to its present state. Both the Accounting Tool and accompanying Instruction Manual have been based upon the assumption that a decentralised approach would be adopted.

The selection of a centralised or decentralised model will form a fundamental consideration in relation to the future development of the Accounting Tool, and will in part influence the nature of the data collection strategy and the required quality management procedures.

The selected model may also address certain inherent risks within the Accounting process – see Section 5.3 for further details. The administrative burdens of one model over another will require careful consideration, given the HA's objective to minimise this aspect. It is recognised that principles of both centralised and decentralised approaches may be incorporated within the Accounting Tool, should certain areas of the HA's operation prove more appropriate to one model over the other. For example, would providing ownership of the Accounting Tool to a facility such as an HA's office be as applicable to a MAC, or for the MACs should the emphasis rather be upon obtaining the data?

Reviewer Question 3:

- **A key consideration is likely to be the balance between reducing the HA's administrative burden of the Accounting process, and the confidence with which the HA can directly collate and report information from its supply chain.**

As such, is a centralised or decentralised data collection model considered to be more appropriate to the HA context?

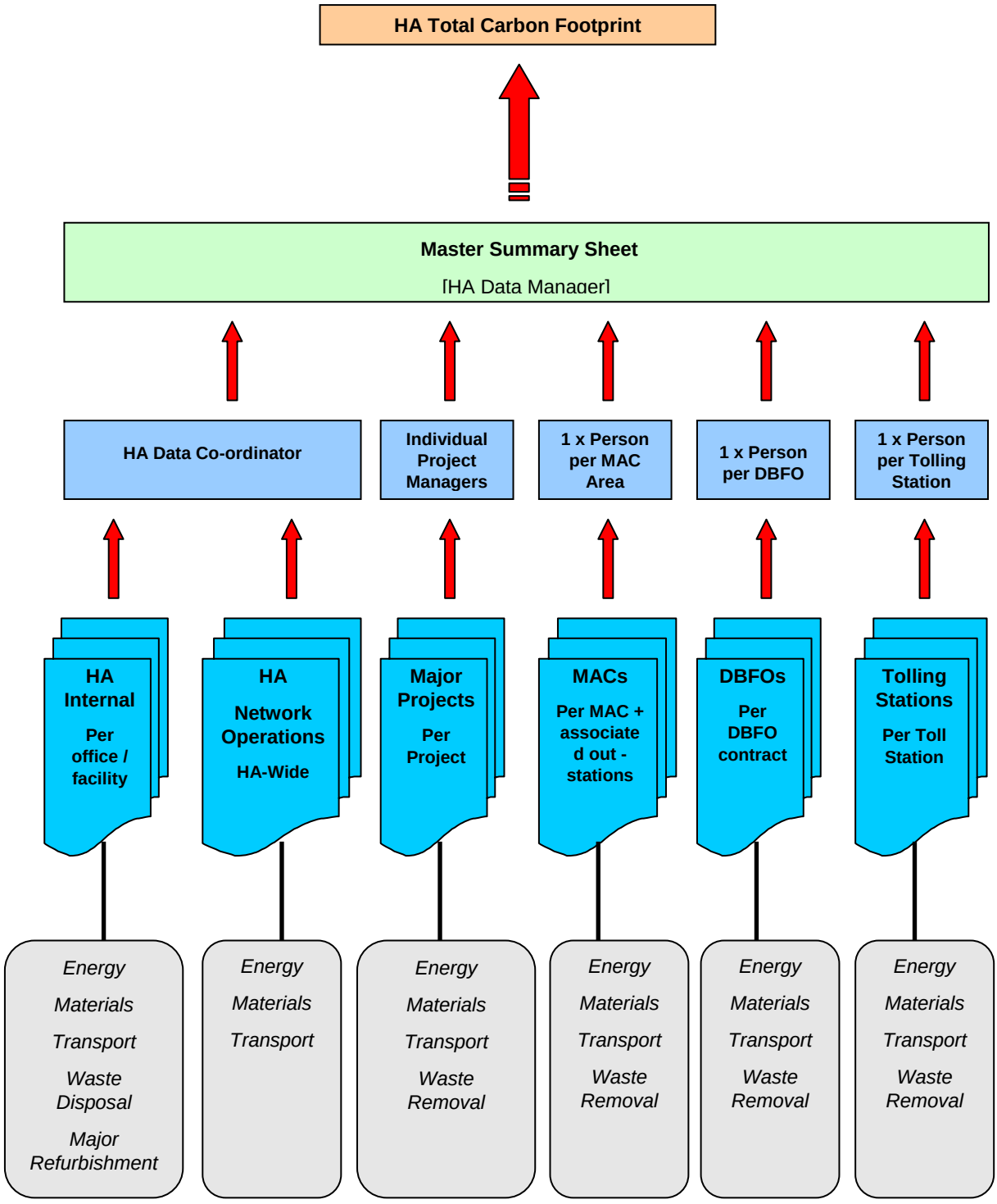
Or alternatively, would the Accounting Tool benefit from a different approach within Reporting Areas?

4.2.2 Data Collection Model

The collection of high quality activity data, such as of electricity consumption or vehicle fuel consumption, will be a significant limitation upon the accuracy and robustness of the HA's Carbon Account. The establishment of standardised data collection procedures are therefore a key priority in the integral design of the HA's Accounting Tool. Such standardisation will ensure that data received from different business areas of the HA, and different suppliers, will prove to be consistent, and provide a key step in reducing the risk of errors within the data collection process itself. The data collection methodology should enable the same data to be efficiently collected year-on-year.

The HA Carbon Accounting Tool has been designed to enable a large and varied data set to be collected, presented and interpreted at a number of different levels. To facilitate an efficient method of data collection, a 'Data Collection Strategy' (DCS) has been devised based on assumptions regarding the structural organisation of the HA. Figure 4.2 below illustrates the different levels through which information will be reported back to the HA and by whom.

Figure 4.2 HA Accounting Data Collection and Reporting Structure



HA Internal

Raw data will be collected from each of the HA's main offices, and also from the RCCs (including associated outstations) and NTCC. This will then be fed back to a 'Data-Co-ordinator', identified within the HA, who will be responsible for entering all of the data into the appropriate Accounting Tool Workbook. Once this has task has been completed, the Data Co-ordinator will report the findings back to the HA Data Manager who will use the workbooks to compile the HA's Total Carbon Account.

Reviewer Question 4:

At this stage, is it necessary to list the "associated out-stations" for HA offices and MACs? This should be included to ensure the same reporting areas are included in each reporting period, however this aspect could be included as a future consideration.

HA Network Operations

It is assumed that raw data pertaining to the Network lighting and Communications system will be collected for the Network as a whole, by the HA Data-Co-ordinator. The Data Co-ordinator will then enter this data into the Workbooks and report the findings back to the Data Manager.

Major Projects

Due to the number of Major Projects undertaken by the HA, there will be a vast amount of very specific data to collect and compile. The most appropriate person to collate this information will therefore be the Project Manager.

It is envisaged that raw data will be collected at project level (for each individual project), and then entered into the Accounting Tool Workbooks by the Project Manager.

MACs

Raw data will be collected by each main office in the 14 MAC areas. MACs will be required to identify their own Data Co-ordinator to take responsibility for collecting data, and for entering data into the Accounting Tool Workbook. It will be essential for each MAC office to include data for any associated out-stations, salt-barns and operational depots as appropriate.

After each of the 14 MAC Data Co-ordinators completes their respective MAC Workbook it should be sent to the HA Data Manager, to enable the HA's Total Carbon Account to be calculated.

DBFOs

Raw data will be collected for each DBFO project. A DBFO Co-ordinator will need to be established to take responsibility for data collection and for entering data into the Accounting Tool Workbook. The DBFO Co-ordinator will also need to liaise closely with the HA to ensure double-counting of emissions is avoided, as some aspects of the DBFO may be accounted for by MACs or Major Projects.

After each DBFO Workbook is completed, it will be sent to the HA Data Manager to enable the HA's Total Carbon Account to be calculated.

Tolling Stations

Raw data will be collected for each individual Tolling Station. A Tolling Station Co-ordinator will need to be established to take responsibility for data collection and for entering data into the Accounting Tool Workbook. The Tolling Station Co-ordinator will also need to liaise closely with the HA to ensure double-counting of emissions is avoided.

After each Tolling Station Workbook is completed, it will be sent to the HA Data Manager to enable the HA's Total Carbon Account to be calculated.

4.3 REPORTING PERIOD

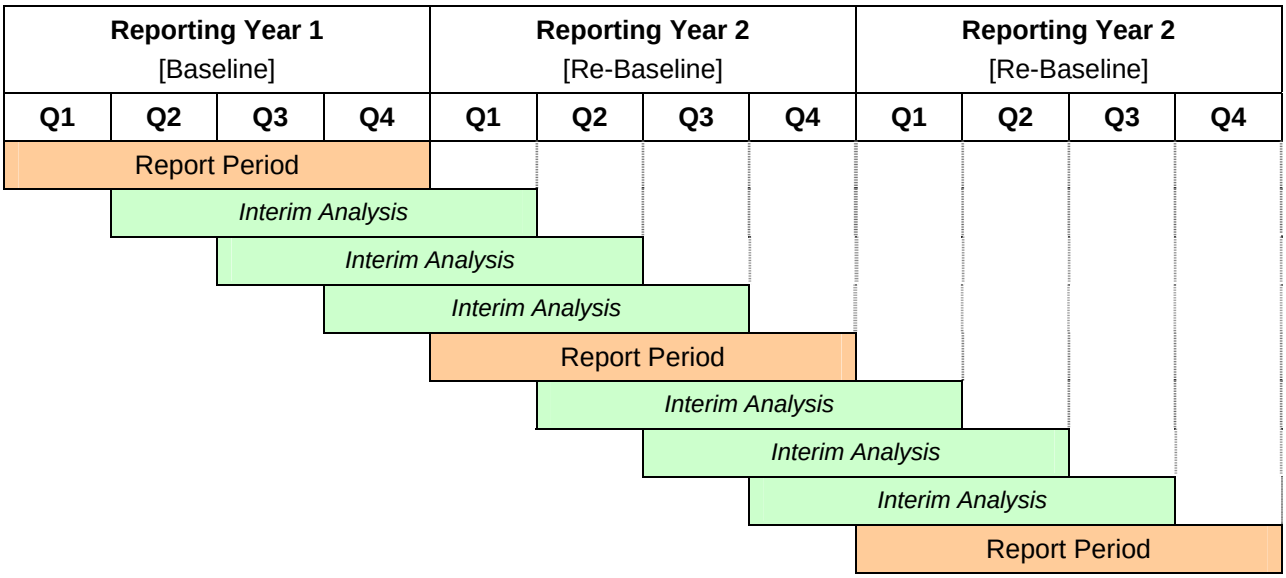
For the purposes of the Accounting Tool, it has been assumed that data would be *collected* on a quarterly basis, whilst the information would be *reported* on a twelve month (annual) basis. This reporting period structure is illustrated within Figure 4.3 below.

This method of data collection allows for interim analysis to be undertaken and also enables seasonal variations in data to be considered, for example. The quarterly data collection period is considered to be an appropriate initial timescale – however, should this prove to detract from the quality and reliability of the data collected, the Tool can be modified to a given reporting period as appropriate.

Given the above factors, certain aspects of the HA's operations are likely to overlap between reporting periods, which could give rise to double-counting of emissions. For example, the implementation of Major Projects may run across numerous reporting years.

Further details of the baselining process are included within Section 3.6 (Emissions Baseline).

Figure 4.3 Rolling Annual Reporting



To alleviate any confusion which may arise from the data collection process, some aspects have been further prescribed (these are also clearly stated within the accompanying Instruction Manual where appropriate). As such, it has been determined that data should be included within the Accounting Tool **at the point of purchase**. For example, construction inputs to a scheme should appear within the Accounting Tool within the quarter that they were purchased, irrespective of whether they are actually utilised within that or subsequent periods. Therefore, by synchronising the carbon accounting process to financial purchasing, certain emissions double-counting issues can be avoided.

Similarly, particularly in relation to embodied carbon calculations of structures such as bridges or road surfaces for example, it has been determined that all emissions should be accounted for at the point of purchase, and not divided across the lifetime of any given structure.

Reviewer Question 5:

Is the quarterly reporting period considered to be adequate and manageable given the scale and volume of data collection required?

5 UNCERTAINTY AND RISKS

To date, the Accounting Tool has been developed based upon a number of key assumptions in relation to its operation, scope and structure, and these assumptions are therefore reflected within the presentation and current functionality of the Tool. These assumptions are detailed within Section 3.2 (Step 2 – Setting Operational Boundaries), Section 3.3 (Step 3 – Identifying Emission Sources), and Annex 4 (GHG Source Inventory). Further limitations include the lack of publicly available emission factors, limited existing HA information upon which to base calculations and trial methods, and the uncertainty surrounding the likely nature and quality of data likely to be available, particularly from the HA's supply chain.

5.1 UNCERTAINTY

The issue of 'uncertainty' arises in two common forms within the Accounting Tool, and with GHG inventories in general. As defined within the GHG Protocol Corporate Standard, *scientific uncertainty* relates to where the science of actual emissions and/or removal processes is not fully understood. For example, in the calculations of Global Warming Potential (GWP) values a significant amount of scientific uncertainty exists. Such uncertainty is therefore inherent within Accounting Tools which are reliant upon emission factors or other values as part of emission calculations. However, the analysis and quantification of such uncertainty is recognised to lie beyond the scope and capacity of most inventory programmes.

Estimation uncertainty, which can be further subdivided into *model uncertainty* and *parameter uncertainty,* relates to the quantification of GHG estimates. Model uncertainty covers the uncertainty associated with the mathematical equations (models) that are used to characterise the relationship between emission-source activities and emission processes. This refers specifically to the use of an incorrect mathematical model or inappropriate inputs into the model. However, as with scientific uncertainty, the estimation of model uncertainty is likely to be beyond the scope of most inventory programmes. Alternatively, parameter uncertainty refers to the uncertainty associated with quantifying the parameters used as inputs to models, such as activity data and emission factors. It is considered that only parameter uncertainties fall within the feasible scope of most inventory programmes.

The GHG Protocol Corporate Standard includes a methodology to develop a basic uncertainty assessment for GHG inventory data. The potential application of such a methodology is detailed within Section 6 (Future Challenges).

5.2 IDENTIFIED RISKS

The Accounting Tool has been designed to incorporate information collected from both the HA, and also it's supporting contractors and suppliers. Due to the large scale over which the accounting tool is expected to perform, there are a number and variety of risks that may affect the success of the Tool. The risks manifest themselves in two predominant forms:

- The availability and reliability of input data; and
- Tool structure and function issues.

Table 4.1 details the keys risks that threaten the completion, operability, credibility or reliability of the Accounting Tool. Although these risks are presented separately, they are considered to be inherently interrelated. Table 4.2 details the key risks in relation to the Tool itself.

Certain risks can be overcome through the DCS detailed within Section 4.2 (Data Collection Strategy), which has The DCS is based upon that principles that clear identification of ownership / responsibility for each aspect of the Accounting Tool is established, and also that the number of individuals directly inputting to the Accounting Tool is limited, and are supported by appropriate training.

Table 4.1 Key Data Risks and Solutions

Risk Area	Issue
(A) Input Data Inaccuracies	Due to the large scale of operations and aspects that the Accounting Tool will cover, and the number of people required to provide, collect or analyse data to input into the process, there are a number of inherent risks pertaining to: ➢ Users entering incorrect data / falsified data / or making 'best-guess' approximations where gaps exist. ➢ Entering data in wrong units. ➢ Entering data in wrong reporting period or overlapping reporting periods (see below) ➢ Data entered into incorrect fields of workbook. *Risk Reduction*: Certain risks identified above cannot be fully avoided, and human error is an inescapable factor. However, the Tool can be designed in a manner to lead users through the process to reduce the opportunities for data inaccuracy, and to simplify the process into clearly defined logical steps. For example, through asking Users to make a choice from a drop-down menu (i.e. to select either tonnes or cubic metres) before inputting relevant data, the menu serves to prompt the user to think about the data they are entering. Furthermore, an accompanying Instruction Manual has been produced to assist users in completing the Accounting Tool.
(B) Data Gaps and Supply Chain Issues	Data gaps are a key risk within the Accounting process, resulting in the potential underestimation of the HA's Carbon Account. A key issue lies in relation to the identification and collation of data and information from the large number of supply-chain sources used by the HA. Additionally, the direct supply-chain (such as the HA's MACs), may have difficulty in obtaining data from their sub-contractors. The coverage of data is a key issue to be considered with regard to making comparisons between areas of the HA business. For example, one MAC may be able to provide a complete inventory of their emissions, whilst another may have significant data gaps. Therefore, the validity in drawing comparisons between MACs and any subsequent management decisions made would be limited - that is the differences in reported emissions would relate to the degree of reporting, rather than differences in actual emissions. *Risk Reduction:* As part of the Tool's development, close liaison with the relevant aspects of the HA's operation (e.g. facilities teams, Major Project's managers and MACs) will be required to ensure that the adopted scope is sufficient to fully identify the range of the HA's direct and indirect emissions sources. Following the provision of information as part of the accounting process, a process of data, checking and validation would be recommended, in order to identify any significant data gaps. Furthermore, the Accounting methodology, alongside the data collection methodology, should be developed in a fully transparent and auditable manner.
(C) Inconsistent Reporting Timescales	Given that the Accounting Tool has been developed for use on a quarterly basis, it is essential that the data collected and reported covers the relevant quarter only. This is to ensure any overlap in data does not result in emissions double-counting. It is recognised that quarterly reporting will suit certain aspects of the HA's operation more than others, as for example Majors Projects will run across a number of reporting periods. *Risk Reduction*: In order to allocate emissions to the correct reporting period, a 'point-of-purchase' allocation is to be adopted. Therefore, all emissions are to be reported at the time / point of purchase, and not be carried forward into subsequent periods. For example, construction materials should be accounted for during the quarter they are purchased in, irrespective of whether they are utilised during this reporting period or the next.
(D) Data Bias	Data quality could be affected through instances of data bias. For example, a bias could be the unintentional exclusion of operations at smaller facilities. The cumulative contributions of excluded operations at the HA-level may however be significant. Information from the supply chain may be biased through 'best guess' data supply, rather than specific, auditable information. Furthermore, data generated for purposes other than preparing a GHG inventory should be approached with caution. The applicability of such data may require verification, in terms of completeness and consistency with HA reporting methods. *Risk Reduction*: Undertaking an 'Uncertainty Assessment' as part of future work, to identify, and quantify the level of uncertainty, and to develop data collection methodologies based upon thee findings (see Section 6, Future Work).

Risk Area	Issue
(E) Reporting Inaccuracies	Reporting inaccuracy may particularly occur where specific data is not available. In this instance, certain 'estimator calculators' have been included within the Accounting Tool - for example, a water consumption estimator based upon the number of employees to be accounted for. Although the 'Estimator Calculators' assist in reducing the risk of the User entering entirely fabricated data, they still have an inherent risk as they are reliant upon the User's own estimates of e.g. employee numbers and floor space, and as such an over- or under-estimation may therefore occur. *Risk Reduction*: To a degree, this risk is avoidable where specific activity data is readily available. These estimator calculators have been developed as a 'last resort', to enable some data collection rather than have data gaps. The assumptions made within estimator calculators should be refined (in the short-term), and monitored and updated as appropriate, to ensure that inaccuracies are minimised. Some degree of inaccuracy is however inevitable in adopting such as approach.

Table 4.2 Key Tool Risks and Solutions

Risk Area	Issues
(A) Double Counting Emissions Through Reporting Overlaps	Should the structure of the Accounting Tool not accurately reflect the operations and responsibilities of the HA and its supply chain (for example, if any unknown overlap in operations exists), then emissions may be accounted for twice within the process. As such, there may be undisclosed areas of the HA's business that have been omitted from the Accounting Tool and therefore not reported at all. This may also extend to individual employees and HA / MAC working responsibilities, particularly where activities / operations cross-over and there are no clearly defined boundaries. *Risk Reduction*: A detailed review of the Accounting Tools coverage of the HA's operations and activities, involving personnel from HA facilities, Major Projects teams, MACs, and other identified areas of the Agency's business, should be undertaken to confirm the designed scope and identify any gaps and areas of potential overlap. The objective is to check that the organisational and operational boundary decisions are correct, and that these decisions are applied correctly and consistently to the collection of activity data.
(B) Insufficient Scope of Accounting Tool	The structure of the HA's internal activities are understood, however the large number of facilities operated by the MACs, and the potential variability between MACs, pose several issues in terms of data collection and reporting lines. Given the number of facilities, the potential for emissions double-counting is considered to be high. Furthermore, new facilities may open / close either within or between reporting periods. Once identified, such changes should be incorporated and highlighted within the reporting process. *Risk Reduction*: As part of the Tool's development, close liaison with the relevant aspects of the HA's operation (e.g. facilities teams, Major Project's managers and MACs) will be required to ensure that the adopted scope is sufficient to fully identify the range of the HA's direct and indirect emissions sources. Clear communication of the requirements for data provision will be necessary, in addition to a robust data verification process at the time of collation. This could include some form of audit.
(C) Tool Inaccuracies	Given the complexity of the development process, there exists a risk of inherent errors included within the Tool – such as incorrect implementation of conversion factors and formulae for example. *Risk Reduction*: Such risk can be overcome and minimised through a robust review and User testing process as part of the Accounting Tool development process.

Risk Area	Issues
(D) Calculation Accuracies	Some methods of emission calculations are more accurate than others. For example, calculating transport emissions should ideally be performed using fuel consumption rather than a distance-based method. However, due to the limitations of data availability it is considered unlikely that the most accurate methodologies can be used throughout – which itself may result in a significant administrative burden. *Risk Reduction*: The format in which data is specified and the data collection strategy is of key importance in reducing such risks. For example, providing suppliers with a pro-forma template to be completed would ensure that data was recorded in a consistent manner, and any data omissions would be immediately apparent. Where an option of using two types of emissions calculation methodologies is provided (e.g. fuel based and distance-based methods of estimating vehicular emissions), the preference for using the more accurate method will be clearly stated.
(E) Inaccurate Data Interpretation / Comparison	Following from Risk (B) identified within Table 4.1, there is a risk that emission values detailed within the Accounting Tool may be unjustly compared with one another. In addition to the data coverage issues from Table 4.1, an example would be the differing coverage of MACs – in terms of the number of staff, number of projects, size of offices, and the area of network maintained. In seeking to set targets in the future, comparisons between MACs would not be directly appropriate. *Risk Reduction*: To undertake a realistic comparison between aspects of the HA's business and operation, scaling factors could be developed in order to ensure a like-for-like evaluation upon which to base management decisions. This may include the calculation of CO_2 emissions per capita for example. Alternatively, comparisons may be made to best practice values.
(F) Tool Updating Issues	Emission factors will change over time, as technologies become more efficient, and research into the field of Carbon Accounting is progressed. Factors for new areas of reporting are also likely to be developed. Structural changes within the HA may also require the Tools structure and functionality to be updated, should existing methods of data collection / management no longer be appropriate / applicable. If conversion factors and methodologies used within the Accounting Tool are not regularly updated to keep abreast of future changes, the above issues would lead to a loss of accuracy, reliability and credibility of carbon accounting data. *Risk Reduction:* To ensure that the underlying assumptions, emissions calculation methods and conversion factors are regularly maintained and updated inline the latest, published guidelines, a clear system for tracking progress needs to be developed.

5.3 WIDER ISSUES

In the light of the provisions of the HA's Carbon Accounting Tool (Version 1), the data collection and management process is of particular significance. In undertaking such processes, there is likely to be a degree of administrative burden, and associated financial cost. Furthermore, new areas of data collection within the HA's operations will inevitable be required – with the key challenge identified as sourcing data from the supply chain.

Certain wider issues have been identified in terms of: (i) the potential for the supply chain to pass on the financial burden of sourcing and providing data to the HA; and (ii) due to a lack of time, resources or training, the implementation of the Accounting Tool may provide insufficient in providing as robust an account of emissions as desired - both internally and from within the supply chain. Such key issues therefore require due consideration, so that the implemented Accounting Tool is not overly cumbersome, but at the same time, not limited in achieving its purpose.

6 FUTURE DEVELOPMENTS

As part of the Accounting Tool development process to date, a number of issues and areas for future refinement and development have been identified. This Section of the Report outlines areas of future development in terms of the following three areas (as detailed below):

- Tool clarifications and enhancements;
- Tool implementation; and
- Areas of further research.

6.1 TOOL CLARIFICATIONS AND ENHANCEMENTS

Certain calculations and aspects within the Accounting Tool have been based upon certain assumptions – with regard to the HA's structure and operation, and the nature of data availability. Such assumptions are likely to be refined following the initial Board Review process. The key aspects are discussed below.

6.1.1 Installed Onsite Renewables

Further information is required regarding the HA's use, and current installation levels of, onsite renewables, in order to update the Accounting Tool to fully reflect such provisions. As a future measure, the Tool could be further enhanced to provide an indicative change in emissions as part of enhanced renewable energy supplies. Should the HA operate, either presently or in the future, any grid-connected projects that result in the displacement or avoidance of electricity distributed over the National Grid, such provisions should be accounted for within the Tool.

6.1.2 Clarification of CO_2e

Within this Report, the use of 'CO_2' has been taken to include emissions of carbon dioxide, and other GHG's expressed as carbon dioxide equivalents (CO_2e). Within the Accounting Tool, emissions have been presented as CO_2, whereas in reality the values represent a combination of both CO_2 and CO_2e. Best practice recommends that different units should be reported separately; particularly given the relative uncertainly surrounding the application of CO_2e (see Section 3.3.1 – GHG Coverage, and 4.1 – Uncertainty). The Accounting Tool would therefore require future refinement to ensure consistency throughout. Some additional clarifications from references data sources would also be required – for example, in terms of the GHG coverage of the Bath Inventory.

6.1.3 Material Selection

Certain inconsistencies currently exist in relation to the lifecycle over which materials within the Bath Inventory have been considered, and as such are reflected within the Accounting Tool. These embodied carbon values are typically from 'cradle to gate', implying from the point of extraction / production through to the arrival at a site. More accurate lifecycle information in terms of the 'cradle to grave' embodied carbon would be desirable. This inconsistency would require therefore further consideration as part of the development phase, to ensure a standardised approach is adopted throughout.

6.1.4 Office Materials

To date, only a limited number of common office materials have been included within the Accounting Tool – including general office paper, personal computers, and light bulbs. This approach has included those materials for which emission factors have been readily obtainable. Values for other potentially significant emission sources, such as air conditioning units, would be incorporated following consultations with manufactures for instance to determine whether suitable emission factors are available. The scope of this category should therefore be expanded to include those materials of particular relevance to the HA and its operations, and the appropriate data regarding emissions and conversions be acquired.

6.1.5 Develop Supply Chain Coverage

The HA's supply chain has not been fully accounted for within the existing Tool, and this could be further developed to ensure it is fully consistent and reflective of the HA's operations. For example, the Accounting Tool does not presently account for the use of consultants employed as part of Major Projects or other aspects of the HA's work. Emissions from such sources would be classified as indirect, but would nevertheless contribute to the HA's Carbon Account.

6.1.6 Car Sharing

During initial internal reviews, the issue of car sharing was raised, along with the capacity of the Accounting Tool to incorporate and demonstrate the emission benefits gained. At present, the adopted methodology does not include such flexibility, given the nature of the transportation emission factors obtained from DEFRA, and their associated assumptions. Should the HA wish to reflect the emission benefits through the promotion of car sharing, this aspect would require further consideration,

6.1.7 Recycling Benefits

The Accounting Tool currently includes a methodology to calculate emission differences between waste management options, in terms of sending a particular waste to landfill, for incineration, or to be recycled. This aspect is currently limited to certain basic office materials, for which emission factors / conversions are available. The benefits of specifying certain recycled construction materials have also been included, and again are limited in terms of available data. These aspects could therefore be further developed in the future, should the HA wish to demonstrate or determine the benefits of waste management options.

6.1.8 Emission Factor Update Facility

As indicated previously, the emission factors used within the Accounting Tool will be subject to future change – in terms of refinements of existing factors, and the addition of new factors following further research within the field. It is therefore recognised that the Accounting Tool would benefit from a facility for users to insert new emission factors as necessary. In some cases, default emission factors might actually be customised in order to better represent actual operations, and therefore an override feature might achieve this.

6.2 TOOL IMPLEMENTATION

6.2.1 Refinement of Data Collection Methodologies

An envisaged data collection methodology is outlined within Section 4.2 (Data Collection Strategy), in order to ensure that data received from different business areas of the HA, and different suppliers, will prove to be consistent, and to provide a key step in reducing the risk of errors within the data collection process itself. This methodology will require User Testing to ensure its appropriateness to meet the data requirement needs of the Accounting Tool. As such, phases of User Testing and refinement of the data collection methodology is included within Section 7 (Proposed Delivery Strategy).

In addition to encompassing the latest emissions data, the Accounting Tool's reliability could be increased through improving the accuracy of the data entered into the Workbooks. This would be applicable to in-house data collection and to that submitted by third-party suppliers. As such, a series of 'proformas' could be further developed to specify the exact data required to be entered into the Tool.

6.2.2 Assurance Audit

In addition to the Data Collection Strategy, a system of ensuring the Accounting Tool itself remains as up-to-date and progressive as possible also requires future consideration. This is in terms of both ensuring the HA's requirements and targets continue to be met and, as discussed in Section 5.3 (Identified Risks), that the risk of using out-of-date conversion factors and assumptions is minimised.

To ensure that the Accounting Tool's integrity is maintained, the underpinning network of emission's conversion factors, methodologies and assumptions will need to be updated on a regular basis. In addition, new areas of emissions sources may be required to be added to the Accounting Tool, whilst in time it may become apparent that other sources (included at this stage) become defunct. Similarly, changes to the HA's requirements for the Accounting Tool may change, as may the HA's organisational and activities structures which would have subsequent influence on the applicability and usability of the Accounting Tool itself.

To keep abreast of any applicable updates which the Tool may require, an annual Assurance Audit should be conducted, to assess the current performance and applicability of the Tool against agreed KPIs. In addition, appropriate guidance and reference sources, as outlined below, should be consulted to verify whether emissions conversion factors and assumptions have been updated. It may also be possible to

sign-up to mailing lists, for various Carbon Management organisations, to receive updates of emissions data as they are developed.

It is envisioned that the Assurance Audit be conducted on an annual basis initially, inline with the specified reporting periods. Any necessary amendments to the Accounting Tool can then be implemented at a known specific and deliberate time and adequately reported across each section of the Tool.

The key data sources for emission conversion factors are summarised as follows, with the full references within Annex 3:

- Bath Inventory;
- Department for Business Enterprise and Regulatory Reform (BERR);
- British Standards Institute;
- Carbon Trust;
- DEFRA;
- GHG Protocol; and
- WRAP.

6.2.3 Development of Tool Interface

The Accounting Tool has been designed using a simple Microsoft Excel interface. The various workbooks (see Section 1.1) have not been linked through macros or other automated factions. During the development phase, this format is considered to be the most appropriate and efficient, in light of the requirements for updates and changes. Other examples of Accounting Tools have been developed as standalone Microsoft Excel files, through to more complex inter / intranet based applications. As a future development, the Accounting Tool could be integrated within the HA's existing intranet provisions, as desired.

Existing systems developed by other organisations have taken steps to streamline corporate-level data consolidation by allowing inventory coordinator's at each facility to configure a spreadsheet, enter monthly data, and send quarterly reports to a centralised database for Reporting. Using this approach, pro-forma spreadsheets are automatically e-mailed to inventory coordinators, and the completed email returns are uploaded to the database by a central individual / team. Inventory coordinators can modify configurations as facilities change (for example should new aspects be construction). Methodologies for estimating emissions and calculation equations are stored centrally and are applied automatically. Certain reporting programmes not only collate information for quarterly emission reporting, but also include estimates for future emission projections – which are subsequently verified as appropriate. In some cases, inventories are periodically reviewed by independent external auditors to provide assurance on the quality and accuracy of the data included.

6.2.4 Consideration of Uncertainty

As detailed within Section 5.1, various issues of uncertainty surrounding GHG accounting and reporting, with only parameter uncertainties (for example in quantifying input parameters such as activity data or emission factors), falling with the feasible scope of most GHG inventories. In considering potential uncertainties, the assessment process will evaluate the overall quality and reliability of input data, and provide feedback from data suppliers. The process can provide valuable information to guide priorities for investment into improving data sources and methodologies. As a future stage of development, it is recommended that a detailed assessment of uncertainty is undertaken, in accordance with the provisions of the GHG Protocol Corporate Standard, following the above refinements to the Accounting Tool.

6.2.5 Reporting and Comparison Analysis

In utilising the Accounting Tool to assist management decisions, it is likely that the HA will seek to compare and contrast the emissions performance of various parts of its business. For example, this may be between offices, or MACs, in order to establish and drive performance targets. Different aspects of the business may however not be directly comparable, and even differences within MACs may persist for example – due to the area covered, staffing levels and so forth. In overcoming such issues, the Carbon Account data could be processed in a manner to allow comparison, such as illustrating emissions on a per capita or per head basis. Major projects, in terms of the number and type are likely to vary from year to

year, and thus from reporting period to reporting period. Therefore, an appropriate means to allow comparison could be standardised upon financial basis such as the volume of emission per thousand pounds spend for example. As part of the Accounting Tool's future development, it is recommended that consideration be given to the most appropriate means of data presentation, to allow the HA to fully utilise the Tool's capacity to inform management decisions.

6.3 AREAS OF FURTHER RESEARCH

6.3.1 Traffic Management Measures

At present, the impact of Traffic Management (TM) upon vehicular transport emissions has been omitted from the Accounting Tool. However, it is accepted that transport emissions are influenced greatly by the speed at which the vehicle is travelling. TM reduces the speed at which traffic travels, which in turn affects the volume of GHG emissions produced. Although the HA cannot be held directly responsible for the volume of traffic using its Network, the HA does have control over the traffic management measures in place across it.

To achieve complete transparency, an estimation of the impact of TM across the Network could be developed for inclusion in the Accounting Tool.

Although TM measures essentially slow traffic, producing an estimation of the impact this has on transport emissions is not as simple as calculating the net increase / decrease in emissions volumes. Many other factors will influence how the changes in emissions volumes are affected, for which detailed emissions modelling would be required.

Examples of indirect impacts that the modelling would need to consider are as follows:

- The change in speed as a consequence of implementing TM;
- The length of road that will incur knock-on effects leading up to TM restrictions;
- The length of road where speed restrictions are enforced;
- The length of road that will incur knock-on effects once the TM has been driven past; and
- The influence on driver-behaviour i.e. the percentage of vehicles using alternative routes, their speed and CO_2 contribution.

Due to the number of possible direct and indirect influences that TM measures may impose on vehicle emissions, it is recommended that a set of 5 – 10 scenarios be developed. Each scenario could incorporate a variation of influences that TM may have on emissions production, and thus provide an estimate of the impact of TM on the HA's Carbon Footprint.

In order to progress this potential accounting aspect, it would be prudent to invite discussion with the Department for Transport (DfT) to ensure responsibilities for traffic are correctly identified.

6.4 CARBON MANAGEMENT STRATEGY (CMS)

The development of the Accounting Tool, in terms of its capturing and reporting of the HA's GHG emissions, forms the initial stage of a CMS. As such, following the establishment of the initial emissions baseline, the focus of the Accounting Tool should be with regard to its application in facilitating such benefits through its application as a management and decision-making tool. Part of this process, therefore, is to ensure that the operation of the Accounting Tool enables sound decision-making through the provision of reliable, transparent and robust information. Developing a Strategy to maintain inventory quality is therefore considered to be key.

Carbon Management, by its inherent nature, requires a comprehensive approach that can impact positively upon all areas of an organisations operation. It is recognised that the adoption of a Carbon Management Strategy can not only provide financial benefits, but can simultaneously provide emissions reductions and therefore reduce environmental impacts.

Adopting a GHG emission reduction target is often the logical follow-up to the initial Carbon Accounting process, which typically constitutes an agreed vision for emission reductions from the base year over a defined period of time. Establishing a high-level target based vision will therefore align the HA's CMS with national targets for GHG emission reductions, and those adopted for the public sector. Such targets can

be, and it is understood will be, embedded within the HA's Business Plan, in order to maintain high-level corporate visibility, and to essentially drive moves towards emission reductions.

It is also important to consider the cost implications of committing to an emissions-reduction target, and investment opportunities should be carefully evaluated with respect to their contribution to emissions reductions and costs.

In developing such a CMS, it is recognised that the role and responsibility of the HA would require due consideration in relation to the Department for Transport (DfT), and consultations would therefore be required.

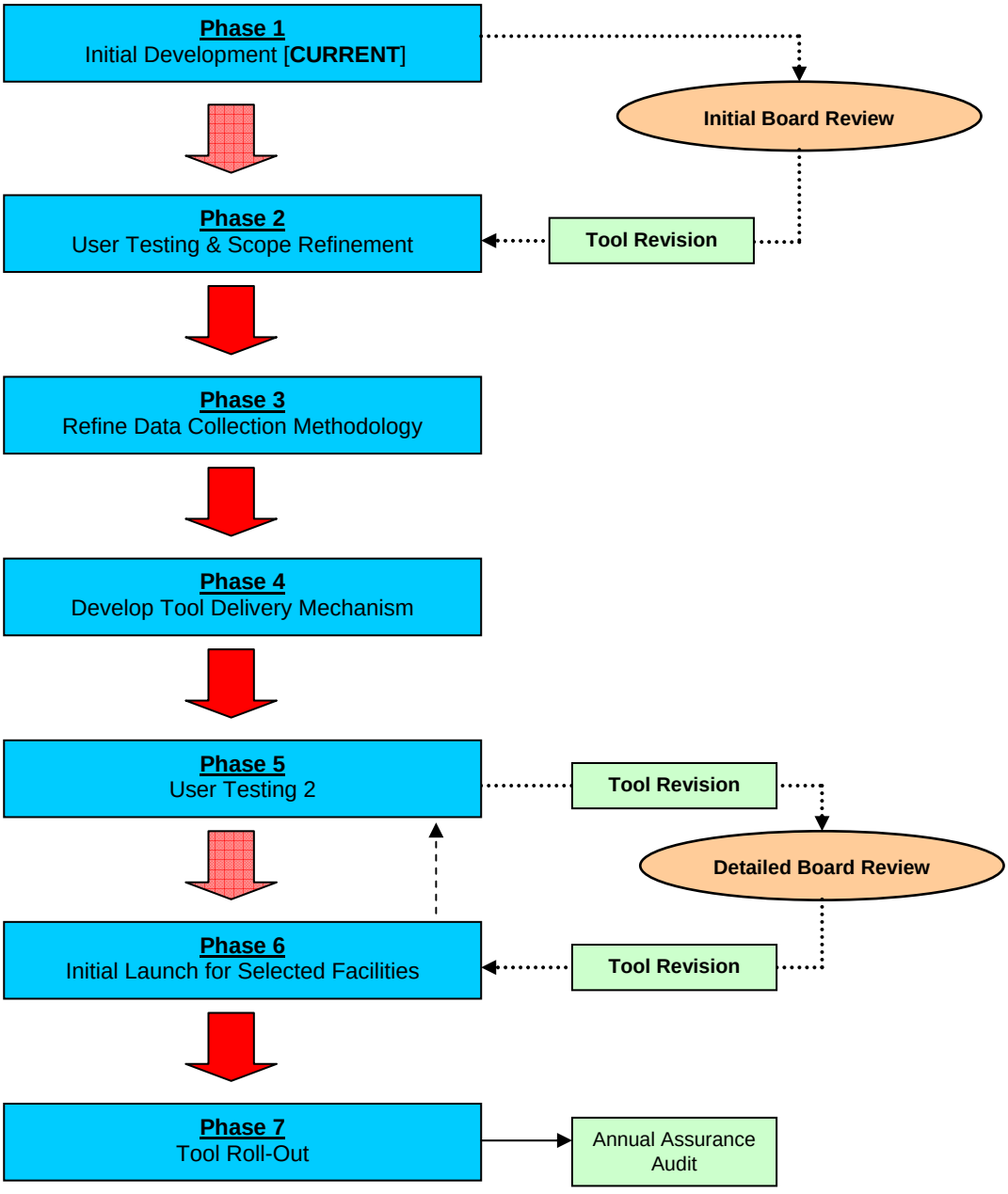
7 PROPOSED DELIVERY STRATEGY

Following from the identified risk and challenges in the proceeding Sections, this Section of the Report outlines a delivery strategy for the development of the HA Carbon Accounting Tool. The objective is to outline a method to evolve the Tool from the point of initial development, through to implementation, and subsequent operation. This is recognised to be a progressive and gradual process given the scope of the exercise, the range of operations and activities to be accounted for, and also the importance of the HA's supply chain in providing the required input data.

Furthermore, it is understood that the HA's Business Plan for 2008-09 will include a target for the capture date on carbon emissions resulting from the HA's business, with figures to be reported within the 2008-09 Annual Report. It is envisaged that this would be used as a benchmark for future targets, and therefore adds to the urgency and the importance of developing a robust Accounting Tool.

The proposed delivery strategy and the recommended phases of development are illustrated within Figure 7.1 below.

Figure 7.1 Proposed Delivery Strategy



Within Table 7.1 below the main activities identified for each stage within the proposed delivery strategy has been summarised. Furthermore, indicative timescales have been included in order to facilitate discussions in relation to a potential programme.

Phase	Main Activities	Indicative Timescales
1 – Initial Development	➢ Initial development of Accounting Tool methodology.	Complete March 2008 – followed by Panel Review / Presentation to Board
2 – User Testing and Scope Refinement	➢ Develop responses to initial Board / Panel Reviews, and issue a strategy paper outlining proposed delivery strategy. ➢ Undertake a programme of User testing with an HA Office, MAC, Major Project Team, DBFO Team, and Tolling Station [*Note – user testing may not be required with all of the above, but direct consultations are strongly recommended*] to ensure scope of Accounting Tool is accurate and achievable. ➢ Undertake further research and address areas of clarification / enhancements as outlined within Section 6.	12 Weeks
3 – Refine Data Collection Methodology	➢ Following user testing, refine data collection methodology as required, to ensure complete coverage of identified emissions sources. ➢ Expand data collection proforma to specify data requirements, and off-screen calculations. ➢ Further consultations with Users and HA Teams.	8 Weeks
4 – Develop Tool Delivery Mechanism	➢ Undertake research of existing Tools and methodologies to establish key benefits and likely issues to be considered. ➢ Establish, through consultations, the preferred medium for distributing, accessing and managing the Accounting Tool – e.g. Microsoft Excel, inter/ intranet based. The likely timescales would therefore be closely linked to the nature of the system required and its complexity.	16 weeks
5 – User Testing 2	➢ Second Stage of User Testing - to trial the revisions and refinements made to the initial Accounting Tool. ➢ This stage will be less extensive than the First Stage of testing, and will focus on the usability of the Tool. ➢ Once completed, the Accounting Tool will undergo a second Board / Panel Review and any comments arising addressed accordingly.	4 Weeks
6 – Initial Launch for Selected Facilities	➢ Accounting Tool to be launched to selected representative HA facilities for one reporting quarter, to further trial and refine methodology as required. ➢ Due to the nature of the Accounting Tool, a continual process of review has been built into Phase 6. This will be implemented in conjunction with Phase 5 to ensure that any comments arising through the use of the Tool, that have not been raised previously, can be addressed as appropriate at the earliest possible stage. Such comments may include changes to organisational and operational structure.	12 weeks
7 – Tool Roll-Out	➢ Accounting Tool to be rolled-out across entire HA operations. ➢ An assurance audit of the Accounting Tool would be conducted on an annual basis.	Assurance Audit undertaken Annually.

ANNEX 1 ABBREVIATIONS

DBFO	Design-Build-Finance-Operate
BERR	Department for Business Enterprise and Regulatory Reform
BSI	British Standards Institute
CCL	Climate Change Levy
CFCs	Chlorofluorocarbons
CH_4	Methane
CMS	Carbon Management Strategy
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
DCS	Data Collection Strategy
DEFRA	Department for Environment, Food and Rural Affairs
DfT	Department for Transport
DTI	Department of Trade and Industry
EA	Environment Agency
EST	Energy Saving Trust
GHG	Greenhouse Gas
GWP	Global Warming Potential
HA	Highways Agency
ICE	Inventory of Carbon and Energy
IPCC	Intergovernmental Panel on Climate Change
KPI	Key Performance Indicator
kWh	Kilowatt Hours
LECs	Levy Exemption Certificates
MAC	Managing Area Contractor
m^2	Square Metres
m^3	Cubic Metres
N_2O	Nitrous Oxide
NOx	Nitrogen Oxides
NTCC	National Traffic Control Centre
OFGEM	Office of Gas and Energy Markets
PAS	Publicly Available Standard
PB	Parsons Brinckerhoff Ltd
PFC	Perfluorocarbons
RCC	Regional Control Centre
SDAP	Sustainable Development Action Plan
SF_6	Sulphur Hexafluoride
SOGE	Sustainable Operations on the Government Estate
TM	Traffic Management
WBCSD	World Business Council for Sustainable Development
WRAP	Waste Resources Action Programme

WRI	World Resources Institute

ANNEX 2 GLOSSARY

General Terms

Assurance Audit The process of an independent third party checking the methodology, data and calculation processes within an Accounting Tool to ensure that they are robust.

Carbon dioxide (CO_2) Considered to be on of the most important greenhouse gas. CO_2 emissions result from the combustion of fuel, from land use changes and from some industrial processes.

Carbon dioxide equivalent (CO_2e) There are six main greenhouse gases which cause climate change and are limited by the Kyoto Protocol. Each gas has a different global warming potential. For simplicity of reporting, the mass of each gas emitted is commonly translated into a carbon dioxide equivalent (CO_2e) amount so that the total impact from all sources can be summed to one figure

Carbon Footprint The total set of greenhouse gas emissions caused by an individual or organisation, event or product. It should be expressed in carbon dioxide equivalent (CO_2e).

Control Approach Under the GHG Protocol, this approach establishes than an organisation accounts for the GHG emissions from operations over which it has control. Organisations do not account for GHG emissions from operations in which it owns an interest, but has no control of. 'Control' is be defined in either financial or operational terms.

Conversion Factor A numerical value to enable a conversion from a unit of activity / consumption (e.g. consumption of aggregate in cubic metres) into an appropriate unit so that an emission factor can be applied (e.g. conversion from cubic metres into tonnes).

Double Counting When a carbon emission or reduction is including within a GHG Inventory twice, which could potentially occur at numerous levels within an Accounting Tool.

Emissions Factor When calculating emissions from energy use it is common to know what quantity of energy was used, either in kWh or by volume or mass of input material. Emissions factors enable a conversion to be made from the input measure of energy to the amount of carbon dioxide emissions that will result.

Equity Share Approach Under the GHG Protocol, this approach establishes than an organisation accounts for GHG emissions from operations according to its share of equity in (business) operations.

Global Warming Potential (GWP) a factor describing the radiative forcing impact of one mass-based unit given a GHG relative to an equivalent unit of carbon dioxide over a given time period.

Greenhouse Gas (GHG) GHGs are those which contribute to the greenhouse effect when present in the atmosphere. Six greenhouse gases are regulated by the Kyoto Protocol, as they are emitted in significant quantities by human activities and contribute to climate change. The six regulated gases are Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and Sulphur hexafluoride (SF_6).

Greenhouse Gas Inventory An organisation's greenhouse gas sources, greenhouse gas sinks, greenhouse gas emissions and removals.

The Greenhouse Gas (GHG) Protocol A widely used standard for emissions reporting. The protocol covers project emissions reporting and corporate emissions reporting. The corporate emissions reporting standard provides a methodology for calculation of a carbon footprint. The protocol was developed by the World Resources Institute and the World Business Council for Sustainable Development.

ISO 14064 ISO 14064 is an international standard for corporate emissions reporting. It builds on the approach outlined in the Greenhouse Gas Protocol.

Offset An emissions reduction, commonly resulting from a project undertaken in the developing world, which has been sold to compensate for emissions elsewhere. Offsets are commonly used to net off corporate emissions so that an organisation can claim to be carbon neutral.

Specific Accounting Tool Terms

Carbon Account (Tier 1) The HA's GHG Inventory, defined as an organisation's greenhouse gas sources, greenhouse gas sinks, greenhouse gas emissions and removals.

Reporting Area (Tier 2) The business areas around which emissions data is collated. The Accounting Tool currently consists of the following six Reporting Areas: HA Internal Operations; HA Network Operations; HA Major Projects; HA Managing Area Contractors; HA DBFO Contracts; and Tolling Stations.

Emission Category (Tier 3) Identified emission sources are classified under various Categories in accordance with their relevant source and type. The Accounting Tool currently consists of the following four Emission Categories: Energy; Materials; Transport; and Waste Removal. For indicative purposes, a further Category is included in terms of Renewables and Recycling but these aspects do not constitute offsets.

Emission Source (Tier 4) The final Tier within the Accounting Tool includes the individual sources of emissions from the various activities and operations, and for which individual mission calculatiors have been developed.

ANNEX 3 REFERENCE LIST

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ANNEX 4 GHG SOURCE INVENTORY

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GHG Source Inventory

HA Internal

- 1. Energy
  - (A) Purchased Electricity Consumption
  - (B) Natural Gas Consumption
  - (C) Water Consumption
  - (D) Hotels & Accomodation
  - (E) Home Working
- 2. Materials
  - (A) Office Equipment & other
  - (B) General Refurbishment
- 3. Transport
  - (A) Business Travel
  - (B) Taxi Journeys
  - (C) Temporary Car Hires
  - (D) Employee Commuting
  - (E) Other Transport
  - Transportation of Materials from 5 Major refirbishment
  - Transportation of Materials from 2 Materials
- 4. Waste Removal
  - (A) Standard Office Waste Removal
  - (B) Indicative Recycled Office Waste Removal
- 5. Major Refurbishment
  - (A) Construction Materials
    - Cements
    - Metals
    - Misc.
    - Mortars
    - Plastics
    - Quarry Mix
  - (B) Ready Mix Concrete
  - (C) Windows
- 6. Renewables & recycling
  - (A) Installed Onsite Renewables Generation
  - (B) Renewable Energy Tarrifs
  - (C) Recycled Office Waste Diverted from Landfill
  - (D) Purchased Recycled Construction Materials

Network Operations

- 1. Energy
  - (A) Lighting System
  - (B) ITS Communication System
- 2. Materials (Per road type)
  - (A) Lighting System
  - (B) ITS System
  - (C) VRF
- 3. Transport
  - (A) Maintenance Activities
- 4. Renewables & recycling
  - (A) Installed Onsite Renewables Generation
  - (B) Renewable Energy Tariffs

Major Projects (per project)

- 1. Energy
  - (A) Site offices and Fixed Plant
  - (B) Mobile Plant
- 2. Materials
  - (A) Construction Materials
    - Cements
    - Metals
    - Misc.
    - Mortars
    - Plastics
    - Quarry Sources Materials
    - Timber
  - (B) Ready Mix Concrete
  - (C) Windows
  - (D) Office Equipment & Other
- 3. Transport
  - (A) Project Travel
  - (B) Taxi Journeys
  - (C) Temporary Car Hires
  - (D) Employee Commuting
  - (E) Transport of Materials – from 2 Materials
- 4. Waste Removal
  - (A) Standard Office Waste Removal
  - (B) Indicative Recycled Office Waste Removal
  - (C) Construction Waste Removal
- 5. Renewables & recycling
  - (A) Installed Onsite Renewables Generation
  - (B) Renewable Energy Tarrifs
  - (C) Recycled Office Waste Diverted from Landfill
  - (D) Purchased Recycled Construction Materials

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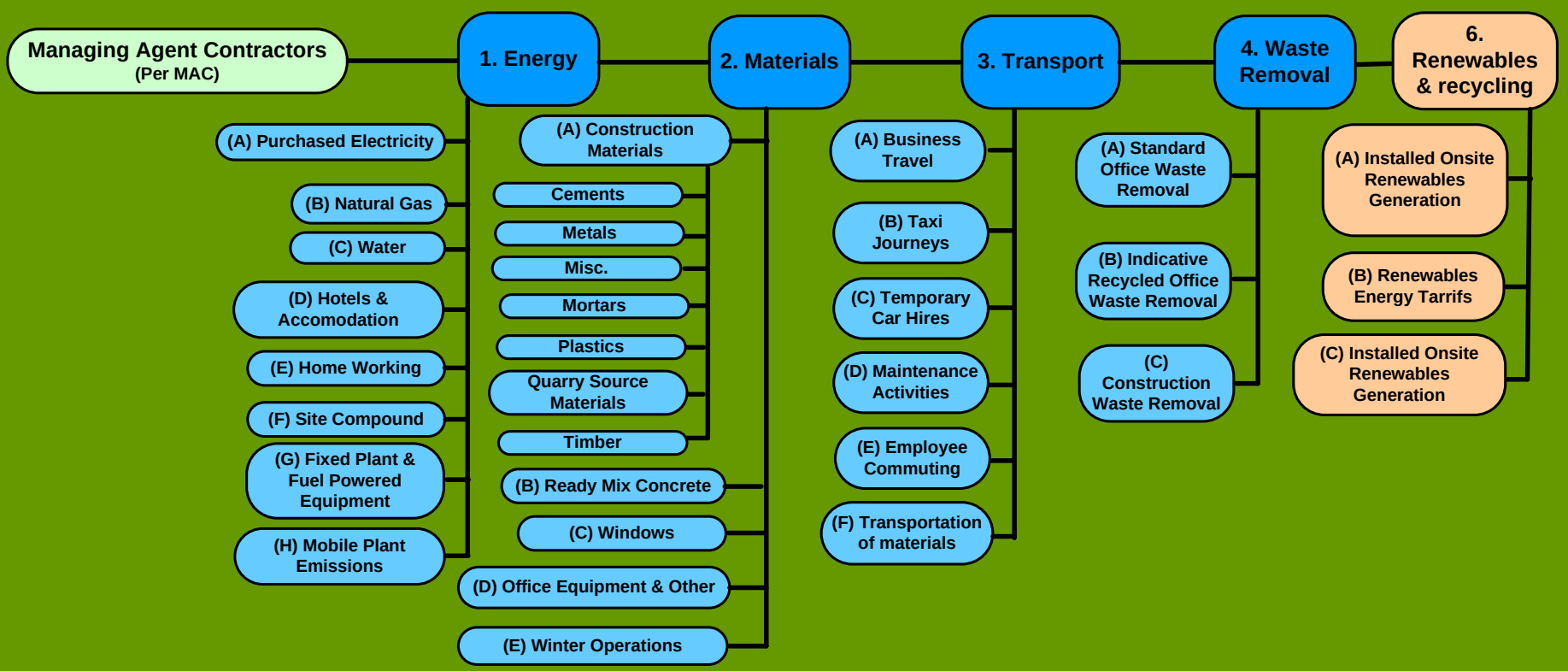
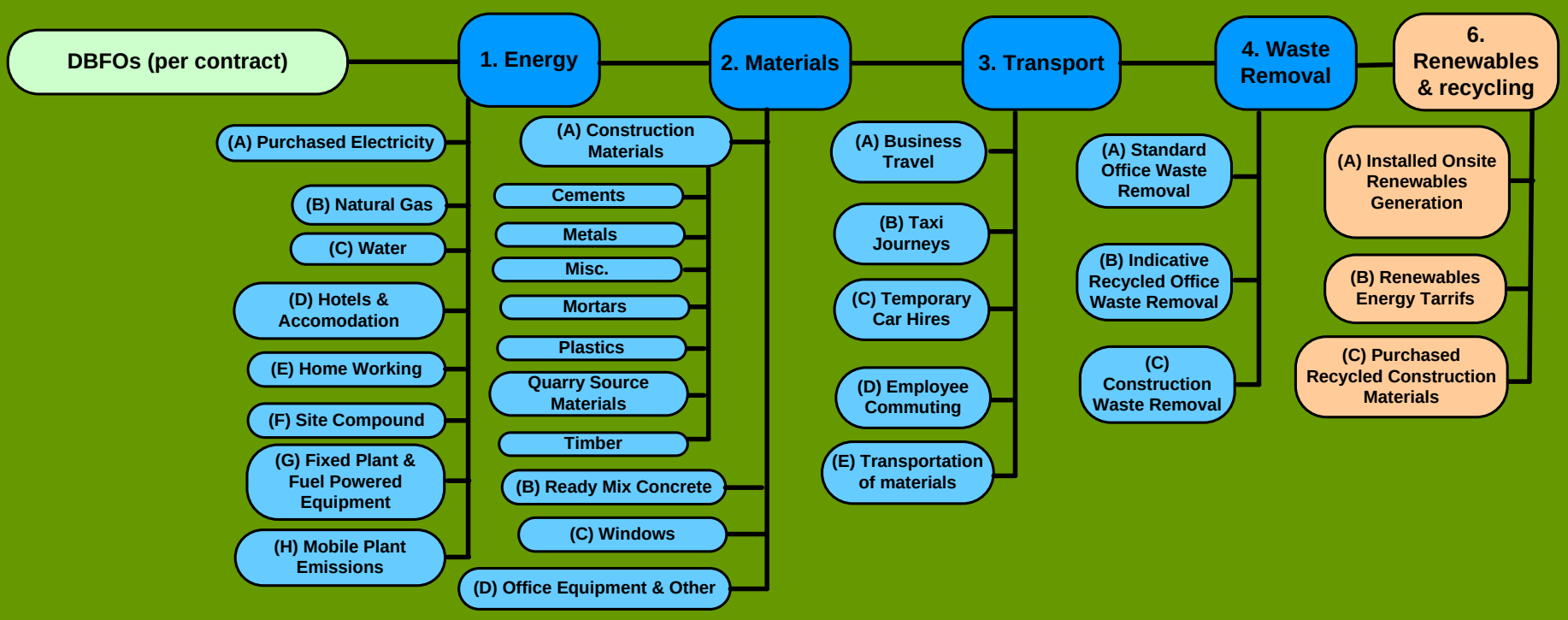
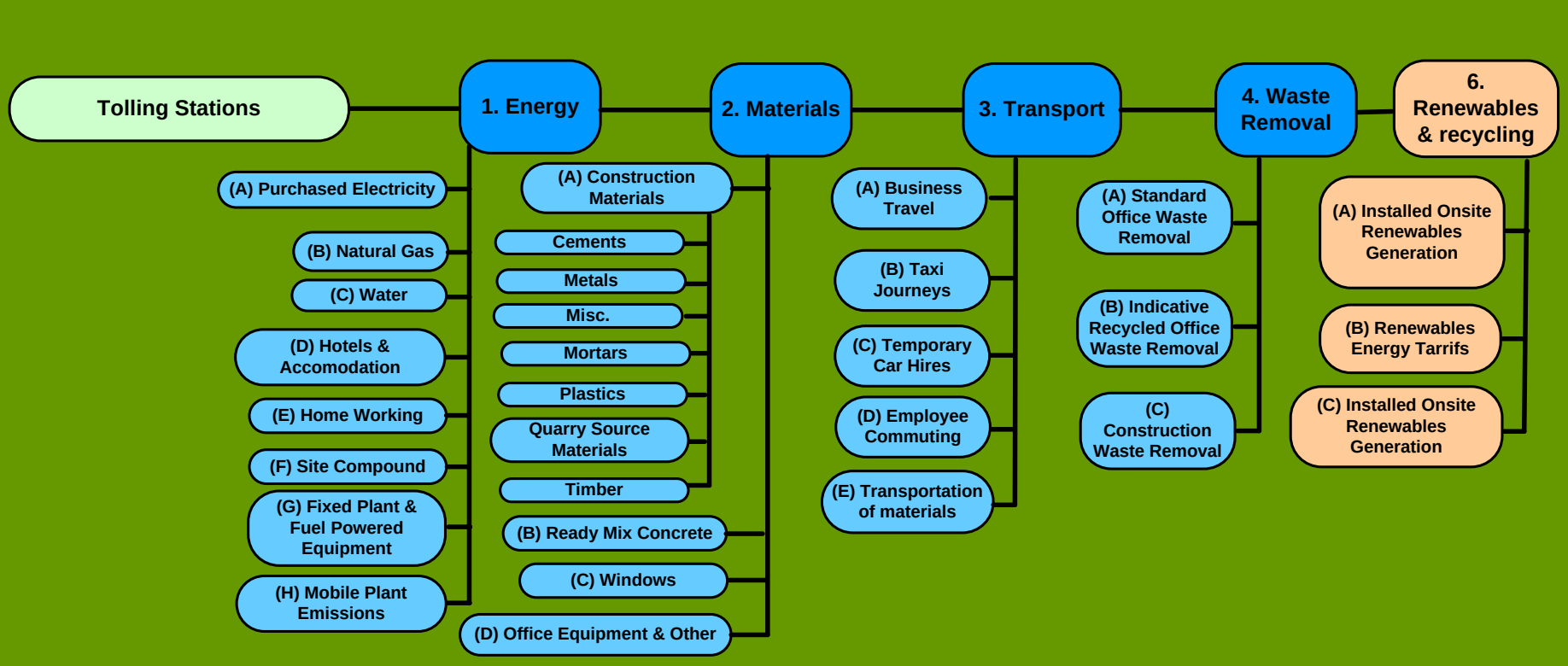
PARSONS BRINCKERHOFF

GHG Source Inventory







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ANNEX 5 ACCOUNTING TOOL DATA ASSUMPTIONS

HA Internal Operations

Aspect	Assumptions
(1) Energy	
Purchased Electricity Consumption	Emission factors for consumed electricity are derived from DEFRA Conversion Factors (2007) and draft updated factors within DEFRA (2008) Draft Code of Best Practice for Carbon Offset Providers. Any assumptions made by DEFRA are therefore incorporated within the Accounting Tool.
	The annual consumption estimator for electricity consumption per area is based upon data contained within CIBSE (2004). Guide F – Energy Efficiency in Buildings, which provides an indicative consumption value of 226kWh/m^2/annum for a standard air conditioned office with typical energy efficiency measures.
	Under current guidance, renewable energy inputs can only qualify for a zero emission factor when organisations have entered into a renewables source contract with an energy supplier which has itself acquired Climate Change Levy Exemption Certificates (LECs) for the electricity supplied as a non-domestic electricity consumer. In calculating emission savings, it has been assumed that renewable supply directly replaces Standard Supply and all associated emissions on a like-for-like kWh basis. OFGEM, DEFRA and the Energy Saving Trust are currently running consultations to revised guidelines on green supply tariffs, and to develop third party accreditation. Revised conversion factors will follow the outcome of these processes. Until this time, DEFRA advises to include renewables factors detailed within 2005 Emission Factors data. This assumes that certified renewables account for zero carbon emissions and this assumption is therefore made here.
Natural Gas Consumption	Emission factors for natural gas are derived from DEFRA Conversion Factors (2007) and draft updated factors within DEFRA (2008) Draft Code of Best Practice for Carbon Offset Providers. Any assumptions made by DEFRA are therefore incorporated within the Accounting Tool.
	The annual consumption estimator for gas consumption per area is based upon data contained within CIBSE (2004). Guide F – Energy Efficiency in Buildings, which provides an indicative gas / oil space and water heating consumption value of 151kWh/m^2/annum for a standard office.
Water Consumption	Emission factors for water consumption are derived from Veolia Corporate Social Responsibility (CRS) Report (2006). Form this report, the delivery of 1000litres of water correlates to the emission of 0.37kg of CO_2. This value is therefore assumed to representative for HA supply. Where actual water consumption data is not available, this can be estimated upon a per employee or floor area basis. As such, the following assumptions are made: • Annual water consumption per office employee = 9.4 m^3/year (data based upon The Watermark Project). Best practice data from the same source is estimated at 6.4 m^3/employee/year.
Hotel Estimates	Average hotel room consumption figures are detailed within Energy Consumption Guide 36 Energy Efficiency in Hotels (Department of the Environment, 1999). Further calculations detailed within Expotel - Carbon Neutral Program document have been adopted here in terms of average UK domestic hotels and hotels abroad, and these emission factor values are assumed to be representative. UK domestic business hotels are similarly allocated a value of 40kg/CO_2/night within CIBSE (2004). Guide F: Energy Efficiency in Buildings.
Home Working	This is an area of current research given increasing flexibility in working regimes offered by employers. Working from home or out of office is often referred to as 'teleworking'. The emission factors included within this tool are however initial assumptions only, and would require further research and quantification in order to refine attributable emission estimates. There exist large uncertainties in terms of average consumption patterns and behaviours. Emission factors for home working have been derived from UK domestic consumption statistics from the DEFRA website for 2005:

Aspect	Assumptions
	http://www.defra.gov.uk/environment/statistics/supp/spkf22.htm. Consumption values for domestic heating and lighting / cooking only have been used. Each annual figure is scaled to a daily basis, based upon an assumed number of hours in a working day. Assumed figures are as follows: • 14.4MWh per annum per household on heating (assume gas) -> equates to a daily household consumption of 39.45MW or 12.33kWh per work day of 7.5hrs. • 1.4 MWh per annum per household on lighting and cooking -> equates to 3.84MW / day consumption or 1.2kWh per work day of 7.5hrs. Water consumption emission factors are derived as detailed above. Average domestic consumption values are derived from OFWAT Security of Supply Report - 2006/07 for industry average daily domestic water consumption excluding pipe leakage. The annual consumption value is scaled to an assumed working day as above from 148 litres / head / day to 46.25l/h/working day of 7.5hrs. It should be noted however that this value does not take into account other uses of water by consumers for purposes unrelated to home - working, and as such is likely to be an over-estimate. In terms of employee's working hours, the following has been assumed: • Full-time employees work 37.5hrs/week, part-time employees work 20hrs/week. • 48 working weeks per year. • Therefore full-time employees work 1800 hours/year (240 days/yr) • Part-time employees work 960 hours/year (128 days/yr).
(2) Materials	
Office Equipment and Other	General Office Paper Paper weights per ream calculated upon 80g/m^2 using standard A4/A3 paper sizes: 2.4948kg/ream A4 and 4.9869kg/ ream A3. Carbon emission factors derived from the 'Bath Inventory' – Hammond, G. & Jones, C. (2006). Inventory of Carbon and Energy (ICE) – Version 1.5a Beta. Mobile Phones CO_2 conversion factors and an average weight of 0.0009t (or 86.5g) per mobile phone handset has been derived using conversion factors from Yamaguchi, H et al (2003) A Life Cycle Inventory Analysis of Cellular Phones. It is recognised that since 2003, more recently produced phones may well be lighter, use improved / different materials, and have been produced through more energy efficient processes. Research is ongoing in the area. Personal Computers (PCs) Conversion factors for PCs have been derived from US EPA (2003) *Background Document for Life Cycle Greenhouse gas Emission Factors for Carpet and Personal Computers*. • It is recognised that technology has progressed rapidly since 2003. Components are more sophisticated and materials may be lighter e.g. flat plasma screens, but that production processes may have become more efficient. These conversion factors only consider the central processing unit (CPU) and monitor, not the peripheral equipment e.g. mouse, keyboard, cables. • Conversion factors are based on an average weight of 70 lbs per PC, which has been converted to 31.75kg per Computer (Conversion factor: 1kg = 2.205 pounds) • These emissions factors do not include the 'embedded energy' in plastic feedstocks e.g energy value of petroleum used to manufacture plastic. • tCO_2 have been measured as metric tonnes of carbon equivalent per tonne of material (tCeq/t). • tCeq/t has been calculated using Total Process Energy Emissions (15.38tCeq/t) + Process Non-Energy Emissions Factor for Personal Computer Manufacturing (0.026tCeq/t). • Transportation Energy Emissions factors have not been included as set out in US EPA (2003) methodologies. Instead, they have been included using DEFRA (2007) as it is assumed these are a more accurate data source to calculate transportation carbon emissions in the UK. Lighting Embodied energy requirements during manufacture obtained via personal communication

Aspect	Assumptions
	with Frank Altena, Sustainability Officer of Philips (Lighting). Values are initial estimates – Philips are currently undertaking studies into the embodied energy / carbon of their products and the indicate emission factors can be updated and refined in due course. Standard incandescent and halogen lamps embodied value of 0.5MJ/Unit. Fluorescent lamps / compact fluorescent lamps embodied value of 5.0MJ/Unit. Energy values have been converted to CO_2 emissions based upon DEFRA conversion factors for equivalent electricity consumption.
General Refurbishment	Carbon emission factors are derived from the 'Bath Inventory' – Hammond, G. & Jones, C. (2006). Inventory of Carbon and Energy (ICE) – Version 1.5a Beta. Conversion into relevant units has been based upon typical weight / density estimates from various sources: • *Carpet* – assumed weight of 1.3kg/m2 for an average carpet. Based upon data obtained direct from Scotmat Carpets (www.scotmap.co.uk). • *Underlay* – 1.935kg/m^2: http://www.tradepriced.co.uk/duralay_carpet_underlay.html • *Insulation* – a suitable conversion factor is a current data gap. • *Wallpaper* – a suitable conversion factor is a current data gap. • *Paint* - On average 5litre paint (undercoat) plus container = 8kg / 5litre paint plus container (exterior wood varnish) = 6kg. http://www.icipaints.co.uk. Assuming 1 kg = container, and average of weight of 1.2kg/litre has therefore been assumed. • *Vinyl Tile Flooring* - a suitable conversion factor is a current data gap. • *Vinyl Flooring* - a suitable conversion factor is a current data gap. • *General Timber* – weight of 0.5t/m^3 has been assumed based upon the Timber Trade Federation websites. http://www.ttf.co.uk/buying/products/ • *MDF* - Due to variations, MDF weights are not constantly proportional to thickness. Therefore a typical density has been assumed from Timber Trade Federation Panel Guide V2 - http://www.ttf.co.uk/buying/panel/. Assumed 12mm thickness mass = 84kg/m^2 has been included.
(3) Transport	
General Emission Factors	Standard transportation emission factors are derived from DEFRA Conversion Factors (2007) and (2005) as appropriate. Any assumptions within these document, and as detailed within the DEFRA Methodology Paper -Passenger Transport Emissions (2007) are therefore incorporated here. The DEFRA factors do not take into account the impact of different UK average driving speeds and cycles relative to those of the NEDC (New European Driving Cycle – used in vehicle type approval) and to an extent the impacts of vehicle age. They also take no account of further 'real-world' effects, such use of accessories (air conditioning, lights, heaters etc), vehicle payload (only driver +25kg is considered in tests, no passengers or further luggage), poor maintenance (tyre under inflation), gradients, weather conditions, more aggressive/harsher driving style, and other such variables. For full details of relevant assumptions the DEFRA Methodology Paper should be referred to. It should be noted that embodied energy / carbon within fuels is not fully accounted for within the emission conversion factors - in terms of extraction, refining, and transportation to point of sale.
Fuel Conversion Tool	The fuel conversion tool is based upon fuel cost figures for petrol and diesel as stated in BERR (2007) *Quarterly Energy Prices Dec 2007 - URN 07/276d ISSN number: 1475-6544*. Figures assume premium unleaded not super unleaded. Fuel prices are as follows: • Premium Unleaded: £0.9427p / litre • Diesel: £0.9685p / litre http://www.berr.gov.uk/energy/statistics/publications/prices/index.html BERR (2007) did not contain fuel prices for Liquid Petroleum Gas (LPG) therefore the fuel price for LPG has been extracted from figures provided by the Automobile Association (2007). Monthly 'average garage and supermarket figures' for Jan – Dec 2007 were used to provide an annual average fuel price for 2007, http://www.theaa.com/motoring_advice/fuel/fuel-price-archive.html LPG: £0.4722p / litre

Aspect	Assumptions
Taxi Journeys	Emissions are calculated based upon an average distance of taxi journeys in the UK of 7.567km (unconfirmed data from The CarbonNeutral Company website - http://www.carbonneutral.com/sbc/sbchelp.asp), multiplied by a DEFRA emission factor for an unknown vehicle.
Hire Car Delivery	No methodology is currently specified for this aspect. It is understood that for insurance reasons hire car deliveries are made directly to employees personal residences. The availability of collated hire car delivery data from respective hire car companies is currently being investigated by the HA to determine whether this aspect can be accurately accounted for within future versions of the Tool.
Air Travel	It has been assumed that specific flight distances are unlikely to be available for HA business trips. Therefore, if information regarding the number of trips is available, flight distances can be calculated based upon the following indicative flight distances from DEFRA (2008): ➢ Domestic – 425km ➢ Short-haul – 1200km ➢ Long-haul – 7000km As detailed within DEFRA Conversion Factors (2007), air travel is subject to an additional 109% uplift to account for no-direct routes. DEFRA Factors do not account for the additional impacts of radiative forcing (i.e. non-CO_2 impacts). This is an area of scientific uncertainty and on-going research. Current statistics suggest the total radiative forcing of aviation emissions are 2-4 times that of CO_2 alone. A figure of 1.9 times has been adopted within this tool - as detailed within the following Report: Jardine, C.N. (2005). Calculating Environmental Impacts of Aviation Emissions.
Other Transport	Other indirect transport is based upon a distance methodology, since it is assumed that data availability for such 3rd party suppliers is unlikely to be available. Such methodology is however accepted to be less accurate than a fuel-consumption based methodology. The following indicative distances have been assumed as part of the methodology based upon PB's own operations: • Local Building Contractors = 5km roundtrip per visit. • Regional Building Contractors = 100km roundtrip per visit. • National Building Contractors = 300km roundtrip per visit. • Local Courier Trips = 50km roundtrip per delivery. • Regional Courier Trips = 100km roundtrip per delivery. • National Courier Trips = 300km roundtrip per delivery. • Caterers assumed to undertaken 5km roundtrip per delivery. At this stage, these values are indicative only and can be revised as part of future Versions of the Tool should this be deemed necessary.

Aspect	Assumptions
(4) Waste Removal	
Standard Office Waste Removal	Waste removal emissions are based upon a road transportation factor outlined with AggRegain CO_2 Estimator Tool (2006), C4S – 0.0003174 tonnes CO_2/tonne/km. Standard Office Waste Removal • Typical office waste density = 0.1tonnes/cu.m waste. • Average wheelie bin contains 0.11tonnes of office waste. Data is based upon Environment and Heritage Service (2003). Municipal Waste Data Monitoring and Reporting: Interim Guidelines. • Average black bag volume of 60 litres, converted to cu.m and assumed to be an arbitrary 75% full at point of disposal generates a water volume per black bag of 0.045cu.m. Unknown Waste Arising – Estimator Tool This tool is for use when specific waste arising's are unknown for a given facility. Two estimators are available for use – based upon known floor areas or number of employees. The assumptions made in these calculations are as follows: • Average waste generation rates of 0.05cu.m/ employee/week, and 0.05cu.m/10m^2 floor area/week. • Typical office waste density of 58.5km/cu.m. • Assumed 48 working weeks per annum. Data is based upon CIBSE (2004). Guide G: Public Health Engineering.
Recycled Office Waste Removal	Waste removal emissions are based upon a road transportation factor outlined with AggRegain CO_2 Estimator Tool (2006), C4S – 0.0003174 tonnes CO_2/tonne/km. Other specific assumptions made are as follows: • *Office Paper Waste* – assumes 1 bag of office paper waste weighs c.10kg (based upon: PACE (2000). Information Note 17/2000: Measuring Waste – Advice for Government Managers on the Government Estate). • *Aluminium Can* – assumes 1 can = 0.02kg (based upon: PACE (2000). Information Note 17/2000: Measuring Waste – Advice for Government Managers on the Government Estate). One 60 litre rubbish bag is assumed to hold 30 cans. • *Toner Cartridge* – assumed 1 cartridge = 2kg (based upon: PACE (2000). Information Note 17/2000: Measuring Waste – Advice for Government Managers on the Government Estate).
(5) Major Refurbishment	
Emission Factors	The range of materials included within the Accounting Tool is based upon the provisions of the EA's Carbon Calculator, which has been developed for construction projects and is therefore applicable to the HA context. CO_2 emission factors within the EA Calculator are derived from the 'Bath Inventory' – Hammond, G. & Jones, C. (2006). Inventory of Carbon and Energy (ICE) – Version 1.5a Beta, which have been cross-referenced within the Accounting Tool. Where appropriate, conversion into relevant units has been based upon typical weight / density estimates from various sources as detailed. Further assumptions made are as follows: Windows Average embodied carbon values within the Bath Inventory have been assumed as follows: • PVC Framed Doubled Glazed – 112.5kgCO_2/m^2 • Aluminium-Clad Timber Framed Double Glazed – 58.5kgCO_2/m^2 • Timber Framed Double Glazed – 18.47kgCO_2/m^2 Additional Carbon factored applied to Krypton and Xenon filled units are 24.65 and 218.32 kgCO_2/m^2 respectively.

Aspect	Assumptions
	Supplier Transport Distances Where drop-down menus are present to select supplier locations, assumed distances (in km) for 'Local' and 'Regional' suppliers are 5km and 100km respectively. These values have been arbitrarily selected at this stage.
(6) Renewables and Recycling	
Installed Onsite Renewables Generation	The calculation for on-site renewables is included for information only and do not constitute carbon offsets. These factors are not discounted from emission calculations within this tool, since these have already been accounted for in terms of reductions of traditional fuel supplies. Further information of the types of renewable energy supplies currently (and potentially) operated by the HA so that the Tool can be modified to reflect this.
Renewable Energy Tariffs	See assumptions above from (A) Energy.
Recycled Office Waste	A limited range of Indicative emission avoidance values are available for certain materials following specific research by organisations, as follows: • WRAP (2006). Environmental Benefits of Recycling – An International Review of Life Cycle Comparisons for Key Materials in the UK Recycling Sector. • Environmental Protection Agency (2006). Solid Waste Management and Greenhouse Gases – A Lifecycle Assessment of Emissions and Sinks. • ERM (2006). Impact of Energy from Waste and Recycling Policy on Greenhouse Gas Emissions.
Recycled Construction Material Purchasing	The emission benefits of purchasing recycled materials have been calculated upon the assumption that recycled materials displace market average materials. Carbon emission factors are derived from the 'Bath Inventory' – Hammond, G. & Jones, C. (2006). Inventory of Carbon and Energy (ICE) – Version 1.5a Beta. Where appropriate, proportions of recycled material %'s have been factored into the calculations.

HA Network Operations

Aspect	Assumptions
(1) Energy	
Purchased Electricity Consumption	Emission factors for consumed electricity are derived from DEFRA Conversion Factors (2007) and draft updated factors within DEFRA (2008) Draft Code of Best Practice for Carbon Offset Providers. Any assumptions made by DEFRA are therefore incorporated within the Accounting Tool.
	Under current guidance, renewable energy inputs can only qualify for a zero emission factor when organisations have entered into a renewables source contract with an energy supplier which has itself acquired Climate Change Levy Exemption Certificates (LECs) for the electricity supplied as a non-domestic electricity consumer. In calculating emission savings, it has been assumed that renewable supply directly replaces Standard Supply and all associated emissions on a like-for-like kWh basis. OFGEM, DEFRA and the Energy Saving Trust are currently running consultations to revised guidelines on green supply tariffs, and to develop third party accreditation. Revised conversion factors will follow the outcome of these processes. Until this time, DEFRA advises to include renewables factors detailed within 2005 Emission Factors data. This assumes that certified renewables account for zero carbon emissions and this assumption is therefore made here.

Aspect	Assumptions
Lighting System and ITS Communications Equipment	Data for this section has been extrapolated from Capita Symonds (2008) *Carbon Footprint of Motorway Electrical Equipment v 4.* Within the Capita Symonds model, only two broad categories of road are investigated, Rural D3M and Rural ATM. Each of these roads has then been categorised by the type of lighting required, either 'passively safe columns, standard columns, or unlit'. Therefore, these types of road have been assumed to be typical of the HA. Further discussion is being carried out by the HA to decide what additional roads, lighting and communications system may be included in the future.
(2) Materials	
Lighting, ITS and Vehicle Restraint Systems	Data for this section has been extrapolated from Capita Symonds (2008) *Carbon Footprint of Motorway Electrical Equipment v 4.* • The embodied tCO2/unit of equipment has been estimated using data provided in the above document. Volumes of material per unit (e.g. lighting column) have been assumed by summing the individual components listed within each item of equipment. • CO_2 conversion factors are derived from the 'Bath Inventory' – Hammond, G. & Jones, C. (2006). Inventory of Carbon and Energy (ICE) – Version 1.5a Beta. Conversion into relevant units has been based upon typical weight / density estimates from various sources, with the exception of the figure for "electrical components", which is a rough estimate from Capita Symonds (2008). These data are typical of the UK market, and take into account the element of recycling that occurs for each material.
(3) Transport	
General Emission Factors	Standard transportation emission factors are derived from DEFRA Conversion Factors (2007) and (2005) as appropriate. Any assumptions within this document, and as detailed within the DEFRA Methodology Paper -Passenger Transport Emissions (2007) are therefore incorporated here. The DEFRA factors do not take into account the impact of different UK average driving speeds and cycles relative to those of the NEDC (New European Driving Cycle – used in vehicle type approval) and to an extent the impacts of vehicle age. They also take no account of further 'real-world' effects, such as use of accessories (air conditioning, lights, heaters etc), vehicle payload (only the driver +25kg is considered in tests, no passengers or further luggage), poor maintenance (tyre under inflation), gradients, weather conditions, more aggressive/harsher driving style, and other such variables. For full details of relevant assumptions the DEFRA Methodology Paper should be referred to. It should be noted that embodied energy / carbon within fuels is not fully accounted for within the emission conversion factors - in terms of extraction, refining, and transportation to point of sale.
Fuel Conversion Tool	The fuel conversion tool is based upon fuel cost figures for petrol and diesel as stated in BERR (2007) *Quarterly Energy Prices Dec 2007 - URN 07/276d ISSN number: 1475-6544*. Figures assume premium unleaded not super unleaded. Fuel prices are as follows: • Premium Unleaded: £0.9427p / litre • Diesel: £0.9685p / litre http://www.berr.gov.uk/energy/statistics/publications/prices/index.html BERR (2007) did not contain fuel prices for Liquid Petroleum Gas (LPG) therefore the fuel price for LPG has been extracted from figures provided by the Automobile Association (2007). Monthly 'average garage and supermarket figures' for Jan – Dec 2007 were used to provide an annual average fuel price for 2007, http://www.theaa.com/motoring_advice/fuel/fuel-price-archive.html LPG: £0.4722p / litre
Maintenance Activities	The maintenance activities listed within the workbook are based upon information received from the HA and an internal review by PB. The list of activities is not exhaustive and the HA are currently investigating further activities for inclusion. CO_2 emissions have been calculated using a fuel-consumption method which is accepted as being more accurate than using a distance-based method (DEFRA 2007). It is also assumed that data is unlikely to be available from MACs, for estimating distances over which maintenance vehicles have travelled as part of their operations.

Aspect	Assumptions
Renewables and Recycling	
Installed Onsite Renewables Generation	The calculations for on-site renewables is included for information only and are not carbon offsets. These factors are not discounted from emission calculations within this tool, since these have already been accounted for in terms of reductions of traditional fuel supply. Further information of the types of renewable energy supplies currently (and potentially) operated by the HA so that the tool can be modified to reflect this.
Renewable Energy Tariffs	See assumptions above from (A) Energy.
Recycled Construction Material Purchasing	The emission benefits of purchasing recycled materials have been calculated upon the assumption that recycled materials displace market average materials. Carbon emission factors are derived from the 'Bath Inventory' – Hammond, G. & Jones, C. (2006). Inventory of Carbon and Energy (ICE) – Version 1.5a Beta. Where appropriate, proportions of recycled material %'s have been factored into the calculations.

HA Major Projects

Aspect	Assumptions
Energy	
Site Offices and Fixed / Static Plant	Emission factors for consumed electricity are derived from DEFRA Conversion Factors (2007) and draft updated factors within DEFRA (2008) Draft Code of Best Practice for Carbon Offset Providers. Any assumptions made by DEFRA are therefore incorporated within the Accounting Tool.
	The annual consumption estimator for electricity consumption per area is based upon data contained within CIBSE (2004). Guide F – Energy Efficiency in Buildings, which provides an indicative consumption value of 226kWh/m^2/annum for a standard air conditioned office with typical energy efficiency measures.
	Renewable energy inputs can only qualify for a zero emission factor when organisations have entered into a renewables source contract with an energy supplier which has itself acquired Climate Change Levy Exemption Certificates (LECs) for the electricity supplied as a non-domestic electricity consumer. In calculating emission savings, it has been assumed that renewable supply directly replaces Standard Supply and all associated emissions on a like-for-like kWh basis. OFGEM, DEFRA and the Energy Saving Trust are currently running consultations to revised guidelines on green supply tariffs, and to develop third party accreditation. Revised conversion factors will follow the outcome of these processes. Until this time, DEFRA advises to include renewables factors detailed within 2005 Emission Factors data. This assumes that certified renewables account for zero carbon emissions and this assumption is therefore made here.
	Emission factors for water consumption are derived from Veolia Corporate Social Responsibility (CRS) Report (2006). Form this report, the delivery of 1000litres of water correlates to the emission of 0.37kg of CO_2. This value is therefore assumed to representative for HA supply.
Mobile Plant	Methodology A and B Emission factors are based upon those assumed within Environment Agency Carbon Calculator: http://www.environment-agency.gov.uk/business/444304/502508/1506471/1506565/1508048/1883907/?lang=_e
Materials	
Emission Factors	The range of materials included within the Accounting Tool is based upon the provisions of the EA's Carbon Calculator, which has been developed for construction projects and is therefore applicable to the HA context. CO_2 emission factors within the EA Calculator are derived from the 'Bath Inventory' – Hammond, G. & Jones, C. (2006). Inventory of Carbon and Energy (ICE) – Version 1.5a Beta, which have been cross-referenced within the Accounting Tool. Where appropriate, conversion into relevant units has been based upon typical weight / density estimates from various sources as detailed.

Aspect	Assumptions
	Further assumptions made are as follows: MDF / Particle Board / Plywood These materials can be purchased in a variety of thicknesses. This calculator assumes a thickness of 20mm for each, based on the figures used in the Environment Agency Carbon Calculator (2007). Due to variations, MDF weights are not constantly proportional to thickness. Therefore a typical density has been assumed from Timber Trade Federation Panel Guide V2 - http://www.ttf.co.uk/buying/panel/. Assumed 12mm thickness mass = 84kg/m^2 has been included. Windows Average embodied carbon values within the Bath Inventory have been assumed as follows: • PVC Framed Doubled Glazed – 112.5kgCO_2/m^2 • Aluminium-Clad Timber Framed Double Glazed – 58.5kgCO_2/m^2 • Timber Framed Double Glazed – 18.47kgCO_2/m^2 Additional Carbon factored applied to Krypton and Xenon filled units are 24.65 and 218.32 kgCO_2/m^2 respectively. Length / Density Calculations Assumed weight data to convert length / density calculations are as follows: *Clay Vitrified Pipes* • Assumed for DN 100 – 200: 10.55kg/m length. • Assumed for DN 200-300: 83.3kg/m length. Data based upon indicative figures derived from: http://www.naylordrainage.co.uk/densleeve.asp *Steel Pipes* Weights of steel pipes vary in accordance with the length and thickness as defined within British Standard - BS 1387:1985. Therefore, for the purpose of the calculations, average weights within each class (light, medium and heavy) have been assumed to cover all pipe dimensions as follows: • BS 1387 Light – 3.75kg/m. • BS 1387 Medium – 6.81kg/m. • BS 1387 Heavy – 7.86kg/m. Given the potential variability, the actual volume of steel used in pipe construction may therefore be over / underestimated accordingly. More detailed carbon emission values can be generated should specific pipe dimensions be provided, however is it currently assumed that the above mass conversion values are representative at this stage.
Supplier Transport Distances	Where drop-down menus are present to select supplier locations, assumed distances (in km) for 'Local' and 'Regional' suppliers are 5km and 100km respectively. These values have been arbitrarily selected at this stage.
Transport	
General Emission Factors	Standard transportation emission factors are derived from DEFRA Conversion Factors (2007) and (2005) as appropriate. Any assumptions within these document, and as detailed within the DEFRA Methodology Paper -Passenger Transport Emissions (2007) are therefore incorporated here. The DEFRA factors do not take into account the impact of different UK average driving speeds and cycles relative to those of the NEDC (New European Driving Cycle – used in vehicle type approval) and to an extent the impacts of vehicle age. They also take no account of further 'real-world' effects, such use of accessories (air conditioning, lights, heaters etc), vehicle payload (only driver +25kg is considered in tests, no passengers or further luggage), poor maintenance (tyre under inflation), gradients, weather conditions, more aggressive/harsher driving style, and other such variables. For full details of relevant assumptions the DEFRA Methodology Paper should be referred to. It should be noted that embodied energy / carbon within fuels is not fully accounted for within the emission conversion factors - in terms of extraction, refining, and transportation to point of sale.

Aspect	Assumptions
Fuel Conversion Tool	The fuel conversion tool is based upon fuel cost figures for petrol and diesel as stated in BERR (2007) *Quarterly Energy Prices Dec 2007 - URN 07/276d ISSN number: 1475-6544*. Figures assume premium unleaded not super unleaded. Fuel prices are as follows: • Premium Unleaded: £0.9427p / litre • Diesel: £0.9685p / litre http://www.berr.gov.uk/energy/statistics/publications/prices/index.html BERR (2007) did not contain fuel prices for Liquid Petroleum Gas (LPG) therefore the fuel price for LPG has been extracted from figures provided by the Automobile Association (2007). Monthly 'average garage and supermarket figures' for Jan – Dec 2007 were used to provide an annual average fuel price for 2007, http://www.theaa.com/motoring_advice/fuel/fuel-price-archive.html LPG: £0.4722p / litre
Taxi Journeys	Emissions are calculated based upon an average distance of taxi journeys in the UK of 7.567km (unconfirmed data from The CarbonNeutral Company website - http://www.carbonneutral.com/sbc/sbchelp.asp), multiplied by a DEFRA emission factor for an unknown vehicle.
Hire Car Delivery	No methodology is currently specified for this aspect. It is understood that for insurance reasons hire car deliveries are made directly to employees personal residences. The availability of collated hire car delivery data from respective hire car companies is currently being investigated by the HA to determine whether this aspect can be accurately accounted for within future versions of the Tool.
Employee Commuting – Methodology B	Emission factors are based upon those assumed within Environment Agency Carbon Calculator: http://www.environment-agency.gov.uk/business/444304/502508/1506471/1506565/1508048/1883907/?lang=_e
Waste Removal	
Waste Removal Emissions	Waste removal emissions are based upon a road transportation factor outlined with AggRegain CO_2 Estimator Tool (2006), C4S – 0.0003174 tonnes CO_2/tonne/km.
Standard Office Waste Removal	Standard Office Waste Removal • Typical office waste density = 0.1tonnes/cu.m waste. • Average wheelie bin contains 0.11tonnes of office waste. Data is based upon Environment and Heritage Service (2003). Municipal Waste Data Monitoring and Reporting: Interim Guidelines. • Average black bag volume of 60 litres, converted to cu.m and assumed to be an arbitrary 75% full at point of disposal generates a water volume per black bag of 0.045cu.m. Unknown Waste Arising – Estimator Tool This tool is for use when specific waste arising's are unknown for a given facility. Two estimators are available for use – based upon known floor areas or number of employees. The assumptions made in these calculations are as follows: • Average waste generation rates of 0.05cu.m/ employee/week, and 0.05cu.m/10m^2 floor area/week. • Typical office waste density of 58.5km/cu.m. • Assumed 48 working weeks per annum. Data is based upon CIBSE (2004). Guide G: Public Health Engineering.

Aspect	Assumptions
Recycled Office Waste Removal	Waste removal emissions are based upon a road transportation factor outlined with AggRegain CO_2 Estimator Tool (2006), C4S – 0.0003174 tonnes CO_2/tonne/km. Other specific assumptions made are as follows: • *Office Paper Waste* – assumes 1 bag of office paper waste weighs c.10kg (based upon: PACE (2000). Information Note 17/2000: Measuring Waste – Advice for Government Managers on the Government Estate). • *Aluminium Can* – assumes 1 can = 0.02kg (based upon: PACE (2000). Information Note 17/2000: Measuring Waste – Advice for Government Managers on the Government Estate). One 60 litre rubbish bag is assumed to hold 30 cans. • *Toner Cartridge* – assumed 1 cartridge = 2kg (based upon: PACE (2000). Information Note 17/2000: Measuring Waste – Advice for Government Managers on the Government Estate).
Construction Waste Removal	Assumed waste density of 2 tonnes per cubic metre, as detailed within EA Construction Carbon Calculator.
Renewables and Recycling	
Installed Onsite Renewables Generation	The calculations for on-site renewables is included for information only and are not carbon offsets. These factors are not discounted from emission calculations within this tool, since these have already been accounted for in terms of reductions of traditional fuel supply. Further information of the types of renewable energy supplies currently (and potentially) operated by the HA so that the tool can be modified to reflect this.
Renewable Energy Tariffs	See assumptions above from (A) Energy.
Recycled Office Waste	A limited range of Indicative emission avoidance values are available for certain materials following specific research by organisations, as follows: • WRAP (2006). Environmental Benefits of Recycling – An International Review of Life Cycle Comparisons for Key Materials in the UK Recycling Sector. • Environmental Protection Agency (2006). Solid Waste Management and Greenhouse Gases – A Lifecycle Assessment of Emissions and Sinks. ERM (2006). Impact of Energy from Waste and Recycling Policy on Greenhouse Gas Emissions.
Recycled Construction Material Purchasing	The emission benefits of purchasing recycled materials have been calculated upon the assumption that recycled materials displace market average materials. Carbon emission factors are derived from the 'Bath Inventory' – Hammond, G. & Jones, C. (2006). Inventory of Carbon and Energy (ICE) – Version 1.5a Beta. Where appropriate, proportions of recycled material %'s have been factored into the calculations.

HA MACs, DBFO and Tolling Stations

Aspect	Assumptions
(1) Energy	
Purchased Electricity Consumption	Emission factors for consumed electricity are derived from DEFRA Conversion Factors (2007) and draft updated factors within DEFRA (2008) Draft Code of Best Practice for Carbon Offset Providers. Any assumptions made by DEFRA are therefore incorporated within the Accounting Tool.
	The annual consumption estimator for electricity consumption per area is based upon data contained within CIBSE (2004). Guide F – Energy Efficiency in Buildings, which provides an indicative consumption value of 226kWh/m^2/annum for a standard air conditioned office with typical energy efficiency measures.
	Under current guidance, renewable energy inputs can only qualify for a zero emission factor when organisations have entered into a renewables source contract with an energy supplier which has itself acquired Climate Change Levy Exemption Certificates (LECs) for the electricity supplied as a non-domestic electricity consumer. In calculating emission savings, it has been assumed that renewable supply directly replaces Standard Supply and all

Aspect	Assumptions
	associated emissions on a like-for-like kWh basis. OFGEM, DEFRA and the Energy Saving Trust are currently running consultations to revised guidelines on green supply tariffs, and to develop third party accreditation. Revised conversion factors will follow the outcome of these processes. Until this time, DEFRA advises to include renewables factors detailed within 2005 Emission Factors data. This assumes that certified renewables account for zero carbon emissions and this assumption is therefore made here.
Natural Gas Consumption	Emission factors are derived from DEFRA Conversion Factors (2007) and draft updated factors within DEFRA (2008) Draft Code of Best Practice for Carbon Offset Providers. Any assumptions made by DEFRA are therefore incorporated within the Accounting Tool.
	The annual consumption estimator for gas consumption per area is based upon data contained within CIBSE (2004). Guide F – Energy Efficiency in Buildings, which provides an indicative gas / oil space and water heating consumption value of 151kWh/m^2/annum for a standard office.
Water Consumption	Emission factors for water consumption are derived from Veolia Corporate Social Responsibility (CRS) Report (2006). Form this report, the delivery of 1000litres of water correlates to the emission of 0.37kg of CO_2. This value is therefore assumed to representative for HA supply.
Hotel Estimates	Average hotel room consumption figures are detailed within Energy Consumption Guide 36 Energy Efficiency in Hotels (Department of the Environment, 1999). Further calculations detailed within Expotel - Carbon Neutral Program document have been adopted here in terms of average UK domestic hotels and hotels abroad, and these emission factor values are assumed to be representative.
Home Working	This is an area of current research given increasing flexibility in working regimes offered by employers. Working from home or out of office is often referred to as 'teleworking'. The emission factors included within this tool are however initial assumptions only, and would require further research and quantification in order to refine attributable emission estimates. There exist large uncertainties in terms of average consumption patterns and behaviours. Emission factors for home working have been derived from UK domestic consumption statistics from the DEFRA website for 2005: http://www.defra.gov.uk/environment/statistics/supp/spkf22.htm. Consumption values for domestic heating and lighting / cooking only have been used. Each annual figure is scaled to a daily basis, based upon an assumed number of hours in a working day. Assumed figures are as follows: • 14.4MWh per annum per household on heating (assume gas) -> equates to a daily household consumption of 39.45MW or 12.33kWh per work day of 7.5hrs. • 1.4 MWh per annum per household on lighting and cooking -> equates to 3.84MW / day consumption or 1.2kWh per work day of 7.5hrs. Water consumption emission factors are derived as detailed above. Average domestic consumption values are derived from OFWAT Security of Supply Report - 2006/07 for industry average daily domestic water consumption excluding pipe leakage. The annual consumption value is scaled to an assumed working day as above from 148 litres / head / day to 46.25l/h/working day of 7.5hrs. It should be noted however that this value does not take into account other uses of water by consumers for purposes unrelated to home -working, and as such is likely to be an over-estimate. In terms of employee's working hours, the following has been assumed: • Full-time employees work 37.5hrs/week, part-time employees work 20hrs/week. • 48 working weeks per year. • Therefore full-time employees work 1800 hours/year (240 days/yr) • Part-time employees work 960 hours/year (128 days/yr).
Site Compound	Emission factors for relevant utility and fuel consumption are derived from DEFRA Conversion Factors (2007). Any assumptions made by DEFRA are therefore incorporated here.
	The annual consumption estimator for electricity consumption per area is based upon data contained within CIBSE (2004). Guide F – Energy Efficiency in Buildings, which provides an indicative consumption value of 226kWh/m^2/annum for a standard air conditioned office with

Aspect	Assumptions
	typical energy efficiency measures.
	Renewable energy inputs can only qualify for a zero emission factor when organisations have entered into a renewables source contract with an energy supplier which has itself acquired Climate Change Levy Exemption Certificates (LECs) for the electricity supplied as a non-domestic electricity consumer. In calculating emission savings, it has been assumed that renewable supply directly replaces Standard Supply and all associated emissions on a like-for-like kWh basis. OFGEM, DEFRA and the Energy Saving Trust are currently running consultations to revised guidelines on green supply tariffs, and to develop third party accreditation. Revised conversion factors will follow the outcome of these processes. Until this time, DEFRA advises to include renewables factors detailed within 2005 Emission Factors data. This assumes that certified renewables account for zero carbon emissions and this assumption is made.
Fuel Powered Equipment	Emission factors for water consumption are derived from Veolia Corporate Social Responsibility (CRS) Report (2006). Form this report, the delivery of 1000litres of water correlates to the emission of 0.37kg of CO_2. This value is therefore assumed to representative for HA supply.
Mobile Plant	Methodology A and B Emission factors are based upon those assumed within Environment Agency Carbon Calculator: http://www.environment-agency.gov.uk/business/444304/502508/1506471/1506565/1508048/1883907/?lang=_e
Installed Onsite Renewables Generation	The calculation for on-site renewables is included for information only and are not carbon offsets. These factors are not discounted from emission calculations within this tool, since these have already been accounted for in terms of reductions of traditional fuel supply. Further information of the types of renewable energy supplies currently (and potentially) operated by the HA is required so that the tool can be modified to reflect this.
(2) Materials	
	The range of materials included within the Accounting Tool is based upon the provisions of the EA's Carbon Calculator, which has been developed for construction projects and is therefore applicable to the HA context. CO_2 emission factors within the EA Calculator are derived from the 'Bath Inventory' – Hammond, G. & Jones, C. (2006). Inventory of Carbon and Energy (ICE) – Version 1.5a Beta, which have been cross-referenced within the Accounting Tool. Where appropriate, conversion into relevant units has been based upon typical weight / density estimates from various sources as detailed.
Construction Materials	Further assumptions made are as follows: MDF / Particle Board / Plywood These materials can be purchased in a variety of thicknesses. This calculator assumes a thickness of 20mm for each, based on the figures used in the Environment Agency Carbon Calculator (2007). Due to variations, MDF weights are not constantly proportional to thickness. Therefore a typical density has been assumed from Timber Trade Federation Panel Guide V2 - http://www.ttf.co.uk/buying/panel/. Assumed 12mm thickness mass = 84kg/m^2 has been included. Windows Average embodied carbon values within the Bath Inventory have been assumed as follows: • PVC Framed Doubled Glazed – 112.5kgCO_2/m^2 • Aluminium-Clad Timber Framed Double Glazed – 58.5kgCO_2/m^2 • Timber Framed Double Glazed – 18.47kgCO_2/m^2 Additional Carbon factored applied to Krypton and Xenon filled units are 24.65 and 218.32 kgCO_2/m^2 respectively. Whilst it is recognised that windows may not directly form part of a HA project, they may be utilised as a mitigation measure and as such have been included. Length / Density Calculations Assumed weight data to convert length / density calculations are as follows: *Clay Vitrified Pipes*

Aspect	Assumptions
	• Assumed for DN 100 – 200: 10.55kg/m length. • Assumed for DN 200-300: 83.3kg/m length. Data based upon indicative figures derived from: http://www.naylordrainage.co.uk/densleeve.asp *Steel Pipes* Weights of steel pipes vary in accordance with the length and thickness as defined within British Standard - BS 1387:1985. Therefore, for the purpose of the calculations, average weights within each class (light, medium and heavy) have been assumed to cover all pipe dimensions as follows: • BS 1387 Light – 3.75kg/m. • BS 1387 Medium – 6.81kg/m. • BS 1387 Heavy – 7.86kg/m. Given the potential variability, the actual volume of steel used in pipe construction may therefore be over / underestimated accordingly. More detailed carbon emission values can be generated should specific pipe dimensions be provided, however is it currently assumed that the above mass conversion values are representative at this stage.
Winter Operations	Values for rock salt used for gritting purposes have been derived from International Fertilizer Society (2007). Energy Consumption and Greenhouse Gas Emissions in Fertilizer Production. A CO_2e value of 0.002 kg CO_2 / tonne for pot ash has been assumed to be representative of rock salt – given that the two are commonly mined together and have a similar level of process.
Supplier Transport Distances	Where drop-down menus are present to select supplier locations, assumed distances (in km) for 'Local' and 'Regional' suppliers are 5km and 100km respectively. These values have been arbitrarily selected at this stage.
Refurbishment Materials	The re-decorating / refurbishment of MAC offices is an internal MAC decision and therefore, the inclusion of such materials has been excluded from the MAC workbook.
Office Equipment and Other	General Office Paper Paper weights per ream calculated upon 80g/m^2 using standard A4/A3 paper sizes: 2.4948kg/ream A4 and 4.9869kg/ ream A3. Carbon emission factors derived from the 'Bath Inventory' – Hammond, G. & Jones, C. (2006). Inventory of Carbon and Energy (ICE) – Version 1.5a Beta. Mobile Phones CO_2 conversion factors and an average weight of 0.0009t (or 86.5g) per mobile phone handset has been derived using conversion factors from Yamaguchi, H et al (2003) *A Life Cycle Inventory Analysis of Cellular Phones.* It is recognised that since 2003, more recently produced phones may well be lighter, use improved / different materials, and have been produced through more energy efficient processes. Research is ongoing in the area. Personal Computers (PCs) Conversion factors for PCs have been derived from US EPA (2003) *Background Document for Life Cycle Greenhouse gas Emission Factors for Carpet and Personal Computers*. • It is recognised that technology has progressed rapidly since 2003. Components are more sophisticated and materials may be lighter e.g. flat plasma screens, but that production processes may have become more efficient. These conversion factors only consider the central processing unit (CPU) and monitor, not the peripheral equipment e.g. mouse, keyboard, cables. • Conversion factors are based on an average weight of 70 lbs per PC, which has been converted to 31.75kg per Computer (Conversion factor: 1kg = 2.205 pounds) • These emissions factors do not include the 'embedded energy' in plastic feedstocks e.g. energy value of petroleum used to manufacture plastic. • tCO_2 have been measured as metric tonnes of carbon equivalent per tonne of material (tCeq/t). • tCeq/t has been calculated using Total Process Energy Emissions (15.38tCeq/t) + Process Non-Energy Emissions Factor for Personal Computer Manufacturing (0.026tCeq/t).

Aspect	Assumptions
	• Transportation Energy Emissions factors have not been included as set out in US EPA (2003) methodologies. Instead, they have been included using DEFRA (2007) as it is assumed these are a more accurate data source to calculate transportation carbon emissions in the UK. Lighting Embodied energy requirements during manufacture obtained via personal communication with Frank Altena, Sustainability Officer of Philips (Lighting). Values are initial estimates – Philips are currently undertaking studies into the embodied energy / carbon of their products and the indicate emission factors can be updated and refined in due course. Standard incandescent and halogen lamps embodied value of 0.5MJ/Unit. Fluorescent lamps / compact fluorescent lamps embodied value of 5.0MJ/Unit. Energy values have been converted to CO_2 emissions based upon DEFRA conversion factors for equivalent electricity consumption.
(3) Transport	
General Emission Factors	Standard transportation emission factors are derived from DEFRA Conversion Factors (2007) and (2005) as appropriate. Draft updated factors within DEFRA (2008) Draft Code of Best Practice for Carbon Offset Providers have also been incorporated. Any assumptions made by DEFRA are therefore incorporated within the Accounting Tool. Any assumptions within this document, and as detailed within the DEFRA Methodology Paper -Passenger Transport Emissions (2007) are therefore incorporated here. The DEFRA factors do not take into account the impact of different UK average driving speeds and cycles relative to those of the NEDC (New European Driving Cycle – used in vehicle type approval) and to an extent the impacts of vehicle age. They also take no account of further 'real-world' effects, such as use of accessories (air conditioning, lights, heaters etc), vehicle payload (only the driver +25kg is considered in tests, no passengers or further luggage), poor maintenance (tyre under inflation), gradients, weather conditions, more aggressive/harsher driving style, and other such variables. For full details of relevant assumptions the DEFRA Methodology Paper should be referred to. It should be noted that embodied energy / carbon within fuels is not fully accounted for within the emission conversion factors - in terms of extraction, refining, and transportation to point of sale.
Fuel Conversion Tool	The fuel conversion tool is based upon fuel cost figures for petrol and diesel as stated in BERR (2007) *Quarterly Energy Prices Dec 2007 - URN 07/276d ISSN number: 1475-6544*. Figures assume premium unleaded not super unleaded. Fuel prices are as follows: • Premium Unleaded: £0.9427p / litre • Diesel: £0.9685p / litre http://www.berr.gov.uk/energy/statistics/publications/prices/index.html BERR (2007) did not contain fuel prices for Liquid Petroleum Gas (LPG) therefore the fuel price for LPG has been extracted from figures provided by the Automobile Association (2007). Monthly 'average garage and supermarket figures' for Jan – Dec 2007 were used to provide an annual average fuel price for 2007, http://www.theaa.com/motoring_advice/fuel/fuel-price-archive.html • LPG: £0.4722p / litre
Taxi Journeys	Emissions are calculated based upon an average distance of taxi journeys in the UK of 7.567km (unconfirmed data from The CarbonNeutral Company website - http://www.carbonneutral.com/sbc/sbchelp.asp), multiplied by a DEFRA emission factor for an unknown vehicle.
Hire Car Delivery	No methodology is currently specified for this aspect. It is understood that for insurance reasons hire car deliveries are made directly to employee's personal residences. The availability of collated hire car delivery data from respective hire car companies is currently being investigated by the HA to determine whether this aspect can be accurately accounted for within future versions of the Tool.
Maintenance Activities	The maintenance activities listed within the workbook are based upon information received from the HA and an internal review by PB. The list of activities is not exhaustive and the HA are currently investigating further activities for inclusion. CO_2 emissions have been calculated using a fuel-consumption method which is accepted as being more accurate than using a distance-based method (DEFRA 2007). It is also assumed that data is unlikely to be available

Aspect	Assumptions
	from MACs, for estimating distances over which maintenance vehicles have travelled as part of their operations.
Other Transport	Other indirect transport is based upon a distance methodology, since it is assumed that data availability for such 3rd party suppliers is unlikely to be available. Such methodology is however accepted to be less accurate than a fuel-consumption based methodology. The following indicative distances have been assumed as part of the methodology based upon PB's own operations: • Local Building Contractors = 5km roundtrip per visit. • Regional Building Contractors = 100km roundtrip per visit. • National Building Contractors = 300km roundtrip per visit. • Local Courier Trips = 50km roundtrip per delivery. • Regional Courier Trips = 100km roundtrip per delivery. • National Courier Trips = 300km roundtrip per delivery. • Caterers assumed to undertaken 5km roundtrip per delivery. At this stage, these values are indicative only and can be revised as part of future Versions of the Tool should this be deemed necessary.
(5) Waste Removal	
Standard Office Waste Removal	Waste removal emissions are based upon a road transportation factor outlined with AggRegain CO_2 Estimator Tool (2006), C4S – 0.0003174 tonnes CO_2/tonne/km. Standard Office Waste Removal • Typical office waste density = 0.1tonnes/cu.m waste. • Average wheelie bin contains 0.11tonnes of office waste. Data is based upon Environment and Heritage Service (2003). Municipal Waste Data Monitoring and Reporting: Interim Guidelines. • Average black bag volume of 60 litres, converted to cu.m and assumed to be an arbitrary 75% full at point of disposal generates a water volume per black bag of 0.045cu.m. Unknown Waste Arising – Estimator Tool This tool is for use when specific waste arising's are unknown for a given facility. Two estimators are available for use – based upon known floor areas or number of employees. The assumptions made in these calculations are as follows: • Average waste generation rates of 0.05cu.m/ employee/week, and 0.05cu.m/10m^2 floor area/week. • Typical office waste density of 58.5km/cu.m. • Assumed 48 working weeks per annum. Data is based upon CIBSE (2004). Guide G: Public Health Engineering.
Recycled Office Waste Removal	Waste removal emissions are based upon a road transportation factor outlined with AggRegain CO_2 Estimator Tool (2006), C4S – 0.0003174 tonnes CO_2/tonne/km. Other specific assumptions made are as follows: • *Office Paper Waste* – assumes 1 bag of office paper waste weighs c.10kg (based upon: PACE (2000). Information Note 17/2000: Measuring Waste – Advice for Government Managers on the Government Estate). • *Aluminium Can* – assumes 1 can = 0.02kg (based upon: PACE (2000). Information Note 17/2000: Measuring Waste – Advice for Government Managers on the Government Estate). One 60 litre rubbish bag is assumed to hold 30 cans. • *Toner Cartridge* – assumed 1 cartridge = 2kg (based upon: PACE (2000). Information Note 17/2000: Measuring Waste – Advice for Government Managers on the Government Estate).
Construction Waste Removal	Assumed waste density of 2 tonnes per cubic metre, as detailed within EA Construction Carbon Calculator.

Aspect	Assumptions
Renewables and Recycling	
Installed Onsite Renewables Generation	The calculations for on-site renewables is included for information only and are not carbon offsets. These factors are not discounted from emission calculations within this tool, since these have already been accounted for in terms of reductions of traditional fuel supply. Further information of the types of renewable energy supplies currently (and potentially) operated by the HA so that the tool can be modified to reflect this.
Renewable Energy Tariffs	See assumptions above from (A) Energy.
Recycled Office Waste	A limited range of Indicative emission avoidance values are available for certain materials following specific research by organisations, as follows: • WRAP (2006). Environmental Benefits of Recycling – An International Review of Life Cycle Comparisons for Key Materials in the UK Recycling Sector. • Environmental Protection Agency (2006). Solid Waste Management and Greenhouse Gases – A Lifecycle Assessment of Emissions and Sinks. ERM (2006). Impact of Energy from Waste and Recycling Policy on Greenhouse Gas Emissions.
Recycled Construction Material Purchasing	The emission benefits of purchasing recycled materials have been calculated upon the assumption that recycled materials displace market average materials. Carbon emission factors are derived from the 'Bath Inventory' – Hammond, G. & Jones, C. (2006). Inventory of Carbon and Energy (ICE) – Version 1.5a Beta. Where appropriate, proportions of recycled material %'s have been factored into the calculations.

ANNEX 6 EMISSION FACTORS

The emission factors indicated below have been sourced from the following locations:

- Environment Agency (2007). *Carbon Calculator for Construction Activities*;
- Environmental Protection Agency (2003). *Background Document for Life Cycle Emission Factors for Carpet and Personal Computers*;
- DEFRA (2007). Guidelines to DEFRA's GHG Conversion Factors for Company Reporting – Annexes, Department of Environment, Food and Rural Affairs, 2007;
- DEFRA (2008). Draft Code of Best Practice for Carbon Offset Providers – Accreditation Requirements and Procedures;
- Department of the Environment (1997). Energy Efficiency in Hotels – A Guide for Owners and Managers;
- International Fertilizer Society (2007). Energy Consumption and Greenhouse Gas Emissions in Fertilizer Production;
- Inventory of Carbon and Energy (ICE). University of Bath, 2006 (referred to as the 'Bath Inventory');
- Yamaguchi, H. *et al* (2003). *A Life Cycle Inventory Analysis of Cellular Phones*; and
- Veolia (2006). *Veolia Corporate Social Responsibility Report*.

Reporting Aspect	Emission Factor	Units	Data Source
Fuel and Utilities			
Biodiesel	0.916	kg CO_2 / litres	DEFRA (2007)
Burning Oil	2.518	kg CO_2 / litres	DEFRA (2007)
Compressed Natural Gas	2.728	kg CO_2 / kg	DEFRA (2008)
Diesel	2.63	kg CO_2 / litres	DEFRA (2007)
Electricity	0.5266	kg CO_2/ kWh	DEFRA (2008)
Fuel Oil	0.281	kg CO_2/ kWh	DEFRA (2007)
Gas	0.206	kg CO_2/ kWh	DEFRA (2007)
Gas Oil	2.674	kg CO_2 / litres	DEFRA (2007)
Hotel Stay - Abroad	50.00	kg CO_2/ room night	Dept. for Env (1997)
Hotel Stay - Domestic	40.00	Kg CO_2/ room night	Dept. for Env (1997)
LPG	1.498	kg CO_2/ litre	DEFRA (2008)
Petrol	2.315	kg CO_2 / litres	DEFRA (2007)
Water	0.37	kg CO_2/ m^3	Veolia (2007)
Mobile Plant Usage			
Very large (construction cost > £10m, more than 25 people permanently onsite)	6.25	t CO_2 /week	EA (2007)
Large (construction const £5m-£10m, between 16-25people permanently onsite)	3.0	t CO_2 /week	EA (2007)
Medium (construction cost £1.5-£5m, between 9-15 people permanently onsite)	1.25	t CO_2 /week	EA (2007)

Reporting Aspect	Emission Factor	Units	Data Source
Small (Construction cost <£1m, fewer than 8 people permanently onsite)	0.5	t CO_2 /week	EA (2007)
Materials			
Aluminium: extruded	8.49	t CO_2 / t [Cradle to Gate]	Bath Inventory
Aluminium: extruded - recycled	1.98	t CO_2 / t [Cradle to Gate]	Bath Inventory
Aluminium: general	8.53	t CO_2 / t [Cradle to Gate]	Bath Inventory
Aluminium: general - recycled	1.69	t CO_2 / t [Cradle to Gate]	Bath Inventory
Aluminium: rolled	8.35	t CO_2 / t [Cradle to Gate]	Bath Inventory
Aluminium: rolled - recycled	1.67	t CO_2 / t [Cradle to Gate]	Bath Inventory
Asphalt	0.045	t CO_2 / t	Bath Inventory
Bricks	0.2	t CO_2 / t [Cradle to Site]	Bath Inventory
Carpet – Average	9.96	t CO_2 / t [Cradle to Gate]	Bath Inventory
Carpet – Underlay	0.99	t CO_2 / t [Cradle to Gate]	Bath Inventory
Cement – Fibre	2.11	t CO_2 / t [Cradle to Gate]	Bath Inventory
Cement – Portland: dry kiln	0.74	t CO_2 / t [Cradle to Gate]	Bath Inventory
Cement – Portland: semi-wet kiln	0.93	t CO_2 / t [Cradle to Gate]	Bath Inventory
Cement – Portland: semi-dry kiln	0.84	t CO_2 / t [Cradle to Gate]	Bath Inventory
Cement – Portland: wet kiln	0.97	t CO_2 / t [Cradle to Gate]	Bath Inventory
Cement – Portland Slag: <10% slag	0.76	t CO_2 / t [Cradle to Gate]	Bath Inventory
Cement – Portland Slag: 40-55% slag	0.44	t CO_2 / t [Cradle to Gate]	Bath Inventory
Cement – Portland Slag: 60-75% slag	0.28	t CO_2 / t [Cradle to Gate]	Bath Inventory
Cement – Portland Ash	0.59	t CO_2 / t [Cradle to Gate]	Bath Inventory
Cement – Soil	0.14	t CO_2 / t [Cradle to Gate]	Bath Inventory

Reporting Aspect	Emission Factor	Units	Data Source
Cement – Unknown	0.97	t CO_2 / t [Cradle to Gate]	Bath Inventory
Clay	0.2	t CO_2 / t [Cradle to Site]	Bath Inventory
Concrete - General Road and Pavement	0.127	t CO_2 / t [Cradle to Gate]	Bath Inventory
Concrete - High Strength	0.211	t CO_2 / t [Cradle to Gate]	Bath Inventory
Copper: general	5.57	t CO_2 / t [Cradle to Site]	Bath Inventory
Copper - recycled	2.685	t CO_2 / t [Cradle to Site]	Bath Inventory
Damp Proof Course/Membrane	8.28	t CO_2 / t [Cradle to Gate]	Bath Inventory
Facing bricks	0.85	t CO_2 / t [Cradle to Site]	Bath Inventory
Flap valves: DN 100 & DN 150	1.82	t CO_2 / t [Cradle to Gate]	Bath Inventory
Flap valves: DN 200 & DN 300	1.82	t CO_2 / t [Cradle to Gate]	Bath Inventory
Flap valves: DN 500	1.82	t CO_2 / t [Cradle to Gate]	Bath Inventory
Handrail: galvanised with fittings	1.98	t CO_2 / t [Cradle to Gate]	Bath Inventory
Handrail: stainless steel with fittings	6.15	t CO_2 / t [Cradle to Gate]	Bath Inventory
Handrail: stainless steel welded	6.15	t CO_2 / t [Cradle to Gate]	Bath Inventory
Insulation	2.606	t CO_2 / t [Cradle to Gate]	Bath Inventory
Lighting - Fluorescent	None – calculated from embodied energy value of 0.5MJ/Unit	-	Phillips (personal communication)
Lighting – Standard	None – calculated from embodied energy value of 5MJ/Unit	-	Phillips (personal communication)
Mobile Phone	0.001	t CO_2 / t	Yamaguchi, H. *et al* (2003)
Paper	1.37	t CO_2/ t	Bath Inventory
PC	15.4	t CO_2 / t	EPA (2003)
Natural rubber	1.54	t CO_2 / t [Cradle to Site]	Bath Inventory

Reporting Aspect	Emission Factor	Units	Data Source
MDF	0.58	t CO_2 / t [Cradle to Gate]	Bath Inventory
Mortar (1:3 cement:sand mix)	0.21	t CO_2 / t [Cradle to Gate]	Bath Inventory
Mortar (1:4 cement:sand mix)	0.17	t CO_2 / t [Cradle to Gate]	Bath Inventory
Mortar (1:1/2:4 1/2 cement:lime:sand mix)	0.24	t CO_2 / t [Cradle to Gate]	Bath Inventory
Mortar (1:1:6 cement:lime:sand mix)	0.2	t CO_2 / t [Cradle to Gate]	Bath Inventory
Mortar (1:2:9 cement:lime:sand mix)	0.18	t CO_2 / t [Cradle to Gate]	Bath Inventory
Paint	6.1	t CO_2 / t [Cradle to Gate]	Bath Inventory
Particle Board	0.48	t CO_2 / t [Cradle to Gate]	Bath Inventory
Plastic – High Density Polyethylene (HDPE)	1.6	t CO_2 / t [Cradle to Gate]	Bath Inventory
Plastic – HDPE Pipe	2	t CO_2 / t [Cradle to Gate]	Bath Inventory
Plastic – Expanded Polystyrene	2.5	t CO_2 / t [Cradle to Gate]	Bath Inventory
Plastic – polyethylene: general	1.94	t CO_2 / t [Cradle to Gate]	Bath Inventory
Plastic – PVC: general	2.41	t CO_2 / t [Cradle to Gate]	Bath Inventory
Plastic – PVC: pipe	2.5	t CO_2 / t [Cradle to Gate]	Bath Inventory
Plywood	0.75	t CO_2 / t [Cradle to Site]	Bath Inventory
Quarried aggregate	0.008	t CO_2 / t [Cradle to Gate]	Bath Inventory
Recycled aggregate	0.00369	t CO_2 / t [Cradle to Gate]	Bath Inventory
Salt (road gritting)	0.2	t CO_2 / t	IFS (2007)
Sand	0.0053	t CO_2 / t [Cradle to Site]	Bath Inventory
Sawn Hardwood	0.47	t CO_2 / t [Cradle to Site]	Bath Inventory
Sawn Softwood	0.44	t CO_2 / t [Cradle to Site]	Bath Inventory

Reporting Aspect	Emission Factor	Units	Data Source
Sheet piling: light use	1.82	t CO_2 / t [Cradle to Gate]	Bath Inventory
Sheet piling: medium use	1.82	t CO_2 / t [Cradle to Gate]	Bath Inventory
Sheet piling: heavy use	1.82	t CO_2 / t [Cradle to Gate]	Bath Inventory
Slate	0.0295	t CO_2 / t [Cradle to Site]	Bath Inventory
Soil	0.024	t CO_2 / t [Cradle to Gate]	Bath Inventory
Steel: general	1.82	t CO_2 / t [Cradle to Gate]	Bath Inventory
Steel: general recycled	0.45	t CO_2 / t [Cradle to Gate]	Bath Inventory
Steel: bar & rod	1.72	t CO_2 / t [Cradle to Gate]	Bath Inventory
Steel: bar & rod recycled	0.42	t CO_2 / t [Cradle to Gate]	Bath Inventory
Steel: pipe (BS1387 Light)	1.8	t CO_2 / t [Cradle to Gate]	Bath Inventory
Steel: pipe (BS1387 Light) Recycled	0.57	t CO_2 / t [Cradle to Gate]	Bath Inventory
Steel: pipe (BS 1387 Medium)	1.8	t CO_2 / t [Cradle to Gate]	Bath Inventory
Steel: pipe (BS 1387 Medium) Recycled	0.57	t CO_2 / t [Cradle to Gate]	Bath Inventory
Steel: pipe (BS 1387 Heavy)	1.8	t CO_2 / t [Cradle to Gate]	Bath Inventory
Steel: pipe (BS 1387 Heavy) Recycled	0.57	t CO_2 / t [Cradle to Gate]	Bath Inventory
Steel: section	1.79	t CO_2 / t [Cradle to Gate]	Bath Inventory
Steel: sheet	1.64	t CO_2 / t [Cradle to Gate]	Bath Inventory
Steel: sheet - recycled	0.44	t CO_2 / t [Cradle to Gate]	Bath Inventory
Steel: wire	2.83	t CO_2 / t [Cradle to Gate]	Bath Inventory
Steel: stainless	6.15	t CO_2 / t [Cradle to Gate]	Bath Inventory
Stone: general	0.021	t CO_2 / t [Cradle to Site]	Bath Inventory

Reporting Aspect	Emission Factor	Units	Data Source
Stone gravel/chippings	0.016	t CO_2 / t [Cradle to Site]	Bath Inventory
Synthetic rubber	4.25	t CO_2 / t [Cradle to Gate]	Bath Inventory
Tile Flooring	0.43	t CO_2 / t [Cradle to Gate]	Bath Inventory
Timber: general	0.476	t CO_2 / t [Cradle to Gate]	Bath Inventory
Vinyl Tile Flooring	2.29	t CO_2 / t [Cradle to Gate]	Bath Inventory
Vitrified clay pipe DN 100 - 200	0.41	t CO_2 / t [Cradle to Site]	Bath Inventory
Vitrified clay pipe DN 200 - 300	0.47	t CO_2 / t [Cradle to Site]	Bath Inventory
Wallpaper	1.74	t CO_2 / t	Bath Inventory
Window: 1.2m x 1.2m Single Glazed Timber Framed Unit	13.88	kg CO_2 / m^2	Bath Inventory
Window: 1.2m x 1.2m Double Glazed (Air or Argon Filled) - Aluminium Framed	265.4	kg CO_2 / m^2	Bath Inventory
Window: 1.2m x 1.2m Double Glazed (Air or Argon Filled) - PVC Framed	112.5	kg CO_2 / m^2	Bath Inventory
Window: 1.2m x 1.2m Double Glazed (Air or Argon Filled) - Aluminium-Clad Timber Framed	58.5	kg CO_2 / m^2	Bath Inventory
Window: 1.2m x 1.2m Double Glazed (Air or Argon Filled) - Timber Framed	18.47	kg CO_2 / m^2	Bath Inventory
Transport			
Air - Domestic Flight	0.1601	kg CO_2 / passenger km	DEFRA (2008)
Air - Long Haul Flight	0.0815	kg CO_2 / passenger km	DEFRA (2008)
Air - Short Haul Flight	0.0910	kg CO_2 / passenger km	DEFRA (2008)
Bus	0.0943	kg CO_2 / passenger km	DEFRA (2008)
Car – Unknown Fuel	0.2075	kg CO_2 / vehicle km	DEFRA (2007)
Diesel Car - Average / Unknown Fuel	0.1987	kg CO_2 / vehicle km	DEFRA (2008)
Diesel Car - Large: > 2 litre engine	0.2653	kg CO_2 / vehicle km	DEFRA (2008)
Diesel Car - Medium: 1.7 - 2 litre engine	0.1881	kg CO_2 / vehicle km	DEFRA (2008)
Diesel Car - Small: < 1.7 litre engine	0.1507	kg CO_2 / vehicle km	DEFRA (2008)
Freight / Waste Transport	0.3174	kg CO_2 / tonne-km	EA (2007)
Hybrid Car - Large	0.224	kg CO_2 / vehicle km	DEFRA (2007)
Hybrid Car – Medium	0.1262	kg CO_2 / vehicle km	DEFRA (2007)
LPG Car – Large	0.2594	kg CO_2 / vehicle km	DEFRA (2008)
LPG Car – Medium	0.1982	kg CO_2 / vehicle km	DEFRA (2008)

Reporting Aspect	Emission Factor	Units	Data Source
LPG Car - Unknown	0.2243	kg CO_2 / vehicle km	DEFRA (2008)
Petrol Car – Small < 1.4 litre engine	0.1831	kg CO_2 / vehicle km	DEFRA (2007)
Petrol Car – Medium: 1.4 - 2 litre engine	0.2162	kg CO_2 / vehicle km	DEFRA (2007)
Petrol Car – Large: > 2 litre engine	0.2964	kg CO_2 / vehicle km	DEFRA (2007)
Petrol Car Average / Unknown engine	0.2095	kg CO_2 / vehicle km	DEFRA (2007)
Motorbike - Large	0.1286	kg CO_2 / vehicle km	DEFRA (2007)
Motorbike - Medium	0.0939	kg CO_2 / vehicle km	DEFRA (2007)
Motorbike - Small	0.0729	kg CO_2 / vehicle km	DEFRA (2007)
Motorbike - Unknown	0.1067	kg CO_2 / vehicle km	DEFRA (2007)
Other Transport (e.g. Couriers)	0.2095	kg CO_2 / vehicle km	DEFRA (2007)
Rail – National Rail	0.0602	kg CO_2 / passenger km	DEFRA (2007)
Taxi Journey	0.1613	kg CO_2 / vehicle km	DEFRA (2008)
Tram / Light Rail	0.0650	kg CO_2 / passenger km	DEFRA (2007)
Underground	0.0526	kg CO_2 / passenger km	DEFRA (2007)