Birmingham Eastside Extension

ES Volume 2 Technical Appendix O: Greenhouse Gases Technical Information

MMD-300207-HS30-DOC-0000-1038

October 2016

West Midlands Combined Authority

Mott MacDonald

Issue and revision record

Revision	Date	Originator	Checker	Coordinator	Approver	Description
A	August 2016	AC	TE	CS	KL	First draft
B	October 2016	AC	TE	CS	KL	Final for submission

Information class: Standard

Contents

Mott MacDonald

1 Introduction

1.1 Background

1.1.1 This Technical Appendix should be read in conjunction with Chapter 12 – Greenhouse Gases of ES Volume 1: Main Statement.

1.1.2 This document presents additional technical information associated with the assessment of the impact of the BEE on greenhouse gases (GHG) emissions during its construction and operation. These emissions will occur through the use of construction materials, through the energy use of the BEE and through changes to the wider transport network.

BEE design in context of carbon effects

1.1.3 The BEE has the potential to lead to GHG emissions during its construction and operations. For clarity, these sources have been numbered. The key emission sources are:

- Construction related emissions:
  - the use of construction materials and products (often referred to as embodied emissions) – source 1;
  - construction related vehicles (delivery of materials to construction sites) which use fuel leading to GHG emissions – source 2; and
  - construction plant and equipment which also use fuel leading to GHG emissions – source 3.
- Operational emissions:
  - traction power use which uses electricity which indirectly leads to GHG emissions – source 4;
  - infrastructure such as signage and lighting which uses electricity which indirectly leads to GHG emissions – source 5; and
  - transport network effects (including changes to the transport network and potential modal shift) which changes the pattern of vehicle use and therefore GHG emissions – source 6.

1.1.4 Construction activities require the use of materials and resources that have associated GHG emissions. During their manufacture, construction materials such as steel and concrete require energy use that has associated GHG emissions. The use of construction plant and construction related transportation also leads to varying levels of energy use and therefore GHG emissions. The BEE will require the installation of new infrastructure including track, overhead line equipment (OLE) and tram stops. The construction of all of these elements will therefore contribute to associated emissions of GHG.

1.1.5 During operation, all modes of transport can lead to emissions of GHG due to their consumption of energy, with the exception of those powered by renewable energy. Typical road transport modes use internal combustion engines which lead to GHG emissions from their use of fossil fuels. Electric vehicles such as those used on the Midland Metro tram network also lead to GHG emissions from power generation that supplies the tram system. In addition, any associated infrastructure also requires electricity that will have associated GHG emissions.

1.1.6 Finally, transport interventions such as BEE can also lead to indirect impacts on the transport network that influence capacity and patterns of travel. Changes in the wider transport network can also influence the amount of GHG emissions from other users of the transport network.

1.2 Legislation, guidance and best practice

European Union policy

1.2.1 The European Commission White Paper "Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system" (2011) outlines the long-term strategy being pursued to achieve a sustainable transport system across the EU by 2050.

1.2.2 The White Paper recognises that "*transport is fundamental to our economy and society,"* but also recognises that transport *"must be sustainable".* In order to limit climate change *"… a reduction of at least 60% of GHGs by 2050 with respect to 1990 is required from the transport sector" and that "By 2030, the goal for transport will be to reduce GHG emissions to around 20% below their 2008 level"*.

1.2.3 To achieve the changes, the White Paper recognises that "*new technologies for vehicles and traffic management will be key to lower transport emissions*…" and *"the challenge is to break the transport system's dependence on oil without sacrificing its efficiency and compromising mobility"* It emphasises that *"curbing mobility is not an option."*

1.2.4 Three strands for future development are set out as follows:

- *"Improving the energy efficiency performance of vehicles across all modes. Developing and deploying sustainable fuels and propulsion systems;*
- *Optimising the performance of multimodal logistic chains, and*
- *Using transport and infrastructure more efficiently through the use of improved traffic management and information systems …"*

National legislation

1.2.5 The UK Climate Change Act (2008) has two key aims:

- to improve carbon management and help the transition towards a low carbon economy in the UK; and
- to demonstrate strong UK leadership internationally, signalling the UK is committed to reducing global GHG emissions.

1.2.6 The Act introduces legally binding net UK carbon emission reduction targets, which are applicable at the national level. The Act specifies a long-term carbon emission reduction target of at least 80% by 2050 and reductions in CO_2e emissions of at least 26% by 2020 (changed to 34% by subsequent legislation in 2009), both against a 1990 baseline. This will be done through five-year “carbon budgets”. Budgets have currently been set covering the periods 2008-2012, 2013-2017, 2018-2022 and 2023-2027 and 2028-32. These targets are reviewed regularly according to the advice of the Committee on Climate Change in line with new evidence and data (most recently in 2015 where the fifth budget was proposed, although it has not yet been passed in to law). Furthermore, the Act requires all departments of the UK Government, including the Department for Transport (DfT), to develop strategies to reduce GHG emissions. Carbon budgets cap the total national emissions over the budget period. They do not require emissions from specific locations, or even specific sectors, to reduce; so long as total emissions from the UK as a whole meet the budget limits.

1.2.7 In December 2011, the UK Government published the Carbon Plan which updates and supersedes the previous 2009 Low Carbon Transition Plan. The Carbon Plan sets out the Government’s strategy for meeting the interim carbon budgets which will help meet the goals of the Climate Change Act. The Carbon Plan identifies that transport has an important role in meeting the Climate Change Act (2008) obligations and includes the following high-profile policies and proposals for the transport sector:

- supporting local authorities in enabling people to make lower carbon travel choices, such as walking, cycling or using public transport, by providing a Local Sustainable Transport Fund;
- incentivising more efficient combustion engines and the use of sustainable biofuels;
- moving towards ultra-low carbon vehicles, such as electric vehicles;
- further electrification of the rail network; and
- capping of emissions from domestic aviation as part of the EU Energy Trading Scheme (ETS).

1.2.8 The DfT White Paper *Creating Growth, Cutting Carbon: Making Sustainable Local Transport Happen* (2011) sets out the government’s vision for a sustainable local transport system that supports the economy and reduces carbon emissions. The White Paper emphasises:

- localism in determining and delivering transport solutions; and
- providing local transport solutions that enable behavioural change towards sustainable transport choices. This includes making public transport more attractive and being the preferred alternative to car travel, smart ticketing and managing traffic to reduce carbon emissions and tackle congestion.

1.2.9 It is recognised that significant difficulties lie in implementing such measures but that these are complemented by wider initiatives such as the EU Regulation for reducing tailpipe emissions on private vehicles (2009) and the move to more renewable electricity sources.

National Planning Policy Framework (NPPF)

1.2.10 The NPPF (Department for Communities and Local Government, 2012) was published on 27 March 2012 and has superseded previous national Planning Policy Statements (PPS) and Planning Policy Guidance (PPG), including Planning Policy Statement 1 on delivering sustainable development. The NPPF (2012) states that local authorities should adopt pro-active strategies to mitigate and adapt to climate change.

1.2.11 At the national level, the following key policy areas of the NPPF are relevant:

- promoting sustainable transport; and
- meeting the challenge of climate change, flooding and coastal change.

1.2.12 The NPPF notes with regards to low-carbon development and sustainable transport that

- "…local planning authorities should…plan for developing in locations and ways which reduce GHG emissions" (Paragraph 95); and
- "encouragement should be given to solutions which support reductions in greenhouse gas emissions and reduce congestion" (Paragraph 30).

Local policies

1.2.13 The Unitary Development Plan (UDP) was adopted by Birmingham City Council (BCC) in 1993 and reviewed in 2005. The UDP is the existing development plan for but will be largely replaced by the Birmingham Development Plan (BDP) when it is adopted. The BDP has been found 'sound' by an inspector appointed by the Secretary of State, but is currently the subject of a holding notice under the Housing and Planning Act 2016. Once this notice is removed, the plan will be able to be adopted, and as such substantial weight can be placed upon it.

1.2.14 The Birmingham UDP has three policies relating to carbon emissions as follows:

- Policy 3.79 - BCC *"is aiming to minimise energy consumption and carbon dioxide emissions within Birmingham and encourage the use of renewable energy resources*";
- Policy 3.79A - BCC "*is committed towards CO_2 reduction and renewable energy targets, in line with the Government's current target for renewable energy generation, i.e. that 10% of UK electricity requirements should be met from renewable energy sources by 2010*". BCC's "*current target is to acquire 15% of its own energy use from renewable energy sources and to reduce its CO_2 emissions by 30% from 1990 levels by 2010*"; and
- Policy 3.79D - "*The achievement of minimising energy consumption and CO_2 emissions will be addressed in a number of ways, including*" the use of "*modes of transport which reduce the impact of travel on energy resources*".

1.2.15 The BDP contains a policy (policy TP1) that includes a target for "*a 60% reduction in total carbon dioxide (CO_2) emissions produced in the City by 2027 from 1990 levels. Actions to help achieve this target will include*"; "*promoting sustainable transport systems including cycling and walking*".

1.2.16 In 2008 BCC also published a Climate Change Strategic Framework. This document outlines the strategy by which Birmingham plans to mitigate and adapt to climate change. Public transport is identified as a key tool for increasing uptake of sustainable forms of transport.

1.3 Methodology

Spatial scope

1.3.1 The assessment of effects during the construction phase focuses on the key construction activities and therefore the spatial scope of the assessment was determined by the location of the main construction works. Further details on the construction compound locations are provided in Chapter 6: Construction Strategy of ES Volume 1: Main Statement.

1.3.2 The BEE has the potential to create GHG emission due to the redistribution of traffic on the affected road network, as presented in Chapter 9: Traffic and Transport in ES Volume 1: Main Statement). Emissions of GHG from road vehicles are a function of the engine size, speed and fuel type. At a network level, emissions are dependent on overall traffic flows and the relative mix of different vehicle classes. The BEE has the potential to affect a combination of these functions, leading to a change in overall GHG emissions. The assessment of the GHG emissions from the transport network therefore considers the changes within the transport network that has been modelled as part of the TA (ES Volume 2 Technical Appendix L2).

1.3.3 During operation of the BEE, the associated GHG emissions from the use of electricity will not necessarily occur in situ and therefore are not considered to have spatial scope.

Temporal scope

1.3.4 Carbon emissions during the construction of the BEE will be confined to the construction period only which is assumed to commence in 2020 and last for approximately 24 months.

1.3.5 Emissions during the operation phase of the BEE, which is expected to commence in 2022, may vary over time depending on a number of factors. These factors could include the relative effects of changes in electricity supply, vehicle engine and battery technologies and growth in the volume of traffic.

1.3.6 As a realistic 'worst case' scenario, the carbon assessment has quantified changes in GHG emissions from the road network for the opening year (2022) based on the traffic data produced within the TA chapter (ES Volume 2 Technical Appendix L2). Note that the traffic data has been modelled for the years of 2021 and 2031, however it has been assumed that this any change between years would be relatively small when comparing the without and with BEE scenarios. The assessment has also considered how the operational carbon emissions may change in the future, based on projected changes to the electricity grid, which would affect the rate at which carbon is produced per unit of energy consumed. Given existing trends, 2022 is considered to be a representative realistic worst case, however, predictions have also been made for 2032 (opening year plus 10 years) to provide additional context.

Sensitive receptors

1.3.7 No specific receptors (and therefore no 'sensitive' receptors) have been focussed upon during the assessment. The potential ‘effect’ due to any given change in GHG emissions caused by the BEE cannot be readily attributed to a resulting specific climate impact or the specific locations of receptors where any impact may occur. The GHG emissions from the BEE are, however, considered in the context of existing emissions which is discussed further in Section 1.4.

Desk study

1.3.8 This assessment has determined the projected carbon emissions based on the best information about the BEE available at the time of the assessment. Emissions for each source are calculated based on the principle that carbon emissions can be calculated according to the following logic:

GHG emissions in tonnes of carbon dioxide equivalent (tCO_2e) = activity (amount) x emission factors (tCO_2e/amount).

1.3.9 The assessment considers the sources identified in paragraph 1.1.3. The sources of activity data for those sources are described in Table 1.1.

Table 1.1: Description of emission types

Ownership	Source
BEE Owned These are where BEE activities lead to emissions of GHG	**Direct** Where GHG emissions occur directly from BEE activities, e.g. from fuel combustion
Not BEE Owned This is where the activities of the BEE lead to GHG emissions, but they are not controlled by the BEE	**Indirect** Where activities of the BEE lead to GHG emissions elsewhere or are not in control of the entity that causes the activity, such as from grid electricity generation or effects on the wider transport network

1.3.10 Table 1.2 presents the sources of emissions considered in this assessment which are discussed more fully in the following sections:

Table 1.2: Summary of emission sources

Ownership	Source
BEE Owned	**Direct** Construction plant and equipment (source 3), Construction traffic (source 2),

MMD/300207/HS30//DOC/0000/1038/B October 2016
http://pims01/pims/llisapi.dll?func=ll&objId=2093539094&objAction=browse&viewType=1

Ownership	Source
	Infrastructure such as signage and lighting (Source 5)
	Indirect Emission associated with the use of construction materials and products (source 1) Traction power use (source 4)
Not BEE Owned	Transport network effects (source 6)

Data sources

1.3.11 The key sources of information used in this assessment are summarised here and described further below:

- the construction phase information;
- traction power modelling; and
- the transport model outputs.

1.3.12 The assessment has used construction phase details provided in Chapter 6 of the Main Statement in conjunction with the available construction material information including an initial bill of materials. At this stage, these are indicative and will be subject to the precise specification of the detailed design. Nonetheless this information has been used to provide an indicative assessment of the GHG emissions associated with the construction of the BEE. Construction materials (source 1) have been assessed based on the amount of materials expected based on the initial design. For each material, an appropriate emission factor has been used to calculate the GHG emissions associated with the manufacture of that product. Based on the schedule of materials, construction plant (source 3) has also been assessed following the same approach.

1.3.13 Construction transport emissions (source 2) have been assessed based on the expected number of transport movements associated with the construction phase. A set of assumptions on the distance travelled have been made in order to estimate emissions from this source, although this is only indicative since it will depend on the specific suppliers that are eventually chosen to construct the BEE.

1.3.14 Traction power modelling has been undertaken to estimate the annual electricity demand of the BEE (source 4). This has been calculated using the traction power model TRAIN. Scenarios were constructed for the baseline and BEE cases and the total annual power demand calculated for both. The emissions associated with this demand have been calculated based on the annual demand anticipated and the national grid emission factor for electricity.

1.3.15 The proposed tram stops will include a small power demand for lighting, communication systems and signage (source 5) and as such will use small amounts of electricity which has associated GHG emissions. At this stage of design, no specific quantification of this potential energy use has been undertaken. However it is likely to be considerably less than that associated with traction power. Therefore although noted as a potential source it is not considered to be significant and these emissions have not been considered further in the assessment.

1.3.16 The BEE will lead to small adjustments in the flow of vehicles on the road network (source 6). Following the overarching approach set out in Design Manual for Roads and Bridges (DMRB), modelled flows for the baseline and BEE cases have been used, which are broken down in to the number of vehicles of mode type and speed. Emissions have been estimated using the Defra (2016) Emissions Factor Toolkit v7.0. The toolkit estimates emissions of GHG for each modelled road based on the flow, composition and speed of the traffic. This information has been obtained from the traffic data derived from the BEE transport network model (further information in the Transport Assessment in ES Volume 2 Technical Appendix L2). Emission factor profiles for 2022 and 2030 (the closest year to the 2032 scenario) have been used).

1.3.17 Emission factors for each type of activity considered have been sourced from published datasets. For the construction phase, data from a number of sources has been used including CESSM4 Major Works (ICE CESMM4 Carbon & Price Book 2013), the Rail Safety and Sustainability Board's Rail Carbon Tool (https://www.railindustrycarbon.com/) and the Inventory of Carbon and Energy v2 (Hammond and Jones, University of Bath 2011). Emission factors associated with construction transport were taken from Greenhouse Gas Reporting Conversion Factors dataset and are presented in Table 1.3.

Table 1.3: Summary of construction transport emission factors

Activity	Value	Unit
HDV Transport (all HDV, per km, fully laden)	1.0452	$kgCO_2e/km$
Workers (3.5t van equivalent, per km, unknown fuel)	0.2665	$kgCO_2e/km$

1.3.18 For electricity use, the Greenhouse Gas Reporting Conversion Factors [ref] have been used, which were published in June 2016. Emission factors change from year-to-year. Government policy suggests that emissions from electricity and transport will decrease in the future in order to meet targets set out in the Climate Change Act. This implicitly means that emission factors associated with electricity use in the future would be lower than those presently.

1.3.19 For this assessment present day emission factors have been used to estimate the impacts of the BEE as a conservative assumption and the value is taken from the latest emission factor dataset published by Defra / Department for Energy and Climate Change (DECC) as part of the Greenhouse Gas Reporting Conversion Factors. An additional calculation has been made of the impact based on projected emissions factors as sensitivity. Future emission factors are published by DECC as part of the Green Book (published September 2015). This provides factors for all years up to 2100. The grid-average factor for 2022 and 2032 is based on 'Industrial' classification has been used as the basis of comparison. The emission factors used are presented in Table 1.4

Table 1.4: Summary of grid electricity emission factors

Activity	Value	Unit
Present day (2016, generated, plus grid losses)	0.449	tCO_2e/MWh
Future emission factor (2022, Industrial, consumption)	0.207	tCO_2e/MWh
Future emission factor (2032, Industrial, consumption)	0.096	tCO_2e/MWh

1.3.20 As noted above, for the assessment of changes to the road network, transport emission factors have been sourced from the Emissions Factor Toolkit v7.0 (EFT) which is provided by the DfT. The emission factors are calculated within the EFT based on the fleet composition and speed for each link individually.

Assessment Criteria

1.3.21 There are currently no statutory criteria for assessing the relative effects of projects in relation to emissions of GHG. Although the Climate Change Act prescribes a national target for reduction, this has not been transposed in to regional, sector or project level targets.

1.3.22 In addition, current planning guidance does not give specific guidance in how to appraise the impacts of developments on GHG emissions.

1.3.23 Emissions arising from the BEE have been compared to those reported for the wider transport network and the regional and national level to assess the overall effect the BEE may have on achieving specific targets that others- such as the government of Department of Transport – may have. This considers direct emissions associated with the operational phase and considers the future trends in emissions that are expected.

1.3.24 Determining the significance of changes in GHG emissions can be difficult as no discrete receptors are affected by changes in these emissions. The significance must be defined in relation to the actual reduction or increase in emissions incurred compared to ‘no development scenario’ in the opening year. The actual amount of any increase or decrease will then be assessed in the context of current mass emissions reduction targets in place at both the local and national level relating specifically to the transport sector.

1.4 Baseline Information

1.4.1 Estimates of emissions of GHG, by local authority area, were published by the Department for Energy and Climate Change (DECC) now the Department of Business, Energy and Industrial Strategy. The exercise is undertaken to provide consistent information across all local authorities in the UK.

1.4.2 Although this data is not directly comparable with the assessment undertaken here due to differences in purpose and assessment methodologies, it does provide an indication of the existing major sources of GHGs and their extent in particular in comparison to emissions from transport network effects.

1.4.3 Table 1.5 presents a subset of the statistics for the BCC's administrative area published by DECC for the period 2005 to 2014. The dataset is split into four main categories by end-user (rather than source): industry and commercial, domestic, road transport and land use change and forestry (LULUCF). They are broken down further by specific uses. The breakdown by end user pertinent to transport (and this assessment) is shown in Table 1.5.

Table 1.5: Emissions in Birmingham by end user, '000 of tonnes of CO_2 equivalent per year ($ktCO_2e/yr$)

Year	2010	2011	2012	2013	2014	% change 2010/2014
Industry and commercial	2,328	2,084	2,232	2,159	1,796	-23
Domestic energy	2,137	1,873	2,010	1,955	1,629	-24
Transport total	1,496	1,476	1,460	1,421	1,449	-3
- A-Roads	403	401	397	379	381	-6
- Motorways	180	182	180	176	190	6
- Minor Roads	857	838	827	809	821	-4
- Diesel railway	32	32	33	33	33	2
- Transport Other	24	24	23	24	24	3
LULUCF (net)	6	5	5	4	4	-38
Grand Total	5,966	5,438	5,708	5,539	4,877	-18
Population ('000s)	1,061	1,074	1,085	1,092	1,101	4
Per Capita Emissions (t)	6	5	5	5	4	-21

Source: Local and Regional CO_2 Emissions Estimates for 2005-2014, produced by AEA for DECC, 2016

1.4.4 The trend shows that in general, total emissions have been declining in recent years, despite an increase in the overall population in Birmingham. Emissions from the transport sector have also declined, which is in line with national trends. There is a small increase in the emissions from the rail sector in the same period. The dataset does not provide an indication of the emissions associated with the electrified rail network as the rail category only includes diesel powered trains; electricity used in the electrified network is accounted for in the Industry and Commercial category.

1.4.5 Table 1.6 presents national data from the DfT which shows the level of GHG emissions by each transport mode. The data shows that GHG emissions of all road vehicles except HGVs have declined in recent years, with cars and taxis contributing most to the GHG emissions.

Rail and HGVs are the only transport modes whose emissions have increased during the same period, which is also reflected in the data for the Birmingham area in Table 1.5.

Table 1.6: UK GHG emissions from the transport sector by source, million tonnes of CO_2 equivalent ($mtCO_2e$)

Mode	2008	2009	2010	2011	2012	% change 2008/2012
Road Transport Total	115.9	111.7	110.4	108.9	108.7	-6%
- Cars and taxis	72.2	69.4	66.3	65.1	64.2	-11%
- Heavy goods vehicles (HGVs)	22.6	21.8	23.5	23.4	24.3	8%
- Light vans	15.4	14.9	15.0	15.2	15.3	-1%
- Buses and coaches	4.6	4.6	4.6	4.3	3.9	-15%
- Motorcycles and mopeds	0.6	0.6	0.6	0.6	0.5	-17%
- Other (road vehicle engines)	0.5	0.4	0.5	0.4	0.4	-20%
Rail	2.0	2.0	2.0	2.1	2.1	5%
Domestic aviation	2.2	2.0	1.8	1.7	1.7	-23%
Domestic shipping	2.7	2.6	2.6	2.5	2.4	-11%
Other (military aircraft and shipping, aircraft support vehicles)	3.8	3.5	3.4	3.3	3.1	-18%
Grand Total	10.8	10.0	9.8	9.6	9.3	-14%

Source: DfT, Transport Statistics Great Britain: 2014, Chapter 3: Energy and environment, data tables, November 2015

1.4.6 Estimates of baseline conditions have additionally been produced. This is based on the predicted GHG emissions due to the operation of the Midland Metro network in 2022 and 2032 without the BEE is in place. This modelling, and as such the baseline, includes all committed tram extensions on the Midland Metro network that will be in operation before the BEE (i.e. Wolverhampton Station extension, Centenary Square extension, Edgbaston extension). Transport network modelling undertaken for the BEE (see Transport Assessment in ES Volume 2 Technical Appendix L2) has been used to provide estimates of the total GHG emissions from the road transport network in 2022 and 2032 without the BEE in operation. These have been used as the basis for the assessment of BEE and are presented in Table 1.7 and Table 1.8. (Note that for source 6, if an emission factor for 2021 was used to match the traffic data year, the baseline value would be 96.7$ktCO_2e$, 1% higher than using 2022 emission factors).

Table 1.7: Baseline emissions from traction energy use (source 4)

Activity	Value	Unit
Predicted baseline 2022 electricity consumption of Metro	4,891	MWh
Calculated emissions 2022 (2016 emission factor)	2.19	$ktCO2_e$
Calculated emissions 2022 (2022 emission factor)	1.01	$ktCO2_e$
Calculated emissions 2032 (2032 emission factor)	0.47	$ktCO2_e$

Table 1.8: Baseline emissions from road transport network (source 6)

Activity	Value	Unit
Baseline emissions of the road transport network, 2022	95.7	$ktCO2_e$
Baseline emissions of the road transport network, 2032	98.8	$ktCO2_e$

1.5 Construction – Likely Significant Effects

1.5.1 GHG emissions associated with the construction phase from sources 1, 2 and 3 have been calculated based on the methodology set out in Section 1.3 and are presented in Table 1.9

Table 1.9: GHG emissions associated with construction phase

Element	ktCO2e
-Source 1: Construction Materials	8.16
-Source 2: Construction Plant	0.93
-Source 3: Construction Transport	0.88

1.5.2 Emissions from materials used in building the BEE are predicted to be the greatest source of GHG emissions in the construction phase. These are indirect emissions (i.e. they occur elsewhere) associated with the production of the materials and equipment. Materials that are more 'finished' products typically have a higher impact per unit weight than more basic materials. For example the overhead line equipment requires more effort to manufacture than concrete, therefore for 1kg of the equipment the impact would be greater than for 1kg of concrete. The key contributors to GHG emissions associated with materials were concrete in the surfacing, concrete to fill the Bull Street/Corporation Street disused subway and steel associated with the tracks and OLE.

1.5.3 Construction plant emissions and construction transport emissions are predicted to be smaller sources of GHG emissions.

1.5.4 As noted in Section 1.5 some efforts have been made to minimise the impact of the BEE's construction. In particular the removal of significant elements of the OLE equipment free sections through catenary free sections of route has lowered emissions by around 3.5ktCO_2e.

1.5.5 The CoCP requires the constructor to aim to source construction materials from local sources as far as possible to reduce the impact of these emissions and to keep diversions and distances to a minimum to keep the local road network operating as optimally as possible. The CoCP seeks to impose rules of working that will minimise the energy use from construction plant and therefore the GHG emissions from the plant.

1.5.6 While emissions of GHG during construction are inevitable, the design process and CoCP have both sought to minimise the amount of work and energy required to construct BEE.

Further efforts to reduce the impact will be made as the design progresses at a later detailed design phase.

1.6 Operation – Likely Significant Effects

1.6.1 Emissions associated with the BEE have been calculated according to the method and BEE stated above. Table 1.10 summarises the emissions from each aspect of the BEE.

Table 1.10: GHG emissions associated with the operational phase - 2022

Element	$ktCO_2e$ per year	Change from baseline
-Source 4: Traction power use		
Present day emission factor (2016)	2.57	+0.38
Future emission factor (2022)	1.19	+0.17
-Source 6: Transport network effects	96.2	+0.50

Table 1.11: GHG emissions associated with the operational phase - 2032

Element	$ktCO_2e$ per year	Change from baseline
-Source 4: Traction power use		
Present day emission factor (2016)	2.57	+0.38
Future emission factor (2032)	0.55	+0.08
-Source 6: Transport network effects	98.5	-0.30

1.6.2 Based on the information from the power demand modelling undertaken for the BEE, the predicted emissions increase resulting from the tram system itself (source 4) is calculated to be between 0.17 and 0.38ktCO_2e (depending on the emission factor used) in 2022 and by less in 2032. This increase is in proportion to the increase in the length of the route that the BEE introduces, increasing the electricity demand of the system by 838MWh per year. While there is predicted to be an increase in GHG emissions, it represents a very small increase compared to the existing sources of transport related GHG emissions in the Birmingham area which currently amount to annual emissions of 1.4mtCO_2e (the Metro as a whole being well below 1% and BEE being responsible for around one-fifth of that). Therefore the increase in emissions associated with the BEE's traction power use is not considered to be significant.

1.6.3 Based on the transport models produced for the BEE, a very small increase in emissions of 0.5ktCO_2e is calculated in the opening year of 2022, and a reduction in emissions of 0.3ktCO_2e by 2032 (note that if a 2021 emission factor was used to match the traffic data year, the total emission are predicted to be 97.2ktCO_2e, and the change compared to the baseline would be the same at 0.5ktCO_2e for the opening year). This is due to small change in vehicle flows and vehicles speeds following the introduction of BEE in the opening year; between the two assessment years, the effects of committed developments such as HS2 affect the number of vehicles, the distance travelled and vehicle speeds such that the effect of BEE on the network changes between 2022 and 2032. In both 2022 and 2032, these changes are very small and the BEE is broadly considered to have a neutral impact on the road transport network in terms of total GHG emissions in the Birmingham area.

1.6.4 As noted in paragraph 1.5.6 some energy saving techniques will be implemented on the trams to minimise the energy consumption of the BEE. These techniques are predicted to lower the energy demand of the system by around 20%, at represent savings in source 4 emissions of around by 0.05 and 0.09ktCO_2 per year for the BEE section in 2022 (i.e. using the present day emission factors, the change from the baseline would be 0.47ktCO_2e rather than 0.38ktCO_2e if regenerative braking was not part of BEE).

1.6.5 As noted, in the future the grid electricity emission factor is expected to continue to fall in line with government policy, meaning the emissions associated with BEE traction energy would also reduce.