Rail Central

Appendix 23.2 Road & Rail Freight Emission Factors

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Contents

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Executive Summary

1. This assessment has reviewed the source of the NS PNN statement that rail freight displaces 70% of road freight tonne for tonne and concludes that this is a slight misinterpretation of out of date data.

2. Using current data and emission factors, rail freight per tonne.km results in 58% fewer GHG emissions than road freight assuming an appropriate vehicle class (>33t articulated HGV) is displaced. At Rail Central, when considering origin and destination points, the reduction in emission from rail to road freight is estimated to be 22%.

3. To assess the impact of decarbonisation of road and rail freight to the end of the short-term operational period (2038), potential emission reduction opportunities up to 2038 for both rail freight and the equivalent road freight anticipated to be displaced by rail, have been identified. Assumptions on take-up and efficiencies delivered have been made based on available literature and a profile of future emission factors has been developed for rail freight and freight moved by articulated HGVs greater than 33 tonnes.

4. Emissions are predicted to reduce for both rail and road over the period, but as the opportunities to reduce GHG emissions in large HGVs are more limited, rail emissions reduce at a faster rate. The differential over time therefore increases, resulting in greater savings for rail freight compared with a road only comparator in the future.

5. It is estimated that by 2028, the transfer of freight from road to rail at Rail Central could result in a reduction of 84,639 tonnes CO_2e by 2028 and 275,393 tonnes CO_2e by 2038.

6. This is the equivalent of a 7% reduction during the construction phase, before the site is fully operational, and an 52% reduction during the short-term operational phase.

7. Emission reductions past this point have not been calculated but would be expected to continue to fall.

1. Introduction

1.1 This assessment has been carried out to support the assessment of greenhouse gases associated with freight for the Chapter 23 and Appendix 23.1 of the PEIR for the Proposed Development of Rail Central.

1.2 The displacement of road freight to rail is consistently identified as an important method for reducing emissions, particularly for large container loads being transported over long distances. However, often quoted emission reductions are based on 2008 data that fails to take into account a number of key considerations:

- Emission factors applied in 2008 were based on crude data from the National Atmospheric Emissions Inventory (NAEI) and DfT transport statistics; since 2008, methods for assessing emissions from road and rail have improved and are now considered more accurate.

- The distance travelled by rail is likely to be longer than comparator distance travelled by road; this is due to the tranship leg between the rail heads and the ultimate origin and destination but is not taken into account in a simple tonne.km comparison.

- Emissions for road and rail freight are reducing over time, but by different amounts; thus altering the emissions differential.

1.3 There is an urgent need to reduce greenhouse gas emissions and the UK has set legally binding Carbon Budgets to deliver against short-, medium-, and long-term reduction targets. As a result, emissions have reduced significantly over the last decade, and are expected to continue reducing into the future. In the context of estimating future GHG emissions, this is important to recognise and take into account.

1.4 To achieve emission reductions on the scale required, efforts are required to both reduce the level of emission generating activity and to reduce the emission content of activities. This assessment has drawn upon currently available reports and research to identify potential emission reduction scenarios for road and rail freight to develop a set of emission factors for road and rail freight movements at Rail Central up to 2038.

2. Modal Shift

2.1 MDS Transmodal have provided an estimate of the quantity of road freight that will be displaced by rail at full operation and an assessment of the GHG emissions associated with this displacement (Appendix F). However, emissions are calculated using 2017 emission factors for average HGV distances travelled (HGV.km) and rail tonnes moved (tonne.km).

2.2 To compare emissions, they must be assessed on a like-for-like basis and BEIS guidance (Ref 1) states that:

"For comparison with other freight transport modes (e.g. road vs. rail), the user may require CO_2 factors in tonne km (tkm) units."

and that:

"The average tonne freight lifted figures are derived from the tkm and vehicle km (vkm) figures given for each class of HGV in Tables RFS0119 and RFS0109, respectively (DfT, 2016). Dividing the tkm by the vkm figures gives the average tonnes freight lifted by each HGV class."

2.3 This section therefore calculates the equivalent tonne.km moved by each mode; sections 3, 4 and 5 assess the appropriate emission factors for application up to the end of the short-term operational phase (2038). It differs from the MDS assessment in the following ways:

- Tonne.km are calculated for road and rail freight assuming the same quantity of freight is moved across the network in both scenarios
- Adjusted emission factors are applied based on our assessment of potential decarbonisation of road and rail
- The applied road emission factor relates to large articulated HGVs (>33t) rather than average HGVs as this is the most likely vehicle type to be displaced.

This results in a more conservative assessment of the emissions saved as a result of modal shift.

2.4 The MDS assessment is based on the GB Rail Freight Model, assuming 335 operating days per annum. Rail freight is assigned to specific routes on the national railway network, thereby allowing the distance over which the forecast rail traffics move to be established. This assumes 72.9million unit-km per annum, which has then been multiplied by 10.6 tonners per unit to estimate the rail tonne-km (derived from DfT Port Statistics and including empty units).

2.5 Distance travelled by road is calculated in a similar way, with and without the displacement by rail freight, with one unit corresponding to one vehicle movement. This results in 209,975,000 HGV-kms travelled with the SRFI in place and 262,922,000 HGV-kms if all transport is via road.

2.6 For the purposes of this assessment, it is assumed that rail freight displaces the largest vehicle class, which is articulated vehicles over 33t. The following data from DfT (Ref 2) relates to this vehicle type and was used to calculated BEIS 2017 emission factors (2016 data):

- 122,515 million tonne km moved (RFS0119)
- 999 million tonnes lifted (RFS0119)
- 9,904 vehicle km (RFS0119/ RFS0109)
- 7.9 miles per gallon (RFS0141)
- 0.67 loading factor (RFS0117)

2.7 As the rail freight is displacing existing road freight, rather than applying the 10.6 tonnes per container assumption as described in paragraph 2.2 above, the same quantity of freight as is being displaced per unit.km must be assumed.

2.8 To calculate the tonne.km for road haulage, the distance travelled must be multiplied by the average vehicle load. This is calculated by dividing the figures above for the total tonne km moved by the total km travelled and equates to 12.3703 tonnes per load.

- 262,922,000 x 12.3703 = 3,252.41 million tonne.km (road only)
- 209,975,000 x 12.3703 = 2,597.44 million tonne.km (with SRFI)

This results in a reduction of 654.97 million HGV tonne.km through the displacement of road freight to rail.

2.9 Assuming rail is displacing journeys that would otherwise be carried out by road requires that the same tonnes per unit.km are applied. This results in a baseline of:

- 72,900,000 x 12.3703 = 901.792 million tonne.km (by rail)

2.10 Total tonne.km by road and rail equates to 3,499 million tonnes, which is an additional 8%, or 247 million tonne.km compared with the road only comparator. Comparing the rail freight element with the equivalent road freight element results in a 27% increase in distance travelled for the rail-displaced freight. This is higher than assumptions applied elsewhere, such as the 10% additional distance assumed by Arup (Ref 3) to take into account the tranship leg between the rail heads and the ultimate origin and destination but is based on likely origin and destination data.

2.11 The quantity of freight transferred to rail is assumed to be directly proportional to the quantity of warehouse space completed and operational in a given year. The reduction in HGV movements is calculated based on the above assessment, assuming that every tonne.km shifted to rail displaces 0.726 tonne.km of road freight. This has been used to profile emissions over the construction period when the SRFI is not yet fully operational.

2.12 Under the SRFI scenario, approximately 20% of the freight is shifted to rail; for this element of freight, it is appropriate to apply the emission factor for average-laden >33t articulated vehicles based on the assumption that rail displaces long-haul heavy freight journeys.

2.13 For the remaining freight, average articulated HGV emission factors would be applicable; this would take into account that the remainder of the freight not displaced by rail is likely to be more regional with a different payload profile. However, given that this proportion remains the same in both road-only and SRFI scenarios, it is unnecessary to calculate this figure.

3. Emission Factors

3.1 The National Policy Statement for National Networks (Ref 4) was published in 2014 and states that:

'Tonne for tonne, rail freight produces 70% less CO_2 than rail freight'

This is based on the document *Delivering a Sustainable Transport System: The Logistics Perspective,* published by DfT in 2008 (Ref 5).

3.2 The 2008 DfT report states that:

'Rail produces around 0.05kg of CO_2 per tonne km compared to around 0.17kg of CO_2 per tonne km for road transport'.

This is based on DfT analysis of NAEI emission data and traffic statistics (Figure 2.4 CO_2 within the document sets out the intensity of road and rail transport).

3.3 This simplistic assessment fails to take into account a number of factors, which are considered further below:

3.3.1 Only direct carbon dioxide (CO_2) emissions are taken into account, with the impact of other GHGs and indirect upstream impacts associated with the production of fuels excluded.

3.3.2 A tonne for tonne comparison does not take into account the distance travelled by rail is likely to be longer than comparator distance travelled by road; this is due to the tranship leg between the rail heads and the ultimate origin and destination. In Arup's work looking at the future potential or modal shift (Ref 3), this was assumed to result in an additional 10% of tonne.km.

3.3.3 The displacement of road freight to rail freight in the context of the SRFI is likely to focus on long-haul container freight. It is assumed that this requires heavier articulated vehicles (>33t), and the profile of these vehicles in terms of emissions and emission reduction potential is different to other vehicles. An average HGV or average articulated HGV freight figure would therefore be an unsuitable comparator assumption to apply.

3.3.4 Similarly, the emissions profile of rail freight will vary depending on a number of factors, although BEIS (Ref 1) identifies: "*Traffic-, route- and freight-specific factors are not currently available, but would present a more appropriate means of comparing modes (e.g. for bulk aggregates, intermodal, other types of freight)*.". This is particularly relevant to this assessment, as emission factors for rail freight increased per tonne.km in 2017, thought by the Office of Road and Rail (ORR) to be as a result of the reduction in movements of bulk coal across the freight network, and an increase in container freight which tends to be less efficient in terms of tonnes/km travelled (Ref 6.

3.4 Current BEIS emission factors (Ref 7) have been used as the basis for comparing emissions that would currently be displaced by the scheme, and the underlying data has been adjusted for future emission scenarios.

3.5 The following sections on road and rail detail the assumptions and adjustments made to current emission factors specific to each mode.

3.6 Without data to allow the assessment of a tonne.km figure specific to container freight, it should be noted that the current and future estimates of emissions may significantly under-estimate the emissions associated with the movement of this is recognised as a limitation of this assessment.

3.7 Applying current (Ref 7) emission factors to the quantities of freight moved outlined in Section 2, results in the emissions reported in Table 3.1.

Road: 0.07735kgCO_2e/tonne.km (direct) + 0.03099 kgCO_2e/tonne.km (indirect) = 0.09985 kgCO_2e/tonne.km

Rail: 0.03394kgCO_2e/tonne.km (direct) + 0.00774 kgCO_2e/tonne.km (indirect) = 0.041681 kgCO_2e/tonne.km

Table 3.1: 2017 Emission Comparison

	Emission Factor [kgCO_2e/ tonne]	Road-only Comparator		SRFI	
		Million Tonne.km	Tonnes CO_2e	Million Tonne.km	Tonnes CO_2e
Average laden, >33t articulated	0.09985	654.970	65,399	0	0
Rail freight (average)	0.041681	0	0	901.792	50,897

3.8 Whilst emission factors indicate than per tonne.km, rail freight is 58% more efficient than via road (assuming appropriate vehicle displacement), when applied to the tonne.km calculated for Rail Central, there is only a 22% reduction in GHG emissions.

3.9 As the purpose of this assessment is to support the GHG assessment for the Rail Central PEIR, a worst-case scenario would be reduced emissions across the HGV network with corresponding lower emissions in the rail sector.

3.10 In order to make adjustments to current emission factors to take into account future scenarios, current BEIS emission factors (Ref 7) have been deconstructed based on their source data and the BEIS methodology detailing how each emission factor has been calculated (Ref 1). In addition to the DfT data outlined in paragraph 2.5, ORR Table 2.100 Sustainable development (Ref 8): Estimates of normalised passenger and freight CO_2e emissions for 2014-16 is used in the assessment of freight emissions.

3.11 In addition, ORR publish details of their methodology (Ref 9) for calculating the emission factors published in Table 2.100. This states that:

- Freight operators provide the ORR with their total traction electricity (kWh) and diesel usage (litres) consumption (Table 2.101: Estimates of passenger and freight energy consumption and CO_2e emissions (by traction type)..
- Energy consumption data is then converted into CO_2e using standard conversion factors from Defra (now BEIS).
- Prior to conversion, electricity consumption is uprated assuming 1.5% of electricity generated is lost during transmission.

- In some instances, actual consumption data is not provided by operators. In these cases, an estimate of CO_2e is made based on the number of train kilometres each operator runs by working out the average CO_2e emissions per train km for the operators who have provided data and applying this factor to the train kilometres for operators that require estimation.
- To calculate the normalised output, the total CO_2e emission for freight operators are normalised by net tonne kilometres sourced from the dataset published in the Rail Freight Usage Statistics (Table13.25: Freight train kilometres by operator and Table 13.7: Freight moved)

3.12 The addition of 1.5% of the reported electricity consumption to take into account electricity lost during transmission would otherwise be accounted for under Scope 3 emission factors and does not correspond with BEIS methodologies; emission factors for losses during transport and distribution are around 9% of Scope 2 electricity emission factors.

3.13 By applying BEIS emission factors to the electricity and diesel quantities provided in Table 2.101, a direct emission factor of 0.0326 kgCO_2e/rail freight tonne.km is calculated; this compares with the 0.0339 kgCO_2e/ rail freight tonne.km reported. Given that the reported figure includes a 1.5% uplift which is accounted for in Scope 3 emissions, the source Table 2.101 and Table 13.7 data has been used as the basis for calculating emission factors and future adjustments.

3.14 Scope 3 emissions associated with rail freight are reported at 0.00774 kgCO_2e per tonne.km, however by assessing the upstream emissions associated with the diesel and electricity consumed as described above, a factor of 0.0077 kgCO_2e per tonne.km is derived. For the reasons stated above, this is used as the basis for future changes.

3.15 BEIS emission factors for electricity are changing rapidly, and the 2017 reported figures relate to 2015 emissions; projected emission factors (Ref 10) relate to the year in which they occur, so to tie these two sets of emission factors together, future emission factors for 2018 have been applied to the data. This results in an emission factor of 0.0323 for direct (Scope 1 & 2 emissions) and 0.400 kgCO_2e/tonne.km for total Scope 1, 2 & 3 emissions.

4. Rail

Emission Factor Methodologies

4.1 In 2008, Defra (Ref 11) set out the methodology for assessing emission factors for rail freight. This explains that the value for rail freight is provisional and based on available information on fuel consumption and CO_2 emissions by diesel freight trains in the UK in 2005 produced by the UK Greenhouse Gas Inventory on the basis of average fuel consumption rates of diesel locomotives and estimated freight train km and DfT statistics on the total tonne km rail freight moved in 2005: Transport Statistics Great Britain (Table 4.1).

4.2 Freight trains are hauled by electric and diesel locomotives, but specific rail freight energy use data was not available nationally and the 2008 factors assume haulage only by diesel locomotives. The resulting emission factor was 21.0 gCO_2 per tonne km; this is significantly different to the figure calculated by DfT in 2008, which stated 0.17kg CO_2 per tonne.km.

4.3 The methodology was updated the following year (Ref 12), when the CO_2 value for rail freight was based on available information on CO_2 emissions by diesel freight trains in the UK in 2007 produced by the Office of Road and Rail (ORR). This resulted in an emission factor of 0.0285 $kgCO_2$ per tonne.km, or 0.0319 $kgCO_2e$ per tonne.km.

4.4 These emission factors were in place until 2012, when they were updated to include data from ORR on both diesel and electric transportation of rail freight; relating to 2011, diesel accounted for 93% of rail freight movements, with an overall rail freight emission factor of 0.0276$kgCO_2$ or 0.03063$kgCO_2e$ per tonne.km. Indirect emissions were also assessed, accounting for a further 0.00571$kgCO_2e$ per tonne.km.

4.5 This methodology has been applied to the calculation of rail emissions ever since, with emission factors updated annually based on emissions data from the previous year.

4.6 Direct emission factors for freight include Scope 1 and 2 emissions associated with fuel and electricity, and indirect emission factors include the upstream Scope 3 emissions associated with each fuel, when combined resulting in total 'well-to-wheel' emissions factors. Emissions are compared on a tonne.km basis.

4.7 In 2008, emissions associated with road and rail freight were crudely estimated and in the intervening years, significantly more data is now available, improving the accuracy of the figures over time. The annual GHG Methodology papers that support BEIS emission factors for company reporting (formerly Defra) set out the sources of data used and associated assumptions. Adjusting that data to take into account future scenarios (for example, an increase in the use of electric traction) allows us to estimate potential future emission factors.

4.8 It is noted that Arup (Ref 3) have assumed that electric traction produces zero carbon (sic) emissions, based on the fact that power generation for electric locomotives is included under the EU emissions trading scheme and therefore already internalized and accounted for at the point of generation. If this approach were to be adopted, then energy generated in power stations would also be excluded from this assessment, as many power stations are also included in the EU Emissions Trading Scheme. For consistency and completeness, this approach has not been applied and electric traction emissions are calculated based on the electricity consumed to generate the required level of electric traction as reported in 2016/17 figures. This is consistent with the BEIS GHG reporting methodology (Ref 1).

Electrification & Rolling Stock

4.9 Although 34% of the rail network is electrified, only 5% of freight is currently transported using electric traction (Ref 6). Even on routes where the majority of the track is electrified (such as the West Coast Mainline), there are still lengths of track (this includes current gaps on key corridors from Felixstowe and the new Thames Gateway development to the Midlands, North West and North East, along with the privately owned intermodal terminals not currently electrified) that are not and the practicalities of transferring from electric to diesel for part of the route mean that for many journeys, diesel trains are the preferred option.

4.10 Whilst bi-mode trains, which can switch between diesel and electric traction along the same route do exist, there are currently only 10 (2%) of such locomotives in operation amongst four of the five major freight operators[1] (purchased between 2015 and 2017 and operated by Direct Rail Services). Similarly, electric locomotives currently comprise circa 10% of these freight fleets.

4.11 Rolling stock requires significant investment and as a result tends to be operational for long periods of time; the average age of rolling stock owned by four of the five major freight operators is 32 years[2]. In addition, the period between putting out a tender for new rolling stock and them becoming operational can be several years, so there is a definite lag in any in bi-mode operation in the freight sector becoming an operational reality. Indeed, Government announcements to date relating to the cancellation of funding for electrification projects only cite passenger use of bi-mode trains, where Government have a greater influence on rolling stock due to franchising arrangements, and as a result, a much higher proportion of journeys are electrified.

4.12 Any further switches to electric traction will require significant investment in infrastructure, which at present is unlikely given the cancellation of a number of electrification projects in 2017 (Ref 13).

4.13 Whilst Government has recently announced that it would like to phase out diesel trains entirely by 2040 (Ref 14), potentially through the use of hydrogen technology and battery storage, it is not yet understood what this will entail, particularly for freight which is not governed by franchise arrangements.

4.14 Although a pilot of a hydrogen powered passenger train is planned by 2020, Rail Freight Group Executive Director Maggie Simpson sounded a note of caution, saying

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[1] *This includes GB Railfreight, Direct Rail Services, Freightliner and Colas Rail, but excludes DB Cargo UK who do not publish this information. DB Cargo UK are the largest operator, but inherited a large fleet from British Rail. It is known that circa 250 locomotives were replaced in 1996, but no further purchases are known.*

[2] *Based on rolling stock data for GB Railfreight, Direct Rail Services, Freightliner and Colas Rail, assessed in Appendix E.*

that whilst battery and hydrogen *'may show promise for lightweight passenger trains, their application for heavy duty freight is at best unproven, and setting an arbitrary deadline of 2040 could well therefore be counterproductive, damaging the case for investment'* (Ref 15).

4.15 Whilst a linear relationship from 95% diesel traction in 2017, to 0% diesel traction in 2040, would result in 17% of traction being delivered by non-diesel sources by 2020, and 41% by 2030, we have assumed that for the reasons stated above, there will be slower initial uptake of alternative traction methods. Given that no new infrastructure is currently planned, in the short-term this would rely on increased uptake of electric or bi-mode trains. As procurement takes time, we have assumed that the current proportion of diesel traction remains until 2020. Between 2020 and 2030, we have assumed that diesel traction reduces to 70%, delivered through an increased uptake in bi-mode trains. Between 2030 and 2040, we have assumed that despite recent announcements, a proportion of freight will remain on diesel traction (20%) and that alternatives are likely to include battery storage and hydrogen technologies.

4.16 Future emission factors for grid electricity take into account decarbonisation and the input of low carbon and renewable energy sources into the overall fuel mix; this results in an emission factor of 0.05495 $kgCO_2e/kWh$ in 2035 compared with 0.2049 $kgCO_2e/kWh$ in 2018. Whilst hydrogen and other alternatives may have lower emissions, this is likely to be balanced out by older locomotives that continue to run, so it is reasonable to assume that the use of electric traction as the alternative to diesel throughout. This also presents a worst-case view of overall emissions, which is consistent with the ES approach.

Freight Efficiency

4.17 Freight emissions from rail are likely to increase over time on a tonne.km basis due to the shift in transportation of bulk materials such as coal, to the transportation of less efficient container freight. This trend is likely to continue as container freight becomes a more significant component of the overall freight mix and given that the modal shift at Rail Central assumes the displacement of container freight movements, current rail freight emissions are an under-estimate.

4.18 Given that BEIS does not have sufficient data to interrogate this further, we are unable to assess this impact further.

4.19 To take this into account in the future, we have assumed that whilst there may be efficiency improvements on a tonne.km basis for road freight, no such improvements occur for rail freight.

5. Road

5.1 There are two categories of emission reduction from road freight: improvements in efficiency; and improvements in emissions associated with fuels used.

5.2 There have been numerous studies and reports over the past several years investigating the opportunities for reductions in road freight emissions, and the purpose of this document is not to repeat that content, but to identify reasonable assumptions relating to how emissions associated with road freight transport could change in the short- to medium-term (up to 2038).

5.3 The following reports have provided the primary basis for our road freight assumptions:

- Freight Carbon Review 2017 Moving Britain Forward (Ref 16)
- Committee on Climate Change (CCC) Sectoral Scenarios for the Fifth Carbon Budget Technical Report (Ref 17)
- Centre for Sustainable Road Freight (SRF) An Assessment of the potential for demand-side fuel savings in the Heavy Goods Vehicle (HGV) Sector (Ref 18)
- Element Energy Low Carbon Transport Roadmaps (Ref 19)

5.4 The 2017 Freight Carbon Review identifies several areas where the road freight sector can deliver reduced GHG emissions. These include:

- Efficient driving and in-cab technologies: Eco-driving techniques, maintenance procedures and vehicle checks designed to achieve greater fuel efficiency,
- Fleet design: Widely available technologies to reduce HGV fuel consumption including retrofit equipment such as aerodynamic devices and fairings and low rolling resistance tyres.
- Alternative fuels: LNG, CNG, biomethane and liquid biofuels are all considered suitable for use in the current generation of HGV engines.
- Low and zero emission technologies: battery electric and hydrogen fuel cell technologies.

5.5 These are supported by a number of UK and EU policy and funding incentives, pilot schemes and research funds to accelerate uptake of new technologies.

5.6 EC plans to publish regulatory proposals on the monitoring and reporting of fuel consumption and CO_2 emissions from all new HGVs by 2018; it is anticipated that these proposals would help to inform purchasing behaviour bad potentially be used to set CO_2 emissions standards within the EU in the longer term. In the future it is possible that manufacturers selling new HGVs into the EU market will face regulatory limits on their fleet average CO_2 emissions in a similar way to that as seen for cars and vans.

Assumptions regarding freight displacement at Rail Central

5.7 It is assumed that the goods being transported by rail are those that would otherwise have been transported long-haul by road. The most suitable vehicles for this type of driving and distance are articulated HGVs with high payloads, so it is assumed that all vehicles displaced by rail are over 33t articulated vehicles.

5.8 This type of vehicle has more limited alternative vehicle fuel options than smaller vehicles. Based on transport roadmaps developed by Element Energy, it is assumed that that diesel is likely to remain a predominant fuel option in the short- to medium-term, with methane/ biomethane and methanol as potential fuel alternatives in the future. Other technologies, such as electric and hydrogen are not expected to play a part in reducing emissions for this vehicle class.

5.9 The roadmaps predict a quantum of each vehicle fuel type on the road at 2020, 2025, 2030 and 2050, and these have been applied using linear interpolation to estimate potential vehicle quantums during the intervening periods. In reality, trajectories may not be linear and will depend on a number of factors, such as the availability of fuelling infrastructure and vehicles; however, for the purposes of this assessment, this is considered acceptable.

5.10 An assessment of the proportion of renewable transport fuels has been made based on the recent consultation relating to the future of the Renewable Transport Fuel Obligation scheme (Ref 210; this sets out that by 2032, 12.4% of transport fuels will be from recognised renewable sources, including biomethane, biodiesel, boiogas and biomethanol.

5.11 Emissions range from 14gCO_2e/MJ fuel for biodiesel produced from used cooking oil to 68gCO_2e/MJ fuel for biodiesel produced from palm oil. Emission savings for biodiesel are based on a central estimate of emissions savings of 49% based on carbon intensity data of different biodiesel production methods supported by the RTFO scheme. Emission factors for diesel have been adjusted so that biodiesel reaches 12.4% of total supply by 2032.

5.12 Similarly, it is assumed that 12.4% of biogas will be from renewable sources by 2032. The range of emission factors for biogas is much smaller, with RTFO default values varying between 15gCO_2e/Mj to for dry manure and 23gCO_2e/MJ from municipal organic waste; an average default GHG emission saving of 79% has therefore been applied.

5.13 It is not simply a case however of substituting for the same quantity of a different fuel and there are a number of research projects currently being undertaken to understand a number of factors including the efficiency loss of alternative fuels compared with diesel and the impacts of methane slip.

5.14 The Low Carbon Truck Trial results indicate that a Scope 1 ‘tank-to-wheel’ emission saving of 11% can be achieved with a dedicated gas vehicle with a 15% biomethane blend. If the biomethane were removed, there would be an increase in emissions due to the reduction in efficiency between spark ignition dedicated gas truck and diesel comparator trucks. Dual fuel used cooking oil/ Diesel trucks achieved an 86% reduction in Scope 1 emissions.

5.15 Unlike with diesel, there is no issue in substituting 100% natural gas with biomethane; it is therefore assumed that post- 2032, the proportion of biomethane increases until reaching 100% in 2050.

Energy Efficiency

5.16 The CCC Sectoral Scenarios for the Fifth Carbon Budget and more recently, the Freight Carbon Review, set out a number of options for demand-side reduction and the potential savings that could result. This includes:

- Efficient driving and in-cab technologies
- Fleet design
- Use of higher capacity vehicles
- Collaboration and consolidation

5.17 A review of efficiency options for road transport to 2050 carried out by AEA (Ref 24) to inform the sectoral scenarios identified a range of potential measures, their likely uptake over time and the level of efficiency over a 2010 baseline that could be delivered. Where measures are identified in the Freight Carbon Review and can be quantified, this data has been used to profile the efficiency improvements expected over time using a linear interpolation between uptake years (typically by 2020 and 2030); the percentage improvement in efficiency over the 2010 baseline has been applied to miles per gallon fuel consumption data for 2010 sourced from DfT. This data forms the basis of BEIS GHG emission factors for freighting goods so is considered a reliable baseline source, consistent with other measures.

5.18 Table X outlines the measures assumed, the resultant efficiency improvement and the anticipated level of uptake by 2030 and 2050. Linear interpolation has been applied to determine the level of annual uptake. This is then multiplied by the efficiency improvement to determine the overall reduction fuel consumed as a result of the measure. Measures are applied to all vehicles, irrespective of fuel type.

Table 5.1: Assumed Uptake of Efficiency Measures

Measure	Uptake by 2030	Uptake by 2050	Efficiency Improvement
General powertrain improvements (2020 - 2030)	-	-	8.3% by 2030
Low rolling resistance tyres	36%	100%	5%
Aerodynamic improvements	21%	100%	13%
Automatic tyre pressure adjustment	33%	100%	3%
Fuel efficiency and use of telematics	67%	100%	3%
Longer/ heavier vehicles	72%	100%	14%

5.19 A weighted emission factor for each year is calculated based on the estimated proportion of each vehicle type and their relative calculated emission factors taking into account the measures described in this section. A full breakdown of the impact of individual measures on an annual basis is included in Appendix B.

6. Assessment & Conclusions

6.1 A profile of emissions considering the measures described in this document is presented in Appendix A.

6.2 Assuming the quantities of freight moved by road and rail as assessed in paragraphs 2.7 and 2.8, annual emissions at key points in time are outlined in Table 6.1 based on the emission factors calculated.

Table 6.1: Comparison of Emissions by Road and Rail

	2018	2028	2038
Road only Emissions	61,083	54,082	47,889
SRFI GHG Emissions	36,064	30,842	19,580
% Reduction as a result of road to rail	40.9%	42.9%	59.1%

6.3 Cumulative freight emissions as a result of the Proposed Development are presented for the construction phase (2019 -2028) and short-term operational phase (2028 - 2038) in Table 6.2.

Table 6.2: Cumulative Freight Emissions as a Result of Rail Central

GHG Emissions [tCO_2e]	2018 - 2028	2028 - 2038
Road-only Comparator	569,478	526,429
SRFI	531,337	251,036
Net SRFI	-84,639	-275,393

Appendix A: Profiled Emissions

Table A.1 Profiled Road-only Emissions (2018 – 2028)

Road only Scenario	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
>33t Articulated Road load moved [tonne.km]	654.97	654.97	654.97	654.97	654.97	654.97	654.97	654.97	654.97	654.97	654.97
Annual Scope 1 Road only GHG Emissions [tCO_2e]	**46,499**	**45,671**	**44,854**	**44,131**	**43,444**	**42,815**	**42,198**	**41,592**	**40,999**	**40,419**	**39,851**
Cumulative Scope 1 Road only GHG Emissions [tCO_2e]	**-**	**45,671**	**90,525**	**134,656**	**178,100**	**220,915**	**263,113**	**304,705**	**345,704**	**386,123**	**425,973**
Annual Scope 3 Road-only GHG Emissions [tCO_2e]	**14,584**	**14,533**	**14,483**	**14,444**	**14,406**	**14,368**	**14,330**	**14,292**	**14,254**	**14,216**	**14,178**
Cumulative Scope 3 Road-only Emissions [tCO_2e]	**-**	**14,533**	**29,016**	**43,461**	**57,867**	**72,235**	**86,565**	**100,857**	**115,111**	**129,327**	**143,504**
Annual Total Road only GHG Emissions [tCO_2e]	61,083	60,204	59,336	58,576	57,850	57,184	56,528	55,884	55,253	54,634	54,028
Cumulative Total Road only GHG Emissions [tCO_2e]	-	60,204	119,541	178,116	235,967	293,150	349,678	405,562	460,815	515,450	569,478

Table A.2 Profiled Rail Central Emissions (2018 – 2028)

Rail Central Scenario	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
>33t Articulated Road load moved [million tonne.km]	654.97	654.97	654.97	654.97	629.65	514.54	419.66	333.24	196.27	85.50	**0**
Rail load moved [million tonne.km]	0	0	0	0	34.87	193.35	323.99	442.98	631.56	784.07	**901.79**
>33t Articulated Road GHG Emissions [tCO_2e]	46,499	45,671	44,854	44,131	41,764	33,635	27,038	21,161	12,286	5,276	0
Rail GHG Emissions [tCO_2e]	0	0	0	0	1,078	5,861	9,649	12,889	17,774	21,627	24,140
Annual Scope 1 & 2 SRFI GHG Emissions [tCO_2e]	**46,499**	**45,671**	**44,854**	**44,131**	**42,842**	**39,496**	**36,687**	**34,050**	**30,060**	**26,904**	**24,140**
Cumulative Scope 1 & 2 SRFI GHG Emissions [tCO_2e]	**46,499**	**92,169**	**137,023**	**181,154**	**223,997**	**263,493**	**300,179**	**334,229**	**364,289**	**391,193**	**415,333**
>33t Articulated Road GHG Emissions [tCO_2e]	14,584	14,533	14,483	14,444	13,849	11,288	9,182	7,271	4,271	1,856	0
Rail GHG Emissions [tCO_2e]	0	0	0	0	267	1,471	2,454	3,339	4,739	5,855	6,703
Annual Scope 3 SRFI GHG Emissions [tCO_2e]	**14,584**	**14,533**	**14,483**	**14,444**	**14,116**	**12,759**	**11,635**	**10,611**	**9,010**	**7,711**	**6,703**
Cumulative Scope 3 SRFI GHG Emissions [tCO_2e]	**-**	**14,533**	**29,016**	**43,461**	**57,576**	**70,335**	**81,971**	**92,581**	**101,591**	**109,302**	**116,004**
Annual Total SRFI GHG Emissions [tCO_2e]	61,083	60,204	59,336	58,576	56,958	52,255	48,322	44,661	39,070	34,615	30,842
Cumulative Total SRFI GHG Emissions [tCO_2e]	-	106,703	166,039	224,615	281,573	333,828	382,150	426,811	465,880	500,495	531,337

Table A.3 Profiled Net Central Emissions (2018 – 2028)

Net Rail Central Emissions	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
>33t Articulated Road GHG Emissions [tCO_2e]	0	0	0	0	-1,680	-9,180	-15,160	-20,431	-28,713	-35,142	-39,851
Rail GHG Emissions [tCO_2e]	0	0	0	0	1,078	5,861	9,649	12,889	17,774	21,627	24,140
Annual Scope 1 & 2 Net GHG Emissions [tCO_2e]	**0**	**0**	**0**	**0**	**-602**	**-3,319**	**-5,511**	**-7,542**	**-10,939**	**-13,515**	**-15,711**
Cumulative Scope 1 & 2 Net GHG Emissions [tCO_2e]	**0**	**0**	**0**	**0**	**-602**	**-3,921**	**-9,432**	**-16,974**	**-27,914**	**-41,428**	**-57,139**
>33t Articulated Road GHG Emissions [tCO_2e]	0	0	0	0	-557	-3,081	-5,148	-7,021	-9,983	-12,360	-14,178
Rail GHG Emissions [tCO_2e]	0	0	0	0	267	1,471	2,454	3,339	4,739	5,855	6,703
Annual Scope 3 Net GHG Emissions [tCO_2e]	**0**	**0**	**0**	**0**	**-290**	**-1,610**	**-2,695**	**-3,681**	**-5,244**	**-6,505**	**-7,475**
Cumulative Scope 3 Net GHG Emissions [tCO_2e]	**0**	**0**	**0**	**0**	**-290**	**-1,900**	**-4,595**	**-8,276**	**-13,520**	**-20,025**	**-27,500**
Annual Total Net GHG Emissions [tCO_2e]	0	0	0	0	-892	-4,929	-8,206	-11,224	-16,183	-20,019	-23,186
Cumulative Net SRFI GHG Emissions [tCO_2e]	-	0	0	0	-892	-5,821	-14,027	-25,250	-41,434	-61,453	-84,639

Table A.4 Profiled Road-only Emissions (2029 – 2038)

Road only Scenario	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
>33t Articulated Road load moved [tonne.km]	654.97	654.97	654.97	654.97	654.97	654.97	654.97	654.97	654.97	654.97
Annual Scope 1 Road only GHG Emissions [tCO_2e]	**39,295**	**38,752**	**42,412**	**41,651**	**40,781**	**39,803**	**38,716**	**37,521**	**36,217**	**34,804**
Cumulative Scope 1 Road only GHG Emissions [tCO_2e]	**39,295**	**78,048**	**120,460**	**162,111**	**202,892**	**242,695**	**281,411**	**318,932**	**355,149**	**389,953**
Annual Scope 3 Road-only GHG Enissions [tCO_2e]	**14,139**	**14,101**	**13,974**	**13,847**	**13,720**	**13,593**	**13,466**	**13,339**	**13,212**	**13,085**
Cumulative Scope 3 Road-only Emissions [tCO_2e]	**14,139**	**28,241**	**42,215**	**56,062**	**69,782**	**83,375**	**96,841**	**110,180**	**123,391**	**136,476**
Annual Total Road only GHG Emissions [tCO_2e]	53,435	52,854	56,386	55,498	54,501	53,396	52,182	50,860	49,429	47,889
Cumulative Total Road only GHG Emissions [tCO_2e]	53,435	106,289	162,675	218,173	272,674	326,070	378,252	429,112	478,540	526,429

Table A.5 Profiled Rail Central Emissions (2019 – 2038)

Rail Central Scenario	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
>33t Articulated Road load moved [million tonne.km]	0	0	0	0	0	0	0	0	0	0
Rail load moved [million tonne.km]	901.792	901.792	901.792	901.792	901.792	901.792	901.792	901.792	901.792	901.792

>33t Articulated Road GHG Emissions [tCO$_2$e]	0	0	0	0	0	0	0	0	0	0
Rail GHG Emissions [tCO$_2$e]	23,349	22,896	21,715	20,534	19,353	18,173	16,992	15,811	14,630	13,449
Annual Scope 1 & 2 SRFI GHG Emissions [tCO$_2$e]	**23,349**	**22,896**	**21,715**	**20,534**	**19,353**	**18,173**	**16,992**	**15,811**	**14,630**	**13,449**
Cumulative Scope 1 & 2 SRFI GHG Emissions [tCO$_2$e]	**23,349**	**46,244**	**67,959**	**88,493**	**107,847**	**126,019**	**143,011**	**158,822**	**173,452**	**186,902**
>33t Articulated Road GHG Emissions [tCO$_2$e]	0	0	0	0	0	0	0	0	0	0
Rail GHG Emissions [tCO$_2$e]	6,671	6,639	6,575	6,512	6,448	6,385	6,321	6,258	6,194	6,131
Annual Scope 3 SRFI GHG Emissions [tCO$_2$e]	**6,671**	**6,639**	**6,575**	**6,512**	**6,448**	**6,385**	**6,321**	**6,258**	**6,194**	**6,131**
Cumulative Scope 3 SRFI GHG Emissions [tCO$_2$e]	**6,671**	**13,310**	**19,885**	**26,397**	**32,845**	**39,230**	**45,552**	**51,809**	**58,003**	**64,134**
Annual Total SRFI GHG Emissions [tCO$_2$e]	30,020	29,535	28,290	27,046	25,802	24,557	23,313	22,069	20,824	19,580
Cumulative Total SRFI GHG Emissions [tCO$_2$e]	30,020	59,554	87,844	114,890	140,692	165,249	188,563	210,631	231,456	251,036

Table A.6 Profiled Net Central Emissions (2019 – 2038)

Net Rail Central Emissions	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**
>33t Articulated Road GHG Emissions [tCO$_2$e]	-39,295	-38,752	-42,412	-41,651	-40,781	-39,803	-38,716	-37,521	-36,217	-34,804
Rail GHG Emissions [tCO$_2$e]	23,349	22,896	21,715	20,534	19,353	18,173	16,992	15,811	14,630	13,449
Annual Scope 1 & 2 Net GHG Emissions [tCO$_2$e]	**-15,947**	**-15,857**	**-20,697**	**-21,117**	**-21,428**	**-21,630**	**-21,724**	**-21,710**	**-21,587**	**-21,355**
Cumulative Scope 1 & 2 Net GHG Emissions [tCO$_2$e]	**-73,086**	**-88,943**	**-109,640**	**-130,756**	**-152,184**	**-173,815**	**-195,539**	**-217,249**	**-238,836**	**-260,191**
>33t Articulated Road GHG Emissions [tCO$_2$e]	-14,139	-14,101	-13,974	-13,847	-13,720	-13,593	-13,466	-13,339	-13,212	-13,085
Rail GHG Emissions [tCO$_2$e]	6,671	6,639	6,575	6,512	6,448	6,385	6,321	6,258	6,194	6,131
Annual Scope 3 Net GHG Emissions [tCO$_2$e]	**-7,469**	**-7,462**	**-7,399**	**-7,335**	**-7,272**	**-7,208**	**-7,145**	**-7,081**	**-7,017**	**-6,954**
Cumulative Scope 3 Net GHG Emissions [tCO$_2$e]	**-7,469**	**-14,931**	**-22,330**	**-29,665**	**-36,937**	**-44,145**	**-51,289**	**-58,370**	**-65,388**	**-72,342**
Annual Total Net GHG Emissions [tCO$_2$e]	-23,415	-23,319	-28,096	-28,452	-28,700	-28,839	-28,869	-28,791	-28,604	-28,309
Cumulative Net SRFI GHG Emissions [tCO$_2$e]	-23,415	-46,734	-74,830	-103,282	-131,982	-160,820	-189,689	-218,480	-247,084	-275,393

Appendix B: Profiled Emission Factors: Road

Table B.1: Vehicle Stocks, Efficiency Improvement Measures & Resulting Emission Factors (2018 – 2028)

Vehicle Stocks	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**
Total HGVs	504,864	507,836	**510,807**	513,778	516,750	519,721	522,692	**525,664**	528,635	531,607	534,578
% HGV > 18t*	146,411	147,272	**148,134**	148,996	149,857	150,719	151,581	**152,443**	153,304	154,166	155,028
% Diesel (some dual fuel)	95%	94%	**92%**	91%	90%	88%	87%	**86%**	85%	84%	82%
Diesel (including dual)	139,383	137,847	**136,283**	135,288	134,272	133,236	132,178	**131,101**	130,002	128,883	127,743
Natural Gas > 18t	2,400	3,200	**4,000**	5,600	7,200	8,800	10,400	**12,000**	14,400	16,800	19,200
Niche/ other fuels	4,628	6,225	**7,851**	8,108	8,385	8,683	9,002	**9,342**	8,902	8,483	8,085
Existing Diesel Articulated >33t	2018	2019	**2020**	2021	2022	2023	2024	**2025**	2026	2027	2028
Use of larger and longer vehicles	0.40%	0.48%	**0.56%**	0.65%	0.75%	0.86%	0.97%	**1.09%**	1.22%	1.35%	1.49%
Uptake	0.00%	0.00%	**0.00%**	7.20%	14.40%	21.60%	28.80%	**36.00%**	43.20%	50.40%	57.60%
% change in load	14%	14%	**14%**	14%	14%	14%	14%	**14%**	14%	14%	14%
% change in average load factor	0.00%	0.00%	**0.00%**	1.00%	2.00%	3.00%	4.00%	**5.00%**	6.00%	7.01%	8.01%
Loading Factor (artics>33t)	0.73	0.73	**0.73**	0.74	0.7	0.75	0.76	**0.77**	0.77	0.78	0.79
Tonnes per load	12.3703	12.37	**12.37**	12.49	12.62	12.74	12.87	**12.99**	13.11	13.24	13.36
Adjusted Emission Factor [kgCO_2e/tonne.km]	0.0774	0.0774	**0.0774**	0.0768	0.0763	0.0758	0.0753	**0.0748**	0.0743	0.0738	0.0732
General Powertrain Improvements											
Efficiency improvement % (2020 - 2030)	0.0%	0.0%	**0.0%**	0.8%	1.7%	2.5%	3.3%	**4.2%**	5.0%	5.8%	6.6%
Adjusted Emission Factor [kgCO2e/tonne.km]	0.0774	0.0774	**0.0774**	0.0767	0.0761	0.0754	0.0748	**0.0742**	0.0735	0.0729	0.0722
Low rolling resistance tyres											
Uptake	15.00%	16.75%	**18.50%**	20.25%	22.00%	23.75%	25.50%	**27.25%**	29.00%	30.75%	32.50%
% increase in fuel efficiency per uptake	5%	5%	**5%**	5%	5%	5%	5%	**5%**	5%	5%	5%
% increase in fuel efficiency	0.75%	0.84%	**0.93%**	1.01%	1.10%	1.19%	1.28%	**1.36%**	1.45%	1.54%	1.63%
Aerodynamic trailers/ bodies*											
Uptake	11.00%	11.83%	**12.67%**	13.50%	14.33%	15.17%	16.00%	**16.83%**	17.67%	18.50%	19.33%
% increase in fuel efficiency per uptake	13%	13%	**13%**	13%	13%	13%	13%	**13%**	13%	13%	13%
% increase in fuel efficiency	1.43%	1.54%	**1.65%**	1.75%	1.86%	1.97%	2.08%	**2.19%**	2.30%	2.40%	2.51%
Automatic tyre pressure adjustment											
Uptake	13.20%	14.85%	**16.50%**	18.15%	19.80%	21.45%	23.10%	**24.75%**	26.40%	28.05%	29.70%
% increase in fuel efficiency per uptake	3%	3%	**3%**	3%	3%	3%	3%	**3%**	3%	3%	3%
% increase in fuel efficiency	0.40%	0.45%	**0.50%**	0.54%	0.59%	0.64%	0.69%	**0.74%**	0.79%	0.84%	0.89%

Existing Diesel Articulated >33t (cont)	2018	2019	**2020**	2021	2022	2023	2024	**2025**	2026	2027	2028
Fuel efficiency and use of telematics											
Uptake	31.60%	34.55%	**37.50%**	40.45%	43.40%	46.35%	49.30%	**52.25%**	55.20%	58.15%	61.10%
Efficiency	1%	1%	**1%**	2%	2%	2%	2%	**2%**	2%	2%	2%
% increase in fuel efficiency	0.40%	0.48%	**0.56%**	0.65%	0.75%	0.86%	0.97%	**1.09%**	1.22%	1.35%	1.49%
Total increase in fuel efficiency	**2.98%**	**3.30%**	**3.63%**	**3.97%**	**4.31%**	**4.66%**	**5.02%**	**5.39%**	**5.76%**	**6.14%**	**6.52%**
Diesel average mpg (all artics)	7.97	8.05	**8.15**	8.28	8.43	8.62	8.83	**9.07**	9.34	9.63	9.96
Adjusted Emission Factor [kgCO_2e/tonne.km]	0.077	0.077	**0.077**	0.076	0.075	0.074	0.073	**0.072**	0.071	0.071	0.070
Biodiesel Mix											
% biodiesel	7.25%	8.50%	**9.75%**	10.10%	10.40%	10.60%	10.80%	**11.00%**	11.20%	11.40%	11.60%
Adjusted Emission Factor [kgCO_2e/tonne.km]	0.071	0.070	**0.069**	0.068	0.067	0.066	0.065	**0.064**	0.063	0.062	0.062
Natural Gas Articulated >33t (90% of diesel)											
% biogas	7.25%	8.50%	**9.75%**	10.10%	10.40%	10.60%	10.80%	**11.00%**	11.20%	11.40%	11.60%
Adjusted Emission Factor [kgCO_2e/tonne.km]	0.065	0.064	**0.064**	0.063	0.062	0.061	0.060	**0.059**	0.059	0.058	0.057
Average >33t Articulated Emission Factor	**0.071**	**0.070**	**0.068**	**0.067**	**0.066**	**0.065**	**0.064**	**0.064**	**0.063**	**0.062**	**0.061**
Upstream (Scope 3 TTW) Emission Factor	**0.022**	**0.022**	**0.022**	**0.022**	**0.022**	**0.022**	**0.022**	**0.022**	**0.022**	**0.022**	**0.022**

Table B.2: Vehicle Stocks, Efficiency Improvement Measures & Resulting Emission Factors (2029 – 2038)

Vehicle Stocks	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**
Total HGVs	537,549	**540,521**	543,492	546,463	549,435	552,406	555,378	558,349	561,320	564,292
% HGV > 18t	155,889	**156,751**	157,613	158,474	159,336	160,198	161,060	161,921	162,783	163,645
% Diesel (some dual fuel)	81%	**80%**	76%	72%	68%	64%	60%	56%	52%	48%
Diesel (including dual)	126,582	**125,401**	119,786	114,102	108,349	102,527	96,636	90,676	84,647	78,549
Natural Gas > 18t	21,600	**24,000**	27,050	30,100	33,150	36,200	39,250	42,300	45,350	48,400
Niche/ other fuels	7,707	**7,350**	10,777	14,273	17,838	21,471	25,174	28,945	32,786	36,695
Existing Diesel Articulated >33t	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**
Use of larger and longer vehicles										
Uptake	64.80%	**72%**	72%	72%	72%	72%	72%	72%	72%	72%
% change in load	**14%**	**14%**	14%	14%	14%	14%	14%	14%	14%	14%
% change in average load factor	9.01%	10.01%	10.01%	10.01%	10.01%	10.01%	10.01%	10.01%	10.01%	10.01%
Loading Factor (artics>33t)	0.796	0.803	0.803	0.803	0.803	0.803	0.803	0.803	0.803	0.803
Tonnes per load	13.48	13.61	13.61	13.61	13.61	13.61	13.61	13.61	13.61	13.61
Adjusted Emission Factor [kgCO_2e/tonne.km]	0.0727	0.0722	0.0722	0.0722	0.0722	0.0722	0.0722	0.0722	0.0722	0.0722

Existing Diesel Articulated >33t	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**
General Powertrain Improvements										
Efficiency improvement % (2020 - 2030)	7.5%	8.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Adjusted Emission Factor [kgCO_2e/tonne.km]	0.0716	0.0709	0.0709	0.0709	0.0709	0.0709	0.0709	0.0709	0.0709	0.0709
Low rolling resistance tyres										
Uptake	34.25%	**36.00%**	39.20%	42.40%	45.60%	48.80%	52.00%	55.20%	58.40%	61.60%
% increase in fuel efficiency per uptake	**5%**	**5%**	**5%**	**5%**	**5%**	**5%**	**5%**	**5%**	**5%**	**5%**
% increase in fuel efficiency	1.71%	1.80%	1.96%	2.12%	2.28%	2.44%	2.60%	2.76%	2.92%	3.08%
Aerodynamic trailers/ bodies*										
Uptake	20.17%	**21%**	25%	29%	33%	37%	41%	45%	49%	53%
% increase in fuel efficiency per uptake	**13%**	**13%**	**13%**	**13%**	**13%**	**13%**	**13%**	**13%**	**13%**	**13%**
% increase in fuel efficiency	2.62%	2.73%	3.24%	3.76%	4.27%	4.78%	5.30%	5.81%	6.32%	6.84%
Automatic tyre pressure adjustment										
Uptake	31.35%	**33%**	36%	40%	43%	46%	50%	53%	56%	60%
% increase in fuel efficiency per uptake	**3%**	**3%**	**3%**	**3%**	**3%**	**3%**	**3%**	**3%**	**3%**	**3%**
% increase in fuel efficiency	0.94%	0.99%	1.09%	1.19%	1.29%	1.39%	1.49%	1.59%	1.69%	1.79%
Fuel efficiency and use of telematics										
Uptake	64.05%	67.00%	68.65%	70.30%	71.95%	73.60%	75.25%	76.90%	78.55%	80.20%
Efficiency	3%	**3%**	**3%**	**3%**	**3%**	**3%**	**3%**	**3%**	**3%**	**3%**
% increase in fuel efficiency	1.64%	1.80%	1.89%	1.98%	2.07%	2.17%	2.27%	2.37%	2.47%	2.57%
Total increase in fuel efficiency	**6.92%**	**7.32%**	**8.18%**	**9.04%**	**9.91%**	**10.78%**	**11.66%**	**12.53%**	**13.41%**	**14.28%**
Diesel average mpg (all artics)	10.32	10.72	11.18	11.71	12.30	12.97	13.71	14.51	15.38	16.33
Adjusted Emission Factor [kgCO_2e/tonne.km]	0.0690	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682
Biodiesel Mix										
% biodiesel	11.80%	12.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Adjusted Emission Factor [kgCO_2e/tonne.km]	0.0608	0.0600	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682
Natural Gas Articulated >33t (90% of diesel)	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**
% biogas	11.80%	12.00%	16.40%	20.80%	25.20%	29.60%	34.00%	38.40%	42.80%	47.20%
Adjusted Emission Factor [kgCO_2e/tonne.km]	0.0565	0.0558	0.0537	0.0516	0.0496	0.0475	0.0454	0.0433	0.0413	0.0392
Average >33t Articulated Emission Factor	**0.0600**	**0.0592**	**0.0648**	**0.0636**	**0.0623**	**0.0608**	**0.0591**	**0.0573**	**0.0553**	**0.0531**
Upstream (Scope 3 TTW) Emission Factor	**0.0216**	**0.0215**	**0.0213**	**0.0211**	**0.0209**	**0.0208**	**0.0206**	**0.0204**	**0.0202**	**0.0200**

Table B.3 Vehicle Stocks, Efficiency Improvement Measures & Resulting Emission Factors (2039 – 2050)

Vehicle Stocks	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**
Total HGVs	567263	570234	573206	576177	579149	582120	585091	588063	591034	594006	596977	600000
% HGV > 18t	164,506	165,368	166,230	167,091	167,953	168,815	169,677	170,538	171,400	172,262	173,123	**174,000**
% Diesel (some dual fuel)	44%	40%	36%	32%	28%	24%	20%	16%	12%	8%	4%	**0%**
Diesel (including dual)	72,383	66,147	59,843	53,469	47,027	40,516	33,935	27,286	20,568	13,781	6,925	**0**
Natural Gas > 18t	51,450	54,500	57,550	60,600	63,650	66,700	69,750	72,800	75,850	78,900	81,950	**85,000**
Niche/ other fuels	40,674	44,721	48,837	53,022	57,276	61,599	65,991	70,452	74,982	79,581	84,248	89,000
Existing Diesel Articulated >33t	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**
Use of larger and longer vehicles												
Uptake	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
% change in load	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%
% change in average load factor	10.01%	10.01%	10.01%	10.01%	10.01%	10.01%	10.01%	10.01%	10.01%	10.01%	10.01%	10.01%
Loading Factor (artics>33t)	0.803	0.803	0.803	0.803	0.803	0.803	0.803	0.803	0.803	0.803	0.803	0.803
Tonnes per load	13.61	13.61	13.61	13.61	13.61	13.61	13.61	13.61	13.61	13.61	13.61	13.61
Adjusted Emission Factor [kgCO_2e/tonne.km]	0.0722	0.0722	0.0722	0.0722	0.0722	0.0722	0.0722	0.0722	0.0722	0.0722	0.0722	0.0722
General Powertrain Improvements												
Efficiency improvement % (2020 - 2030)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Adjusted Emission Factor [kgCO_2e/tonne.km]	0.0709	0.0709	0.0709	0.0709	0.0709	0.0709	0.0709	0.0709	0.0709	0.0709	0.0709	0.0709
Low rolling resistance tyres												
Uptake	64.80%	68.00%	71.20%	74.40%	77.60%	80.80%	84.00%	87.20%	90.40%	93.60%	96.80%	100%
% increase in fuel efficiency per uptake	**5%**	**5%**	**5%**	**5%**	**5%**	**5%**	**5%**	**5%**	**5%**	**5%**	**5%**	**5%**
% increase in fuel efficiency	3.24%	3.40%	3.56%	3.72%	3.88%	4.04%	4.20%	4.36%	4.52%	4.68%	4.84%	5.00%
Aerodynamic trailers/ bodies*												
Uptake	57%	61%	64%	68%	72%	76%	80%	84%	88%	92%	96%	100%
% increase in fuel efficiency per uptake	**13%**	**13%**	**13%**	**13%**	**13%**	**13%**	**13%**	**13%**	**13%**	**13%**	**13%**	**13%**
% increase in fuel efficiency	7.35%	7.87%	8.38%	8.89%	9.41%	9.92%	10.43%	10.95%	11.46%	11.97%	12.49%	13.00%
Automatic tyre pressure adjustment												
Uptake	63%	67%	70%	73%	77%	80%	83%	87%	90%	93%	97%	100%
% increase in fuel efficiency per uptake	**3%**	**3%**	**3%**	**3%**	**3%**	**3%**	**3%**	**3%**	**3%**	**3%**	**3%**	**3%**
% increase in fuel efficiency	1.89%	2.00%	2.10%	2.20%	2.30%	2.40%	2.50%	2.60%	2.70%	2.80%	2.90%	3.00%
Fuel efficiency and use of telematics												
Uptake	81.85%	83.50%	85.15%	86.80%	88.45%	90.10%	91.75%	93.40%	95.05%	96.70%	98.35%	100%
Efficiency	**3%**	**3%**	**3%**	**3%**	**4%**	**4%**	**4%**	**4%**	**4%**	**4%**	**4%**	**4%**
% increase in fuel efficiency	2.68%	2.79%	2.90%	3.01%	3.13%	3.25%	3.37%	3.49%	3.61%	3.74%	3.87%	4.00%

Existing Diesel Articulated >33t	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Total increase in fuel efficiency	**15.17%**	**16.05%**	**16.93%**	**17.82%**	**18.71%**	**19.60%**	**20.50%**	**21.39%**	**22.29%**	**23.19%**	**24.10%**	**25.00%**
Diesel average mpg (all artics)	17.34	18.42	19.57	20.80	22.09	23.45	24.88	26.39	27.96	29.61	31.33	33.12
Adjusted Emission Factor [kgCO_2e/tonne.km]	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682
Biodiesel Mix												
% biodiesel	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Adjusted Emission Factor [kgCO_2e/tonne.km]	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682	0.0682
Natural Gas Articulated >33t (90% of diesel)												
% biogas	51.60%	56.00%	60.40%	64.80%	69.20%	73.60%	78.00%	82.40%	86.80%	91.20%	95.60%	100%
Adjusted Emission Factor [kgCO_2e/tonne.km]	0.0371	0.0351	0.0330	0.0309	0.0288	0.0268	0.0247	0.0226	0.0205	0.0185	0.0164	0.0143
Average >33t Articulated Emission Factor	**0.0508**	**0.0483**	**0.0457**	**0.0429**	**0.0399**	**0.0367**	**0.0334**	**0.0299**	**0.0263**	**0.0225**	**0.0185**	**0.0143**
Upstream (Scope 3 TTW) Emission factor	**0.0198**	**0.0196**	**0.0194**	**0.0192**	**0.0190**	**0.0188**	**0.0186**	**0.0184**	**0.0182**	**0.0180**	**0.0178**	**0.0176**

Appendix C: Profiled Emission Factors - Rail

Table C.1: Impact of Increased Electric Traction on Emission Factors (2018 – 2028)

30% Electric by 2030 & 80% by 2040	2015/16	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Electricity [million kWh]	58.40	58.40	58.40	58.40	58.40	87.60	116.80	146.00	175.20	204.40	233.60	262.80	292.00
Diesel non-forecourt [million litres]	203.90	203.90	203.90	203.90	203.90	198.53	193.17	187.80	182.44	177.07	171.71	166.34	160.97
Proportion Electric Traction	5%	5%	5%	5%	5%	8%	10%	13%	15%	17%	20%	23%	25%
Proportion Diesel Traction	95%	95%	95%	95%	95%	92%	90%	88%	85%	83%	80%	77%	75%
Freight distance [million km]	33.98	33.98	33.98	33.98	33.98	33.98	33.98	33.98	33.98	33.98	33.98	33.98	33.98
Freight moved (million tonne.km)	17,250	17,250	17,250	17,250	17,250	17,250	17,250	17,250	17,250	17,250	17,250	17,250	17,250
Calculated Emission Factors													
Electricity [ktCO_2e]	16.496	12.461	11.971	11.368	10.564	14.969	17.265	21.062	26.298	28.778	26.681	31.370	31.649
Non-forecourt diesel [ktCO_2e]	545.677	544.807	544.807	544.807	544.807	530.470	516.133	501.796	487.459	473.122	458.785	444.448	430.111
Total Scope 1 & 2 Emissions [ktCO_2e]	**562.173**	**557.268**	**556.777**	**556.175**	**555.371**	**545.439**	**533.397**	**522.858**	**513.757**	**501.900**	**485.466**	**475.818**	**461.759**
Emission Factor [kgCO_2e/tonne.km]	**0.0326**	**0.0323**	**0.0323**	**0.0322**	**0.0322**	**0.0316**	**0.0309**	**0.0303**	**0.0298**	**0.0291**	**0.0281**	**0.0276**	**0.0268**
WTT Diesel [ktCO_2e]	112.687	127.572	127.572	127.572	127.572	124.215	120.858	117.501	114.143	110.786	107.429	104.072	100.715
T&D Electricity [ktCO_2e]	2.177	1.920	1.920	1.920	1.920	2.879	3.839	4.799	5.759	6.719	7.678	8.638	9.598
WTT Electricity Generation [ktCO_2e]	3.614	3.273	3.273	3.273	3.273	4.910	6.547	8.183	9.820	11.457	13.093	14.730	16.367
WTT Electricity T&D [ktCO_2e]	0.327	0.306	0.306	0.306	0.306	0.459	0.612	0.765	0.918	1.071	1.224	1.377	1.530
Total Scope 3 Emissions [ktCO_2e]	**118.805**	**133.071**	**133.071**	**133.071**	**133.071**	**132.463**	**131.856**	**131.248**	**130.640**	**130.033**	**129.425**	**128.817**	**128.210**
Emission Factor [kgCO2e/tonne.km]	**0.0069**	**0.0077**	**0.0077**	**0.0077**	**0.0077**	**0.0077**	**0.0076**	**0.0076**	**0.0076**	**0.0075**	**0.0075**	**0.0075**	**0.0074**

Table C.2: Impact of Increased Electric Traction on Emission Factors (2028 – 2040)

30% Electric by 2030 & 80% by 2040	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2029**
Electricity [million kWh]	321.20	350.40	408.80	467.20	525.60	584.00	642.40	700.80	759.20	817.60	876.00	934.40	321.20
Diesel non-forecourt [million litres]	155.61	150.24	139.51	128.78	118.05	107.32	96.58	85.85	75.12	64.39	53.66	42.93	155.61
Proportion Electric Traction	27%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	27%
Proportion Diesel Traction	73%	70%	65%	60%	55%	50%	45%	40%	35%	30%	25%	20%	73%
Freight distance [million km]	33.98	33.98	33.98	33.98	33.98	33.98	33.98	33.98	33.98	33.98	33.98	33.98	33.98
Freight moved (million tonne.km)	17,250	17,250	17,250	17,250	17,250	17,250	17,250	17,250	17,250	17,250	17,250	17,250	17,250
Calculated Emission Factors													
Electricity [ktCO_2e]	30.856	36.525	42.612	48.699	54.787	60.874	66.962	73.049	79.136	85.224	91.311	97.399	30.856
Non-forecourt diesel [ktCO_2e]	415.774	401.437	372.763	344.089	315.415	286.741	258.066	229.392	200.718	172.044	143.370	114.696	415.774
Total Scope 1 & 2 Emissions [ktCO_2e]	**446.629**	**437.961**	**415.375**	**392.788**	**370.201**	**347.615**	**325.028**	**302.441**	**279.855**	**257.268**	**234.682**	**212.095**	**446.629**
Emission Factor [kgCO_2e/tonne.km]	**0.0259**	**0.0254**	**0.0241**	**0.0228**	**0.0215**	**0.0202**	**0.0188**	**0.0175**	**0.0162**	**0.0149**	**0.0136**	**0.0123**	**0.0259**
WTT Diesel [ktCO_2e]	97.358	94.000	87.286	80.572	73.858	67.143	60.429	53.715	47.000	40.286	33.572	26.857	97.358
T&D Electricity [ktCO_2e]	10.558	11.518	13.437	15.357	17.276	19.196	21.116	23.035	24.955	26.875	28.794	30.714	10.558
WTT Electricity Generation [ktCO_2e]	18.003	19.640	22.913	26.187	29.460	32.733	36.007	39.280	42.553	45.826	49.100	52.373	18.003
WTT Electricity T&D [ktCO_2e]	1.683	1.836	2.142	2.448	2.754	3.060	3.366	3.672	3.978	4.284	4.590	4.896	1.683
Total Scope 3 Emissions [ktCO_2e]	**127.602**	**126.994**	**125.779**	**124.563**	**123.348**	**122.133**	**120.917**	**119.702**	**118.487**	**117.271**	**116.056**	**114.840**	**127.602**
Emission Factor [kgCO_2e/tonne.km]	**0.0074**	**0.0074**	**0.0073**	**0.0072**	**0.0072**	**0.0071**	**0.0070**	**0.0069**	**0.0069**	**0.0068**	**0.0067**	**0.0067**	**0.0074**

Appendix D: Profiled Emission Factors – Fuel & Electricity Inputs

Table D.1: Emission Factors for Fuel & Electricity Inputs

Emission Factors	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
BEIS Electricity[1] [kgCO_2e/kWh]	*0.4455*	*0.4943*	*0.4622*	*0.4121*	*0.3516*	-	-	-	-	-	-	-	-	-	-	-
BEIS Electricity[2] (real-time) [kgCO_2e/kWh]	*0.4622*	*0.4121*	*0.3516*	-	-	-	-	-	-	-	-	-	-	-	-	-
EEP 2015[2] [kgCO_2e/kWh]	-	-	*0.4220*	*0.3511*	*0.3003*	*0.2903*	*0.2728*	*0.2430*	*0.2140*	*0.1971*	*0.1678*	*0.1763*	*0.1652*	*0.1468*	*0.1452*	*0.1218*
EEP 2017[3] [kgCO_2e/kWh]	-	-	-	-	*0.2134*	*0.2050*	*0.1947*	*0.1809*	*0.1709*	*0.1478*	*0.1443*	*0.1501*	*0.1408*	*0.1142*	*0.1194*	*0.1084*
Applied Electricity [kgCO_2e/kWh]	0.4622	0.4121	0.3516	0.2824[5]	0.2134	0.2050	0.1947	0.1809	0.1709	0.1478	0.1443	0.1501	0.1408	0.1142	0.1194	0.1084
Diesel (non-forecourt) [kgCO_2e/litre]	2.6705	2.6691	2.6761	2.6762	2.6719	2.6719	2.6719	2.6719	2.6719	2.6719	2.6719	2.6719	2.6719	2.6719	2.6719	2.6719
WTT Diesel	0.5677	0.5785	0.5796	0.55266	0.6257	0.6257	0.6257	0.6257	0.6257	0.6257	0.6257	0.6257	0.6257	0.6257	0.6257	0.6257
T&D Electricity [kgCO_2e/kWh]	0.0381	0.0432	0.0382	0.03727	0.0329	0.0329	0.0329	0.0329	0.0329	0.0329	0.0329	0.0329	0.0329	0.0329	0.0329	0.0329
WTT Electricity Generation [kgCO2e/kWh]	0.0703	0.0753	0.0689	0.06188	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561
WTT Electricity T&D [kgCO_2e/kWh]	0.0060	0.0066	0.0057	0.0056	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052
WTT CNG/LNG [tonne.km]	-	-	-	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176
WTT diesel [tonne.km]	-	-	-	0.0225	0.0225	0.0225	0.0225	0.0225	0.0225	0.0225	0.0225	0.0225	0.0225	0.0225	0.0225	0.0225

Emission Factors	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
EEP 2015 [kgCO_2e/kWh]	*0.1065*	*0.1027*	*0.0969*	*0.0915*	*0.0787*	*0.0777*	*0.0646*	*0.0646*	*0.0646*	*0.0646*	*0.0646*	*0.0646*
EEP 2017 [kgCO_2e/kWh]	*0.0961*	*0.1042*	*0.0955*	*0.0777*	*0.0745*	*0.0665*	*0.0550*	*0.0550*	*0.0550*	*0.0550*	*0.0550*	*0.0550*
Applied Electricity [kgCO_2e/kWh]	0.0961	0.1042	0.1042	0.1042	0.1042	0.1042	0.1042	0.1042	0.1042	0.1042	0.1042	0.1042
Diesel (non-forecourt) [kgCO_2e/litre]	2.6719	2.6719	2.6719	2.6719	2.6719	2.6719	2.6719	2.6719	2.6719	2.6719	2.6719	2.6719
WTT Diesel	0.6257	0.6257	0.6257	0.6257	0.6257	0.6257	0.6257	0.6257	0.6257	0.6257	0.6257	0.6257
T&D Electricity [kgCO_2e/kWh]	0.0329	0.0329	0.0329	0.0329	0.0329	0.0329	0.0329	0.0329	0.0329	0.0329	0.0329	0.0329
WTT Electricity Generation [kgCO2e/kWh]	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561	0.0561
WTT Electricity T&D [kgCO_2e/kWh]	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052
WTT CNG/LNG [tonne.km]	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176
WTT diesel [tonne.km]	-	-	-	0.0225	0.0225	0.0225	0.0225	0.0225	0.0225	0.0225	0.0225	0.0225

[1] As reported in the relevant year for the purposes of company reporting

[2] BEIS emission factors for company reporting run two years behind (i.e. 2017 figures relate to 2015 emissions). These figures have been adjusted to reflect emission factors in real time.

[3] & [4] Energy & Emissions Projections (EEP) taken from Figure 5.2 https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2017

[5] A figure for 2016 has been estimated based on the emissions trajectory

Appendix E: Rail Freight Operator Rolling Stock

Table E.1: GB Railfreight Rolling Stock

Class	Type	Built	Number	Age
Class 08	Shunter	1953	2	65
Class 09	Shunter	1959	2	59
Class 20	Diesel locomotive	1957-1968	11	56
Class 59	Diesel locomotive	1985	1	33
Class 66	Diesel locomotive	2000-2015	78	11
Class 73	Electro-diesel locomotive	1962, 1965-7	22	54
Class 92	Electric locomotive	1993-1996	16	24
Vanguard 0-6-0DH	Diesel locomotive	2011	2	7
Average Age	-	-	**64**	**39.7**

Table E.2: Colas Rolling Stock

Class	Type	Built	Number	Age
Class 37	Diesel locomotive	1960-1965	8	56
Class 56	Diesel locomotive	1976-84	7	38
Class 60	Diesel locomotive	1989	10	29
Class 66	Diesel locomotive	1998-2015	5	12
Class 67	Diesel locomotive	1999-2000	2	3
Class 70	Diesel locomotive	2014, 2016-17	17	3
Average Age	-	-	**49**	**22.9**

Table E.3: Direct Rail Services Rolling Stock

Class	Type	Built	Number	Age
Class 37	Diesel locomotive	1960 -1965	21	56
Class 57	Diesel locomotive	1998-2004	21	17
Class 66	Diesel locomotive	2002 -2008	19	13
Class 68	Diesel-electric	2013 – 2017	12	12
Class 88	Bi-mode	2015 -2017	10	3
Average Age	-	-	**83**	**23.5**

Table E.4: Freightliner Rolling Stock

Class	Type	Built	Number	Age
Class 47	Diesel locomotive	1953	1	65
Class 66	Diesel locomotive	1965	127	53
Class 70	Diesel locomotive	1999	19	19
Class 86	Electric locomotive	2009	16	9
Class 90	Electric locomotive	1987	10	31
Average Age	-	-	**173**	**44**

Appendix F: MDS Intermodal Mode Shift

MODE SHIFT AND GREENHOUSE GAS EMISSIONS BENEFITS AT RAIL CENTRAL

This technical note describes the methodology adopted to estimate the level of *mode shift* likely to be generated by the *Rail Central SRFI* and the associated reductions in *greenhouse gas (GHG)* emissions. The outputs for both are subsequently presented.

Environmental benefits are one of the 'drivers of need for SRFIs' identified by the *National Planning Statement for National Networks* (NPS, Section 4). It notes that modal transfer from road to rail has an important part to play in reducing GHG emissions and addressing climate change It is therefore important to demonstrate that the proposed *Rail Central SRFI* at Milton Malsor will lead to an overall reduction in the level of cargo moved by road, thereby generating wider mode shift benefits, including a reduction in GHG emissions. However, before estimating mode shift, two important concepts need to be understood.

Background – Measuring Mode Shift

The first refers to how mode shift is 'measured' or quantified. The recognised measure of mode shift adopted by planners and economists when undertaking transport appraisals is to ***estimate the overall reduction in road vehicle-km resulting from a scheme when compared with a 'baseline' or 'do-nothing' comparator scenario***. This subsequently allows the national benefits to be demonstrated in sustainability terms, for example by equating the reduction in vehicle-km as GHG emissions savings or into some form of monetised environmental benefit.

Consider the current *Mode Shift Revenue Support (MSRS)*[1] freight grant scheme operated by the *Department for Transport (DfT)* or the former *Freight Facilities Grants*[2] scheme. The value of grants under these schemes is partly derived from the environmental benefits generated, and these in turn are estimated by considering both the number of HGVs transferring to rail and the distances those HGVs would have travelled i.e. reduction in HGV-km when compared with a road-only comparator. Similarly, the DfT's WebTAG[3] system specifies that a proposal for a new passenger railway station should be appraised by considering the number of passengers transferring from cars to trains due to the new station and also the distances those cars would have travelled i.e. reduction in passenger-km by car when compared with the existing no-station comparator.

This contrasts with an approach which measures a simple road/rail split in terms of units or tonnes-lifted, which is unable to fully quantify the wider global benefits of mode shift. In the case of Rail Central, therefore, the appropriate mode shift 'measure' will be the overall reduction in HGV-km resulting from the scheme when compared with an alternative *comparator scenario*.

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[1] A grant scheme which effectively provides a subsidy to shippers under limited defined circumstances when switching unit load freight to rail from road transport.
[2] A scheme which used to provide capital grant contributions for new rail freight terminals.
[3] Transport Appraisal Guidance – guidance when undertaking appraisals of new transport schemes.

Background – Comparator Scenario

The second concept concerns the development of new-build warehousing. Over the past 25-30 years, around one million square metres of new warehouse floor space has been built annually in Great Britain (taking a long-term trend to smooth out years of high and low building activity). However, the total 'stock' of floor space nationally has not grown by a similar level, the amount of freight handled has not increased by a proportionate quantity and all the major retailers, their suppliers and appointed third-party logistics companies already operate multiple warehouse facilities nationwide. This apparent anomaly can essentially be explained by a combination of three main reasons.

Firstly, a significant proportion of new-build warehousing is simply replacing existing capacity, which has become life-expired or reached the end of its useful economic life, on a like-for-like basis. This can include older warehouse stock which has become physically obsolete and therefore needs to be demolished. More recently, whilst many buildings are still in good physical condition many have become functionally obsolete. This includes units originally designed to distribute consignments in full HGV-loads solely to other distribution centres or retail outlets, but are unable to handle growing demand for e-commerce (difficult/impossible to retro-fit the automated stock handling equipment required in such facilities). Alongside this, distributors have commissioned large single warehouse units to replace multiple smaller units, thereby generating economies of scale. This has been made possible by advances in ICT inventory management systems which have permitted much larger warehouses to be operated more efficiently than was previously the case.

Secondly, growth in the general economy over time generates increasing retail sales. This in turn generates growth in freight traffics, which subsequently drives a demand for additional floor space to handle that traffic (cargo throughput is broadly directly related to floor space). Existing warehouse buildings therefore 'fill-up', and occupiers require new facilities in order to handle additional cargo. In addition, the growth of imports (at the expense of domestic production) has created a need for additional floor space to hold goods which were previously stored at domestic production sites. Commercial reorganisation, consolidation or take-over can also radically expand the volume of goods to be distributed through a single location. Finally, as market conditions change, sites which were previously competitive locations for warehousing gradually can become less attractive to the logistics market.

Thirdly, freight traffic derives from demand within the wider economy for goods and services. Consequently, new-build warehousing in itself (as described) does not therefore generate additional freight traffic beyond that already moving across transport networks. Instead, it simply changes the routes over which that cargo flows and where it is handled/stored. Likewise, traffic growth over the long run is a function of wider economic growth and other society trends. Consequently, for the purposes of assessing mode shift under a comparator scenario, SRFIs such as Rail Central are assumed to result in the transfer of existing cargo flows, which hitherto have been handled/stored at non rail-served sites (i.e. by road), to locations where there is the option of using rail freight direct.

It is this concept which under-pins mode shift and generates the wider benefits which are key to the Government's case for SRFIs.

The south Midlands region is a key location for large warehousing serving a national hinterland, but at the same time has attracted significant units serving the regional market. Given this and the continual process of warehouse renewal as described, this implies that in the event Rail Central SRFI is not developed, the freight concerned would continue to flow into and out of the immediate south Midlands region, and that instead it would be handled at other warehouse facilities, most likely located at sites which are not rail-served.

This subsequently suggests a *comparator scenario* involving the same quantum of warehousing floor space that is planned for Rail Central, but instead being constructed on non rail-linked sites within the same sub-regional market. This could include distributing that floor space across several established B8 sites in the wider Northampton area. This assumption of equivalent supply provision within the south Midlands region is purely made for the purposes of devising the comparator scenario, with no assessment of the likeliness of this occurring. However, the *comparator scenario* has therefore been taken to be a road-only based scheme at the same location i.e. the same quantum of floor space. This is simplest comparator to explain and model (see below) and it allows a direct comparison to be made between road-only and rail-served schemes at the same location. The same volume of cargo that can be expected to pass through the warehousing will also be assumed, albeit that it will all arrive or depart by road. Mode shift will be generated when the Rail Central SRFI can be shown to result in a significant reduction in HGV-km compared with this road only comparator.

Mode Shift Estimate

The starting point for the mode-shift assessment is therefore the Rail Central SRFI traffic forecasts by mode that have already been produced. The table below summarises these forecasts. The underlying basis of these forecasts is that the large scale warehouse units planned for Rail Central will receive, store and then re-distribute finished consumer cargo. As Rail Central will be developed from the outset as a SRFI, the rail terminal can be expected to handle a significant proportion of the inbound and outbound cargo. Therefore both road haulage and intermodal rail freight will be utilised for inbound and outbound flows. The *MDS Transmodal GB Freight Model* was utilised to estimate the likely road-rail modal split.

The methodology by which these forecasts were produced (including cargo throughput, turnover rates, backloads and warehouse cargo origins/destinations) has been previously agreed with Highways England and Northants County Council, and they have subsequently been adopted by TPA as part of their highway and junction capacity modelling work.

Table 1: Forecast HGV and Rail Traffic at Rail Central SRFI (per day)

Inbound	Units	Outbound	Units
HGVs			
Loaded to warehouses	1,633	Loaded from warehouses - backload	408
Empty to warehouses	1,415	Loaded from warehouses - empty inbound	1,415
Loaded to intermodal terminal	165	Empty from warehouses - loaded inbound	1,225
Empty to intermodal terminal	124	Loaded from intermodal terminal	165
		Empty from intermodal terminal	124
Total HGVs	***3,336***	***Total HGVs***	***3,336***
Rail			
Loaded to warehouses	295	Loaded from warehouses	105
Empty to warehouses	15	Empty from warehouses	182
Loaded for off-site	165	Loaded from off-site	165
Empty for off-site	23	Empty from off-site	46
Total Rail	***498***	***Total Rail***	***498***

Source: GB Freight Model

Derived from the *GB Freight Model*, an origin/destination matrix was also produced estimating the likely origins and destinations of the forecast inbound and outbound HGVs presented in the table above (this was subsequently supplied to TPA for assignment in their own highway model). This origin/destination matrix describes forecast daily HGV numbers by Post Code District (PCD) to and from Rail Central; it reflects the current distribution of cargo nationally to and from the wider Northampton area.

One of the components of the *GB Freight Model* is a road assignment model, which allows generated HGV numbers between origin/destination PCDs to be assigned onto specific routes on the national highway network. Using this tool, the road distances between Rail Central and each origin/destination PCD can be established, thereby allowing the annual HGV-km associated with the forecast inbound and outbound HGVs described in the table above to be calculated.

The above process was repeated for the comparator scenario, the only difference being that all the cargo passing through the warehousing or terminal will arrive or depart by road i.e. the rail traffics described above will instead move by road haulage (for the actual forecasts, the estimated the number of units likely to directly arrive/depart by rail freight were subsequently deducted from the road traffics). As noted above, the same quantum of floor space planned for the Rail Central SRFI has been adopted in the comparator scenario. Likewise, the same baseline assumptions with respect to cargo throughput, turnover rates, backloads and warehouse cargo origins/destinations were also adopted. Daily HGV numbers, inbound and outbound, were subsequently modelled and an origin/destination matrix was produced by the GB Freight Model, again showing daily number of HGVs by PCD to and from Rail Central. As per above, this was also assigned to the national highway network using the GB Freight Model's road assignment model, and the annual HGV-km associated with the comparator scenario was subsequently calculated. The results for both processes are shown in the table below.

Table 2: Forecast HGV-kilometres for Rail Central SRFI and Road-Only Comparator

	Daily HGV-km	Annual HGV-km (000s)*
Rail Central SRFI	626,790	209,975
Road-only comparator	784,842	262,922
Change	-158,052	-52,947
(%)	(-20.1%)	(-20.1%)

Source: GB Freight Model

** Assumes 335 operating days per annum, as per traffic forecast assumptions*

It is therefore estimated that the proposed Rail Central SRFI would lead to a reduction of just under 53 million HGV-km per annum when compared with a road-only connected development with the same quantum of floor space at the same location. This is approximately a 20% reduction. The current Mode Shift Benefit value used by the DfT to value its MSRS grants are £0.36 per HGV-km on a weighted average basis. This implies that Rail Central SRFI will generate around £19 million of wider environmental benefits per annum.

Reducing Greenhouse Gas Emissions

The strategic case for SRFIs is partly based on the widely accepted principal that rail freight generates less impact on the wider environment and produces fewer GHG emissions when compared with moving goods by road transport (the environmental 'driver of need'). As a result, the mode shift estimated above should result in lower GHG emissions when compared with the comparator scenario.

The *Department for Business, Energy and Industrial Strategy (BEIS)* publishes conversion factors for use by organisations when quantifying and reporting their GHG emissions[4]. These conversion factors allow the consumption of hydrocarbon fuels (e.g. diesel in HGVs or railway locomotives, or coal/gas used to generate electricity) to be converted into kilograms of carbon dioxide equivalent (CO_2e)[5]

[4] https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2016

[5] Greenhouse gases include carbon dioxide(CO_2), methane (CH_4) and nitrous oxide (N_2O). The 'radiative forcing' of each gas is converted into an equivalent amount of CO_2 required to produce the same effect. The unit used is kilograms of carbon dioxide equivalent or CO_2e

greenhouse gas emissions. The latest conversion factors and reporting methodology (October 2016) are as follows with respect to road and rail freight transport:

- Diesel articulated HGVs (average laden) – 1.20856kg of CO_2e per HGV-km (comprising direct emissions of 1.00031kg of CO_2e per HGV-km plus 'well-to-tank' emissions of 0.20825kg of CO_2e per HGV-km); and
- Rail freight – 0.03551kg of CO_2e per tonne-km (comprising direct emissions of 0.02950kg of CO_2e per tonne-km plus 'well-to-tank' emissions of 0.00601kg of CO_2e per tonne-km)

Total annual GHG emissions (kg of CO_2e) associated with the road and rail freight flows at Rail Central SRFI and road freight the comparator scenario have subsequently been estimated. The following methodology has been adopted:

- The annual HGV-km for the proposed Rail Central SRFI and the road-only comparator (as calculated) converted to kilograms of CO_2e using the BEIS conversion factor of 1.20856kg of CO_2e per HGV-km (as per above);
- Annual rail freight tonne-km established for the proposed Rail Central SRFI using the GB Freight Model's rail assignment module. In a similar manner to the road assignment model, O/D rail flows can be assigned to specific routes on the national railway network, thereby allowing the distance over which the forecast rail traffics move to be established. This has then been multiplied by 10.6 tonnes per unit to estimate the annual rail tonne-km (derived from DfT Port Statistics which shows 10.6 tonnes per 40ft maritime container);
- Rail freight tonne-km (goods moved) converted to kilograms of CO_2e using the BEIS conversion figure 0.03551kg of CO_2e per tonne-km (as per above);
- The total emissions of greenhouse gases for the proposed Rail Central SRFI established by adding together the road haulage and rail freight emissions; and
- Total emissions for the proposed Rail Central SRFI compared with the road-only comparator

The results of this analysis are presented in the table below. Essentially, the proposed SRFI scheme generates significant modal shift and produces fewer emissions of greenhouse gases compared with road-only based scheme at the same location (reduction of 36.5 million kg CO2e per annum or 11.5% at Rail Central SRFI).

Table 3: Estimated Annual GHG Emissions at Rail Central SRFI and Comparator Scenario

		per annum
	HGV-km (000s)	GHG Emissions (000s kg of CO_2e)
Road		
Rail Central SRFI (a)	209,975	253,767
Road-only comparator (b)	262,922	317,757

		per annum
	Tonne-km (000s)	GHG Emissions (000s kg of CO_2e)
Rail		
Rail Central SRFI (c)	773,060	27,451
Road-only comparator	NA	NA

	per annum
	GHG Emissions (000s kg of CO_2e)
Total	
Rail Central SRFI (a+c)	281,218
Road-only comparator (b)	317,757
Change	-36,539
(%)	(-11.5%)

Source: GB Freight Model and BEIS Conversion Factors 2017

Rail tonne-km assumes of 72.9 million unit-km per annum (as estimated by the GB Freight Model) and an average loading of 10.6 tonnes per unit (derived from DfT Port Statistics and including empty units)

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