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Lumo & Hull Trains Carbon Calculator

Assumptions to accompany data tables

09/01/2024

Overview

This is a technical assumptions note that sets out the emission factors and calculation methodology used to develop the underlying data for the Lumo & Hull Trains Carbon Calculator.

Data on emissions factors for rail, underground, car and flights have been used and all sources are documented. Data from the Department for Business, Energy and Industrial Strategy (BEIS) has informed the emission factors for certain legs of the rail journeys, underground and car. First Rail owned data has been used to calculate the emission factors for the rail journeys on the Lumo and Hull Trains leg. Data from the International Civil Aviation Organization (ICAO) has been used to produce the emissions of flights on key competing routes.

The report summarises the methodology used for calculating total passenger emissions for rail, car and flight trips.

Emission factors

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Train and London Underground

LUMO data and BEIS Conversion Factors 2022

Vehicle type	Scope 1 $kgCO_2e$	Scope 2 $kgCO_2e$	Scope 3 $kgCO_2e$ [c]	Scope 1, 2 & 3 $kgCO_2e$
	passenger.km			
Lumo rail [a]	n/a	0.006	0.004	0.011
Hull Trains rail [b]	Varied	Varied	Varied	Varied
National rail (average) [d]	0.035		0.009	0.044
London Underground [e]	n/a	0.028	0.007	0.035

a. LUMO Scope 1 emissions factor sourced from FirstRail data, calculated using weighted average (by passenger km) of emissions between April 2022 and January 2023 (see 'Rail Air Share – Lumo v1.4.xlsm' spreadsheet)

b. Hull Trains use a bi-mode fleet with both electric and diesel operations. For direct services between London Kings Cross and stations on the Hull Trains route a bespoke emissions factor has been used that considers the proportion of the specific route on electric (using the Lumo rail emission factors) or diesel (using the National Rail emissions factor) operation. For journeys that traverse the network an emissions factor has been applied that is weighted according to the approximate proportion of the full Hull Trains route that is electrified (73%) / is not electrified (27%).

c. Scope 3 emissions factor sourced from BEIS Conversion Factors 2022: WTT- UK electricity (T&D)

d. National rail (average) factors sourced from BEIS Conversion Factors 2022: Business travel-land National rail (Scope 1 & 2 because national rail combines diesel and electric); WTT travel-land National rail (Scope 3). Emissions factor is an average emission per passenger kilometre for diesel and electric trains in 2020-21.

e. London Underground factors sourced from BEIS Conversion Factors 2022: Business travel-land London Underground (Scope 1); WTT travel-land London Underground (Scope 3)

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Train and London Underground

BEIS Conversion Factors 2022 (further detail)

- National rail emissions factor is an average emission per passenger kilometre for diesel and electric trains in 2020-21. The factor is sourced from information from the Office of the Rail Regulator's National rail trends for 2019-20. Calculated based on total electricity and diesel consumed by the railway for the year sourced from the Association of Train Operating Companies (ATOC), and the total number of passenger kilometres (from National Rail Trends).
- London Underground emissions factor is an average emission per passenger kilometre based on TfL data.

https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting

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Car

BEIS Conversion Factors 2022

Vehicle type	Scope 1 $kgCO_2e$	Scope 2 $kgCO_2e$	Scope 3 $kgCO_2e$	Scope 1, 2 & 3 $kgCO_2e$
	passenger.km			
Average car – Petrol [a]	0.170	n/a	0.049	0.219
Average car – BEV	n/a	0.051	0.014	0.066

a. Vehicle factors sourced from BEIS Conversion Factors 2022: Business travel-land Average car - Petrol (Scope 1); WTT travel-land Average car - Petrol (Scope 3)

- For average-sized cars
- Vehicle payload: only driver + 25kg is considered, no passengers or further luggage

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Aviation

ICAO Carbon Emissions Calculator and BEIS Conversion Factors 2022

From	To	Vehicle type	Distance	$kgCO_2e$				
				Scope 1 (w/o RF*)	Scope 1 (w RF*)	Scope 3	Scope 1 & 3 (w/o RF*)	Scope 1 & 3 (w RF*)
			km	passenger.km				
London Heathrow	Edinburgh	319, 320, 321, 32A	533	0.134	0.253	0.027	0.161	0.280
London Heathrow	Glasgow	319, 320, 321, 32A	554	0.139	0.262	0.027	0.166	0.289
London Heathrow	Aberdeen	319, 320, 321, 32A	647	0.132	0.249	0.027	0.159	0.276
London Heathrow	Newcastle	319, 320, 321, 32A	404	0.151	0.286	0.027	0.178	0.312
London Heathrow	Inverness	319, 320, 32A	711	0.126	0.238	0.027	0.153	0.265
Luton	Edinburgh	319, 320	494	0.147	0.278	0.027	0.174	0.305
Luton	Glasgow	319, 320	517	0.135	0.255	0.027	0.162	0.282
Luton	Aberdeen	319, 320	604	0.143	0.270	0.027	0.170	0.297

*RF: Radiative Forcing

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Aviation

ICAO Carbon Emissions Calculator (ICEC) and BEIS Conversion Factors 2022

- The ICAO (International Civil Aviation Organization) Carbon Emissions Calculator (ICAO Carbon Emissions Calculator) is used to derive Scope 1 passenger emissions between OD pairs. ICAO is a specialised agency of the UN responsible for the safe and orderly cooperation of air transport.
- The ICAO Carbon Emissions Calculator uses the following methodology (Methodology to the ICAO Carbon Emissions Calculator) a summary of which has been laid out on the following page.
- The ICAO methodology uses a Tier 3 methodological approach as per EMEP/EEA air pollutant emission inventory guidebook an overview of this can be found here. A Tier 3 approach uses data to calculate the average emissions of a range of aircraft type operating on a route-by-route basis taking origin and destination airports, determining the distance, applying the aircraft types and calculating fuel burn. This provides emissions on route-by-route basis rather than at an aggregated level. Traffic data can be applied to deliver a per passenger emissions output.
- The averaged ICAO passenger km emissions factor for the routes selected equals 0.138 kgCO2e compared with 0.13 kgCO2e stated in BEIS Conversion Factors 2022: WTT-business travel-air Domestic.
- Distance, vehicle type and Scope 1 emissions are sourced from ICAO Carbon Emissions Calculator
- Scope 3 emissions are sourced from BEIS Conversion Factors 2022: WTT-business travel-air Domestic
- Scope 1 emissions without Radiative Forcing (RF) are converted into Scope 1 emissions with RF using the ratio between BEIS Conversion Factors 2022: Business travel- air Domestic emissions factors with and without RF.
- BEIS Business travel- air Domestic non-RF to RF ratio = 1.89 (3sf)

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Aviation

ICAO Carbon Emissions Calculator (further detail)

- CO_2 emissions per passenger only consider passenger load factors (i.e. belly freight is not considered). This is based on complex and regularly updated databases (incl. Traffic by Flight Stage (TFS)) on scheduled flights, passengers/cargo load factors and aircraft fuel burn.
- The calculation of the passengers' fuel burn is based on a passenger to freight ratio factor.
- Occupied seats (assumption: all aircraft are entirely configured with economic seats) = Total seats*Load Factor
- CO_2 emissions per passenger = (Passengers' fuel burn * 3.16) / Seat occupied
- An average passenger with baggage is assumed as 100 Kg, plus a 50 Kg add-on to account of the on-board equipment and infrastructure associated with passenger use (for example, the weight of seats, toilets, galleys and crew)
- For intra-Europe flights, passenger load factor = 82.3% and passenger to freight factor = 96.12%
- This load factor aligns with the following analysis using data published by the CAA and OAG flight schedules.
    - CAA 2019 passenger figures between London Heathrow & Edinburgh = 1,196,921 total passengers
    - Total 2019 seat capacity between London Heathrow and Edinburgh derived from OAG scheduled flights data = 1,460,942
    - Passenger load factor = 81.9%

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Scope 1, 2 and 3 emissions

Context

- Scope 1 emissions are the direct emissions resulting from combustion of fuel (also referred to as ‘Tailpipe’ emissions).
- Scope 2 emissions are associated with the purchase and consumption of electricity, heat, steam or cooling. These indirect emissions are a consequence of an organisation’s energy use but occur at sources not owned or controlled (for example a power station).
- Scope 3 emissions (also referred to as ‘Well-To-Tank’, or simply WTT, emissions usually in the context of transport fuels) are the emissions ‘upstream’ from the point of use of the fuel. They result from the extraction, transport, refining, purification or conversion of primary fuels to fuels for direct use by end-users and the distribution of these fuels.

Emission calculations methodology

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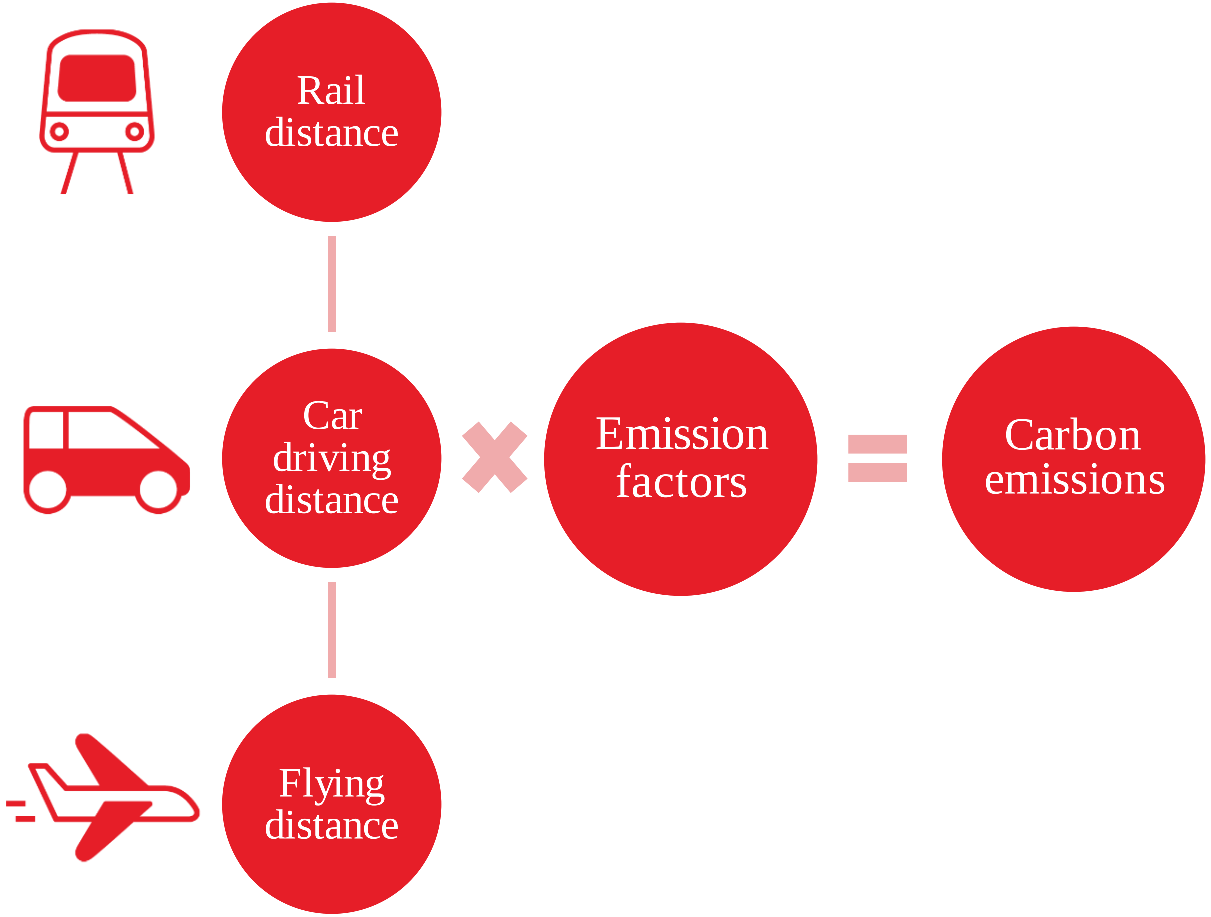
Methodology

1. Using Google API to determine distance between the Origin and Destination pairs provided by client.
2. Multiply distance by mode by emission factors.
3. Compare the carbon emissions for each trip by mode.



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Rail

1. Google API has been interrogated to determine the rail distance between two stations (origins and destinations)
2. 'Via' function has been applied to journeys that require interchanging between stations on the Lumo or Hull Trains network
3. Distance data has been split into different travel legs made by Lumo rail, Hull Train rail, non-Lumo/non-Hull Train rail, and the London Underground
4. Emissions Factors (EF) have been applied to the different travel legs accordingly
5. The carbon emissions of each leg made by Lumo rail, Hull Train rail, non-Lumo/non-Hull Train rail, and the London Underground are calculated individually and aggregated to provide a total emissions amount for the whole journey

Legs	Route	Distance (km)	Emission Factors	Carbon emissions (kg CO2e/passenger)
Lumo leg	Edinburgh to London Kings Cross	630.9	0.011	6.760
Underground leg	London Kings Cross to London Waterloo	6.0	0.044	0.209
Non-Lumo leg	London Waterloo to Bournemouth	173.3	0.035	7.698
Total for Edinburgh to Bournemouth				14.667

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Car

- Google API has been interrogated to determine the driving distance on the road network between two stations (origins and destinations).
- The same coordinates of the stations have been used as origins and destinations for consistency for mode comparisons.
- Google API extracted the route choice suggested at the time of the query, any discrepancies across route choice if the API is interrogated at the different time are considered negligible.