Emissions Comparison Project Methodology

**Prepared by Campaign for Better Transport
for the Rail Delivery Group**

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1. Introduction

Campaign for Better Transport was commissioned by the Rail Delivery Group to calculate the carbon emission savings that can be made by switching to rail from other, more polluting modes of transport. These emission savings are in turn compared to the emission outputs of different everyday activities, which clearly demonstrate the environmental benefits of train travel to a wide range of audiences. These comparisons highlight the large impact that changing even some journeys to rail can have for sustainability.

To achieve this, we have used various respected and reliable national data sets throughout the project. Predominantly, we have used Department for Energy Security and Net Zero's (DESNZ) Greenhouse Gas (GHG) data to calculate the average carbon emissions per km by train and various sizes of car, and what can be saved by switching.

2. Rail journeys emissions

- The Rail Delivery Group provided us with the information below on the number and length of rail journeys, based on more than 51 billion kms travelled in 2022/23.
- We see that the average National Rail train journey (regardless of whether it is made in a diesel or electric train is 37.3km.

		Average journey distance in km	Total annual km travelled	Total number of journeys
Total		**37.3**	**51,305,451,413**	**1,376,662,710**
Train type	Diesel	37.9	20,109,578,024	530,473,956
	Electric	36.9	31,195,873,389	846,188,753

- The DESNZ GHG conversion factors 2023 data shows that National Rail trains (on average for all diesel and electric trains) produce 0.035 kg CO2e per passenger km.
- To calculate the emissions for diesel and electric trains separately, the Office for Rail and Road's (ORR) rail emission (Table 6100) data. Dividing the CO2e from traction energy per vehicle km (627.1g) by CO2e per passenger km (47.5g) gives an assumed average of 13.21g of CO2e per passenger per vehicle km travelled.
- The ORR data states electric trains and diesel trains produced 358g and 1,400g (respectively) of CO2e per vehicle km, so each figure was divided by the average CO2e per passenger per vehicle km travelled (13.21g). This gives us 27.12 g (0.027 kg) of CO2e per passenger km travelled for electric trains and 106 g (0.106 kg) of CO2e per passenger kms for diesel trains.

- Multiplying the average train journey distance by each of the emission factors gives the emissions per journey. This means that the average train journey of 37.3 kms produces 1.32 kgs of CO2e, while the average electric train journey of 36.9 kms produces 1 kg of CO2e.

Mode	Emissions per (passenger) km (kg CO2e)
National Rail (Rail total)	0.035
Diesel train	0.106
Electric train	0.027
International rail	0.004

3. Car journey emissions

- The DESNZ GHG conversion factors data sheet provides emission figures for different vehicles, including passenger cars of various sizes and fuel types. The average car emissions are based on the average from all journeys made in various car sizes and fuel types including diesel, petrol and electric. These are all reproduced in the second column of the table below.
- To calculate emissions per passenger per km, each vehicle's emissions per km are divided by 1.5 – the average car occupancy, according to the Department for Transport's 2023 National Travel Survey (Table NTS0905). These are shown in the third table column.
- Dividing each car's emissions per km by the National Rail train emissions per passenger km gives us how many times more polluting each car is compared to the train, as shown in the last table column. For example, travelling in an average car produces 4.7 (nearly 5) times as much CO2e per km than rail.

Vehicle	Emissions per km (single occupancy) (kg CO2e)	Car journey (single occupancy) - times more polluting than rail	Emissions per passenger km (average occupancy) (kg CO2e)	Car journey (average occupancy) - times more polluting than rail
Average car	0.167	4.7	0.111	3.1
Average petrol car	0.164	4.6	0.109	3.1
Large petrol car	0.272	7.7	0.181	5.1
Medium petrol car	0.178	5.0	0.119	3.3
Small petrol car	0.141	4.0	0.094	2.6
Average diesel car	0.17	4.8	0.113	3.2
Large diesel car	0.209	5.9	0.139	3.9
Medium diesel car	0.167	4.7	0.111	3.1
Small diesel car	0.139	3.9	0.093	2.6
Average unknown (average fuel) car	0.167	4.7	0.111	3.1
Large average fuel car	0.226	6.4	0.151	4.3
Medium average fuel car	0.172	4.9	0.115	3.2
Small average fuel car	0.14	4.0	0.094	2.6
Average battery electric vehicle (BEV)	0.055	1.5	0.055	1.0
Large BEV	0.058	1.6	0.039	1.1
Medium BEV	0.053	1.5	0.035	1.0
Small BEV	0.048	1.4	0.032	0.9

4. Emission savings from switching from car to train for the average journey

- To calculate how much emissions the average train journey saves if it had been made in a car, we multiplied the emissions per passenger km for each vehicle by the average train journey distance of 37.3km. For example, travelling the average rail journey in an average car produced 4.14 kg CO2e, so making the journey by train saves 2.82 kg CO2e.
- Making the journey in an electric train (on a fully electrified route) rather than in an average car (assuming average occupancy) would save 3.1 kg CO2e.

Vehicle	Emissions per passenger km (average occupancy) (kg CO2e)	Emissions per passenger for a 37.3 km journey (kg CO2e)	CO2 savings compared to rail (kg CO2e)
Average rail journey (37.3 km)	0.035	1.32	
Average car	0.111	4.14	2.82
Average petrol car	0.109	4.08	2.75
Large petrol car	0.181	6.77	5.45
Average diesel car	0.113	4.22	2.90
Large diesel car	0.139	5.19	3.86
Average BEV	0.055	1.36	0.04

5. Kettle comparison

- To then calculate how much this saved carbon equates to in terms of everyday activities, we calculated the emissions associated with different activities.

Appliances	Emissions	kWh used
Emissions for electricity consumed (total CO2e per kWh)	0.2252	
Heating 250ml of water in a kettle	0.0062	0.0275
Charging a smartphone for a year	0.338	1.5

- For the kettle, according to Carbon Footprint, 0.11 kWh is used on average for heating 1 litre of water. Therefore, boiling one 250ml cup of water in the kettle uses 0.0275 kWh of electricity.
- Electricity consumed produces 0.2252 CO2e per kWh (DESNZ GHG emissions conversion factors methodology paper, Table 9), so boiling a cup of water produces 0.006kg of CO2e.
- Therefore, the 2.82 kg CO2e saved from switching the average train journey from car to train is the equivalent to boiling 455 cups of water in a kettle.
- The equivalent savings for other types of car are listed below.
- Making the journey in an electric train (on a fully electrified route) rather than in an average car (assuming average occupancy) would save 3.1 kg CO2e, which is equivalent to boiling 501 cups of water.

Vehicle/appliance	CO2 savings compared to rail per passenger km (kg CO2e)	Cups boiled in kettle equivalent
Boiling 1 cup of water in kettle	0.006 used	
Average car	2.82	455
Average petrol car	2.75	444
Large petrol car	5.45	879

Average diesel car	2.90	468
Large diesel car	3.86	624
Average BEV	0.04	6

6. Smartphone comparison

- According to a number of articles we found (e.g. Forbes, Energy Saving Trust), an android smartphone uses 1kWh of electricity in a year, whereas an iPhone uses 2 kWh of electricity in a year. The latest data shows that android and iPhone have a roughly even market share in the UK. Therefore, we can say that the average UK smartphone uses 1.5 kWh a year, which equates to 0.338 kg CO2e for a year of use. Please note that this only includes the emissions associated with powering the phones and not any emissions related to manufacturing or data processing (estimates suggest an iPhone 14 emits 61 kg of CO2 emissions over its four-year lifespan).
- Dividing the saving of 2.82 kg CO2e from travelling by train for the average train journey rather than car by the phone emissions, means the carbon saving is the equivalent of over 8 years of electricity needed for charging powering the average smartphone.
- The equivalent savings for other types of car are listed below.
- Making the journey in an electric train (on a fully electrified route) rather than in an average car (assuming average occupancy) would save 3.1 kg CO2e compared to the average car journey, which is equivalent to powering your smartphone for more than 9 years.

Vehicle	CO2 savings compared to rail per passenger km (kg CO2e)	Years of phone charging equivalent
Charging a smart phone for a year	0.338 used	
Average car	2.82	8
Average petrol car	2.75	8
Large petrol car	5.45	16
Average diesel car	2.90	9
Large diesel car	3.86	11
Average BEV	0.04	0

7. Research limitations

- DESNZ, the ORR and Energy Saving Trust do not produce all the data needed for this study. Where necessary, referenced data from other trustworthy UK organisations has been used.
- The most up-to-date data has been used throughout the study.