Rail emissions
April 2022 to March 2023

14 November 2023

Background:

This annual statistical release contains information on rail emissions from traction energy (i.e. energy used to power train movements) for passenger and freight trains in Great Britain.

It covers: **traction energy consumption of electricity and diesel**, and estimates of total and operator level **CO_2e emissions**. Emissions have also been **normalised** by vehicle kilometres and by passenger kilometres or by net freight tonne kilometres.

Source: Passenger and freight operators, and Network Rail.

Latest year: 1 April 2022 to 31 March 2023

Contents:

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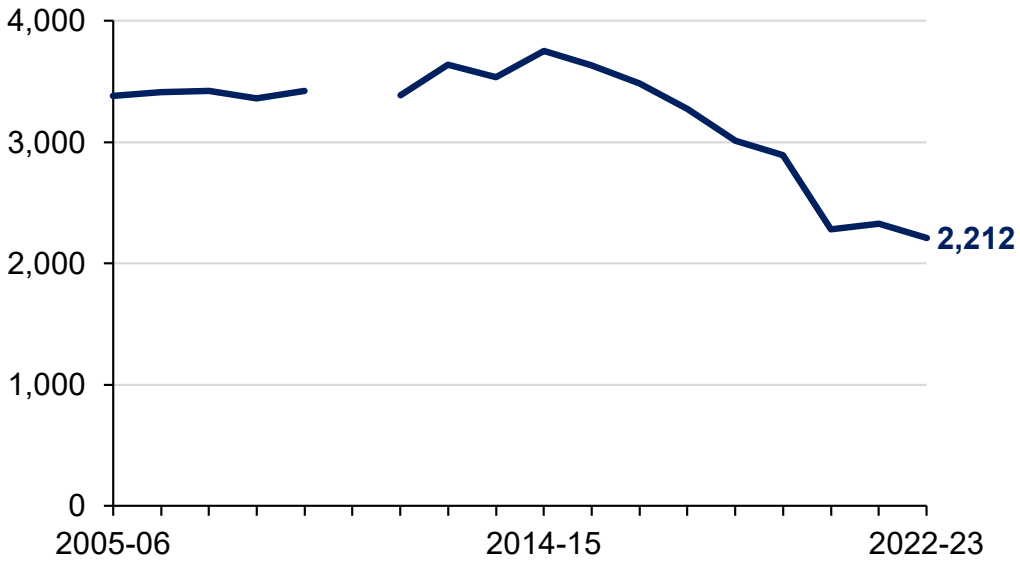
In the latest year (April 2022 to March 2023), for all passenger and freight trains combined, total **traction electricity consumption was 3,709 million kilowatt hours**. This was down 1% compared with the previous year. Total **traction diesel consumption was 538 million litres**. This was down 2% compared with the previous year. As a result, total estimated **carbon dioxide equivalent (CO_2e) emissions** decreased by 5% to **2,212 kilotonnes** in the latest year. Of which, 1,778 kilotonnes were from passenger trains and 434 kilotonnes from freight trains.

Figure 1 Total emissions from traction energy consumption have decreased

Total passenger and freight train CO_2e emissions (kilotonnes), Great Britain, annual data, April 2005 to March 2023 (Table 6105 and 6115)



Note: Data not available for 2010-11

New: Data by individual passenger and freight operators has been published for the first time. We have also produced a Rail emissions data catalogue.

All data tables, a quality and methodology report and an interactive dashboard associated with this release are published on the Rail emissions page of the data portal. Key definitions are in annex 1 of this release.

1. Passenger train emissions

The data in this section covers mainline passenger operators and Eurostar (UK side). This means that the usage totals used to normalise emissions data will differ from GB totals published in our Passenger rail usage statistical release.

Energy consumption

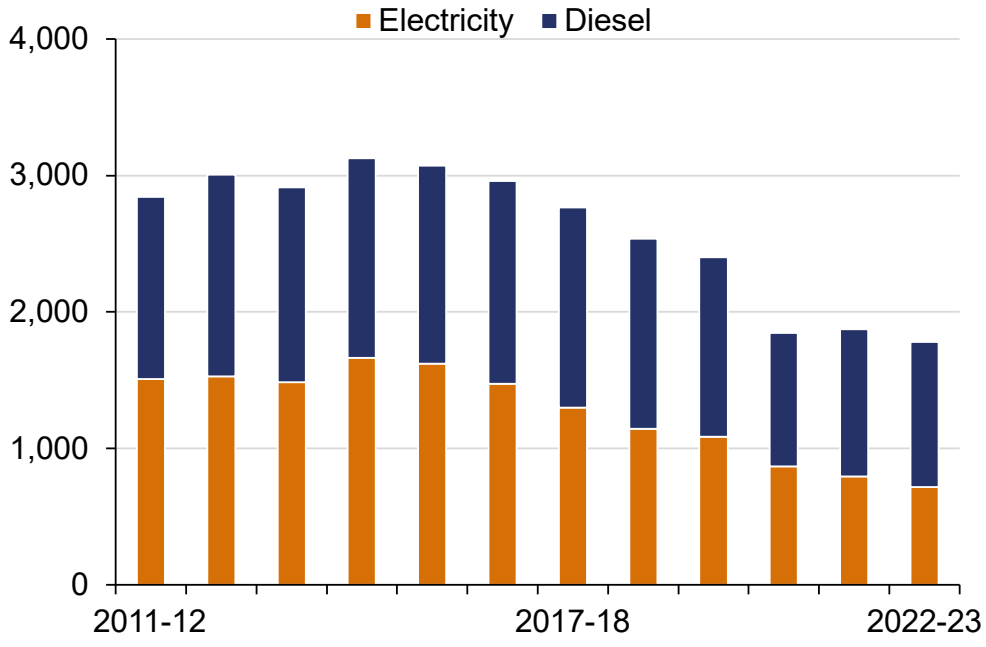
In the latest year (April 2022 to March 2023), total traction electricity consumption for passenger trains was 3,650 million kilowatt hours. This is down 1% compared with the previous year (April 2021 to March 2022). Total traction diesel consumption for passenger trains was 385 million litres. This was down 2% compared with the previous year.

Emissions

Carbon dioxide equivalent (CO_2e) emissions are estimated from energy consumption data. In the latest year, total emissions from passenger trains were 1,778 kilotonnes. This is down 5% compared with the previous year. This is the lowest emissions level since the start of the comparable time series in April 2011.

Figure 1.1 Passenger train emissions for both electricity and diesel decreased

Passenger train CO_2e emissions (kilotonnes), by electricity and diesel, Great Britain, annual data, April 2011 to March 2023 (Table 6105)



Of the total, emissions from traction electricity consumption were 717 kilotonnes. This was down 10% compared with the previous year. Meanwhile, emissions from diesel consumption were 1,061 kilotonnes. This was down 2% compared with the previous year. The decrease in electricity emissions (down 10%) exceeds the fall in electricity consumption (down 1%). This is caused by the change in the conversion factor, meaning the emissions per kilowatt of electricity is less than in the previous year. The conversion factor for diesel is unchanged, meaning the decrease in emissions is proportional to the decrease in diesel consumption.

Since the year April 2016 to March 2017, diesel emissions have exceeded electricity emissions each year. Prior to this, electricity emissions had been greater than those from diesel.

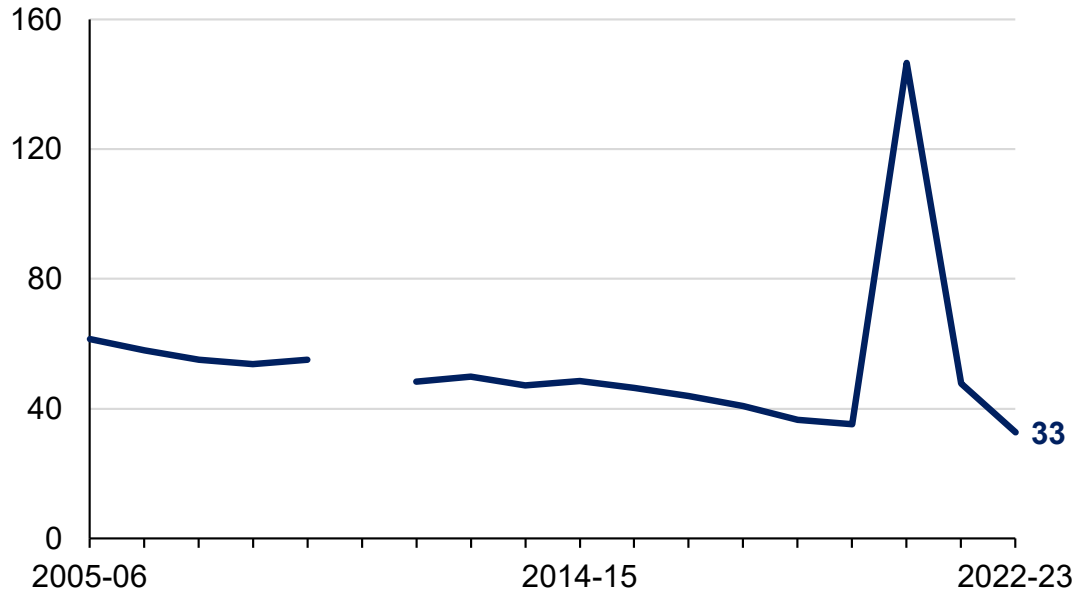
Emissions normalised by passenger kilometres

Comparisons of total emissions over time and between operators should be treated with caution because usage varies over time and between operators. Normalisation by usage (measured by passenger kilometres) presents data on a more comparable basis.

In the latest year, emissions per passenger kilometre was 33 grams of CO_2e. This was down 31% from the 47 grams of CO_2e per passenger kilometre in the previous year. This decrease can be attributed to the reduction in emissions (down 5%), as well as the increase in passenger kilometres (up 37% compared with the previous year).

Figure 1.2 Passenger train emissions per kilometre peaked during the pandemic

Passenger train CO_2e emissions (grams) per passenger kilometre, Great Britain, annual data, April 2005 to March 2023 (Table 6100)



Note: Data not available for 2010-11

Emissions normalised by vehicle kilometres

Last year we introduced new normalised emissions measures based on vehicle kilometre data. This data is split by traction type, which allows us to produce emissions per electric or diesel vehicle kilometre, as well as for all traction types.

In the latest year, emissions per vehicle kilometre for all traction types was 616 grams of CO_2e. This was down by 3% from the 632 grams per vehicle kilometre in the previous year and was the lowest level since the start of the time series in April 2011.

There was a decrease in the grams of CO_2e per electric vehicle kilometre in the latest year (down 8%), while the grams of CO_2e per diesel vehicle kilometre increased by 3%. As previously mentioned, this can partly be attributed to the change in the electricity conversion factor, which led to a 10% decrease in electricity emissions, despite electricity consumption (down 1%) and electric vehicle kilometres (down 2%) being relatively similar to the previous year.

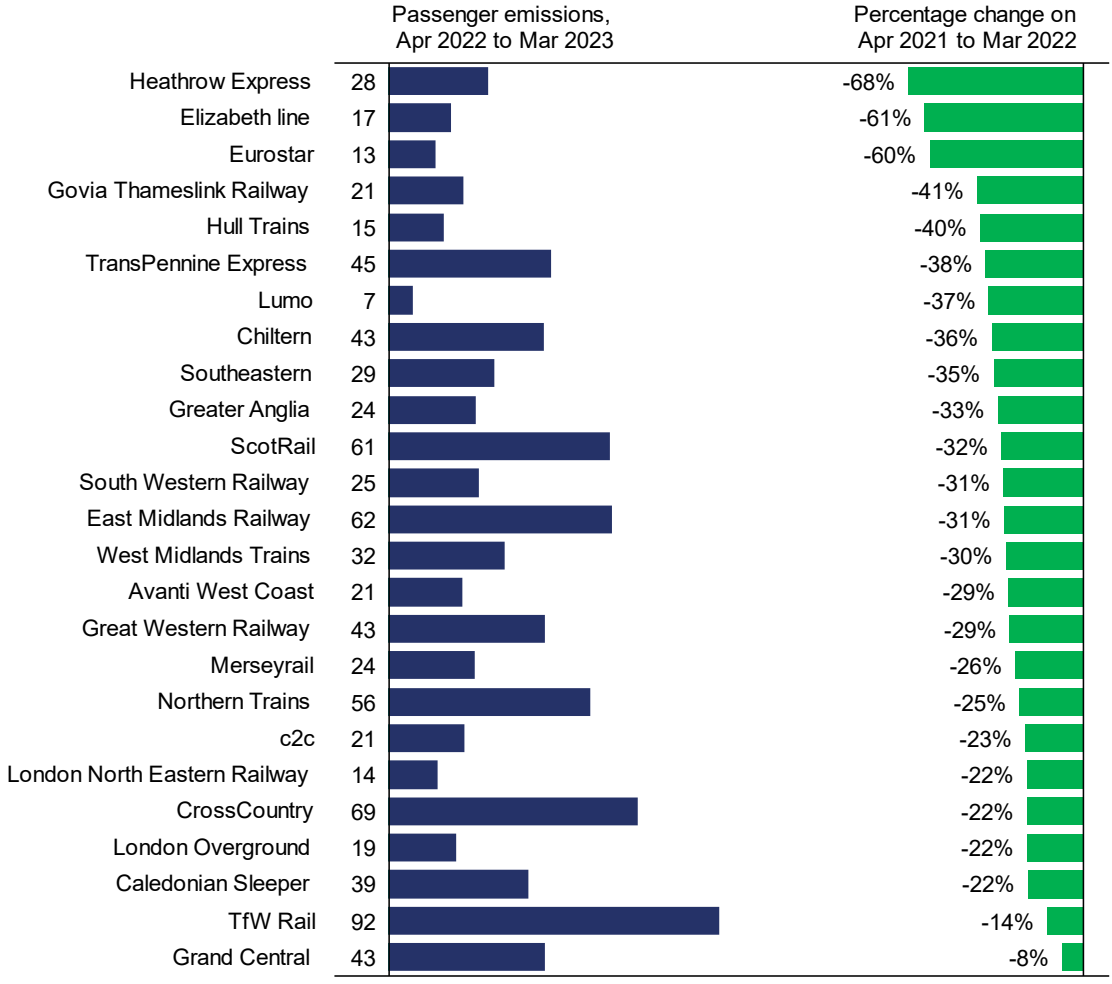
2. Passenger train emissions by operator

Emissions normalised by passenger kilometres

For all operators, the carbon dioxide equivalent (CO_2e) emissions per passenger kilometre decreased compared with the previous year. This can be attributed to the increase in passenger kilometres relative to the previous year.

Figure 2.1 Emissions per passenger kilometre decreased for all operators

Passenger train CO_2e emissions (grams) per passenger kilometre by operator, April 2022 to March 2023, and percentage change compared with April 2021 to March 2022 (Table 6103)



Note: London Overground's emissions are an estimate.

Heathrow Express had the largest decrease in emissions per passenger kilometre compared with the previous year (down 68%), while Grand Central had the smallest decrease (down 8%).

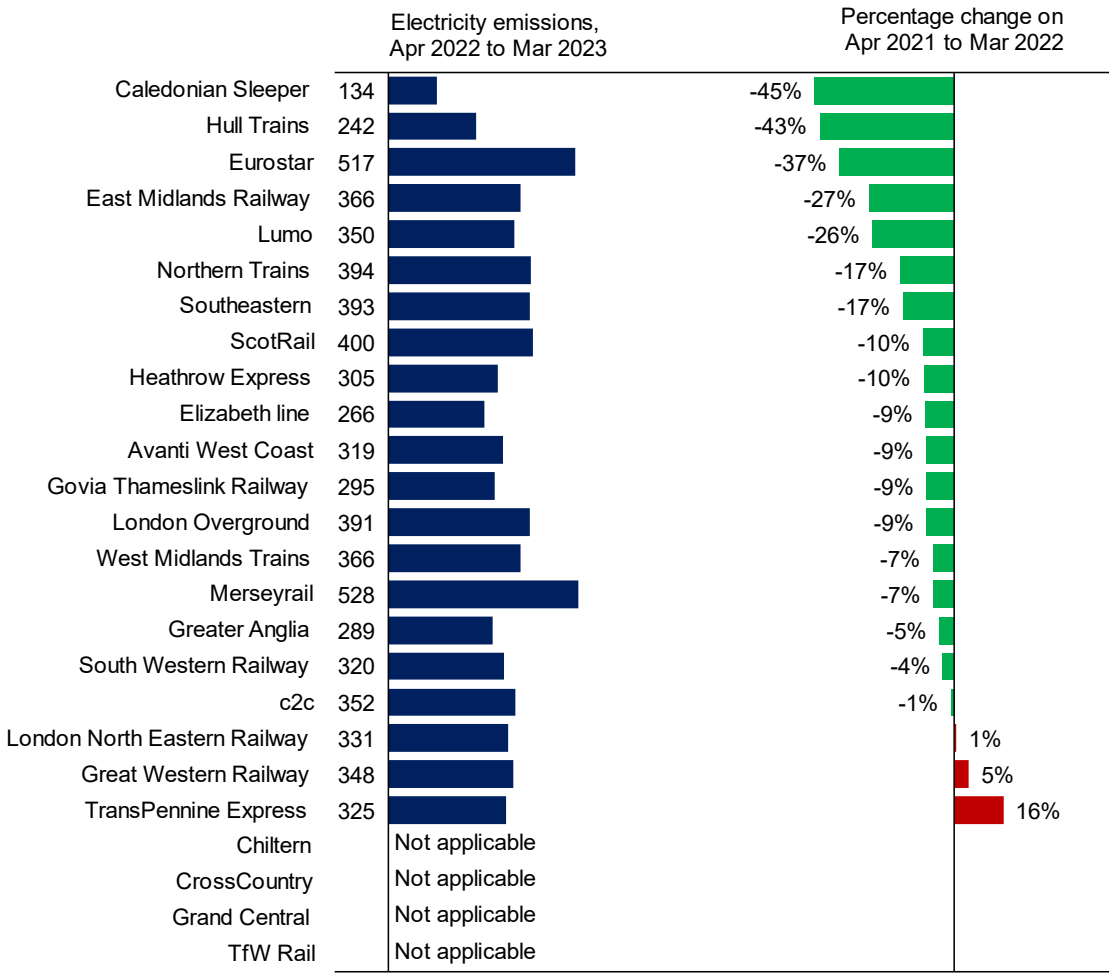
Emissions normalised by vehicle kilometres

Emissions normalised by electric vehicle kilometres

For 18 operators, electricity emissions per electric vehicle kilometre decreased compared with the previous year. For three operators, there was an increase in emissions per electric vehicle kilometre. Four operators did not run any electric rolling stock.

Figure 2.2 Electricity emissions per electric vehicle kilometre decreased for most operators

Passenger train CO_2e emissions (grams) from electricity consumption per electric vehicle kilometre by operator, April 2022 to March 2023, and percentage change compared with April 2021 to March 2022 (Table 6103)



Note: London Overground's emissions are an estimate.

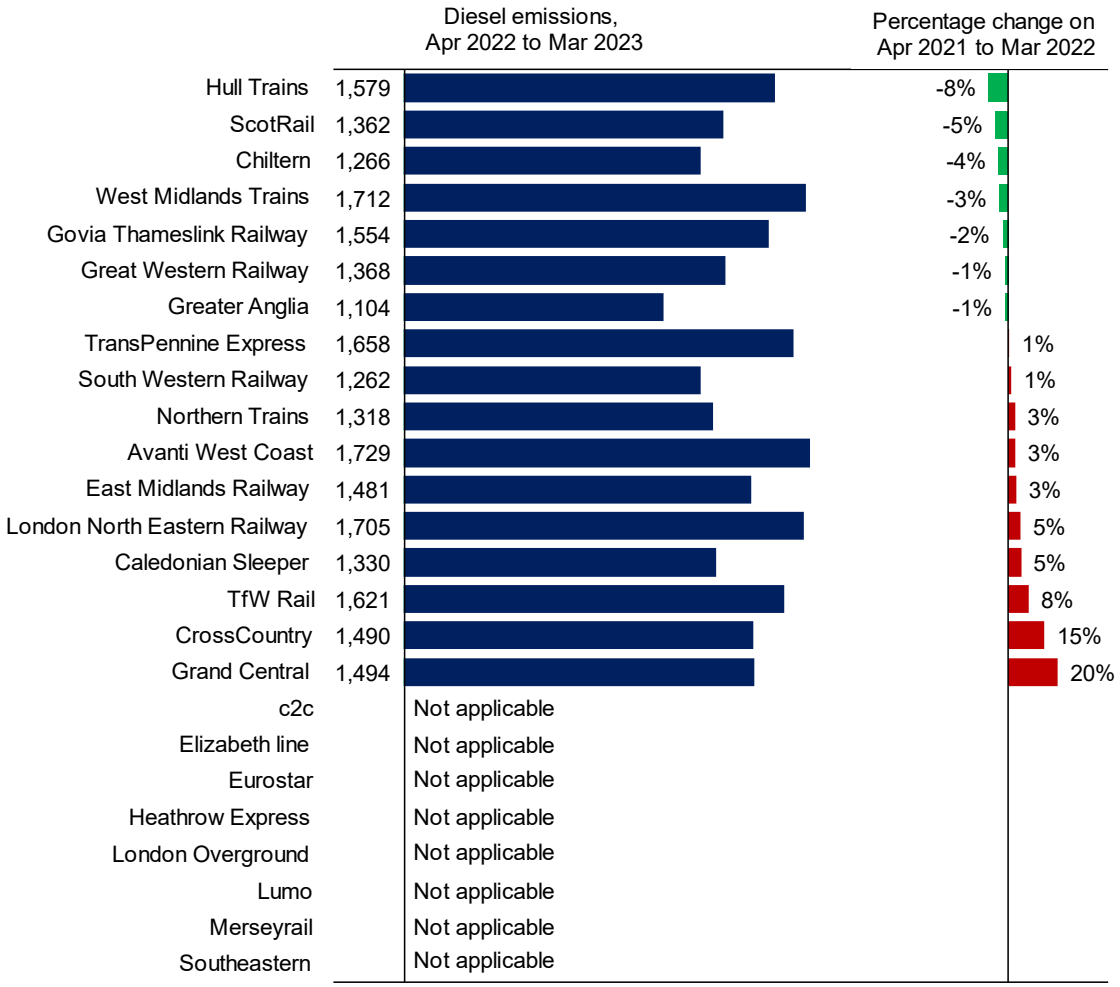
Caledonian Sleeper had the largest decrease in electricity emissions per electric vehicle kilometre compared with the previous year (down 45%). This is due to a 37% reduction in electricity consumption. TransPennine Express (up 16%), Great Western Railway (up 5%) and London North Eastern Railway (up 1%) all increased relative to the previous year.

Emissions normalised by diesel vehicle kilometres

For seven operators, diesel emissions per diesel vehicle kilometre decreased compared with the previous year. For 10 operators, there was an increase. Eight operators did not run any diesel rolling stock.

Figure 2.3 Diesel emissions per diesel vehicle kilometre increased for 10 operators

Passenger train CO_2e emissions (grams) from diesel consumption per diesel vehicle kilometre by operator, April 2022 to March 2023, and percentage change compared with April 2021 to March 2022 (Table 6103)



Hull Trains had the largest decrease in diesel emissions per diesel vehicle kilometre compared with the previous year (down 8%). This can be attributed to an increase in their diesel vehicle kilometres (up 16%).

3. Freight train emissions

The data in this section covers the six largest freight operators and an estimate for the smaller freight operators that we do not request data from. These include operators for the purpose of infrastructure maintenance and other rail-related activities (e.g. transport of rolling stock).

Energy consumption

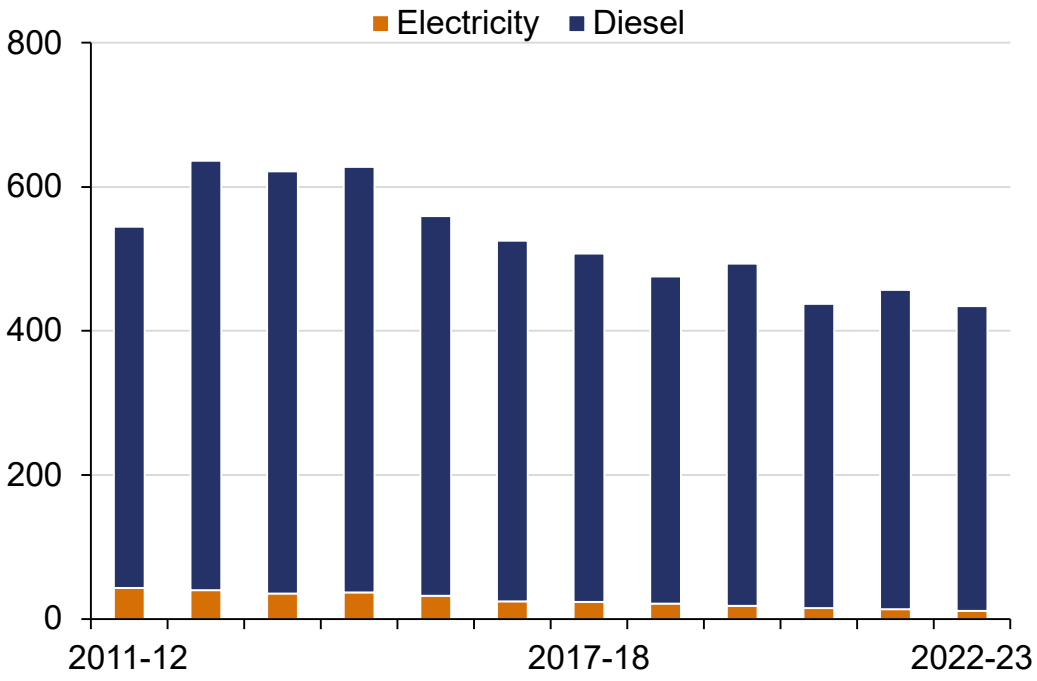
In the latest year (April 2022 to March 2023), total traction electricity consumption for freight trains was 59 million kilowatt hours. This is down 10% compared with the previous year (April 2021 to March 2022). Total traction diesel consumption for freight trains was 153 million litres. This was down 4% compared with the previous year.

Emissions

Carbon dioxide equivalent (CO_2e) emissions are estimated from energy consumption data. In the latest year, total emissions from freight trains were 434 kilotonnes. This is down 5% compared with the previous year.

Figure 3.1 Freight train emissions have decreased, largely driven by a reduction in diesel emissions

Freight train CO_2e emissions (kilotonnes), by electricity and diesel, Great Britain, annual data, April 2011 to March 2023 (Table 6115)



Of the total, emissions from electricity consumption were 12 kilotonnes. This was down 18% compared with the previous year. Meanwhile, emissions from diesel consumption were 423 kilotonnes. This was down 4% compared with the previous year.

The decrease in electricity emissions (down 18%) exceeds the fall in electricity consumption (down 10%). This is caused by the change in the conversion factor, meaning the emissions per kilowatt of electricity are less than last year. Meanwhile, the conversion factor for diesel is unchanged, meaning the decrease in emissions is proportional to the decrease in diesel consumption.

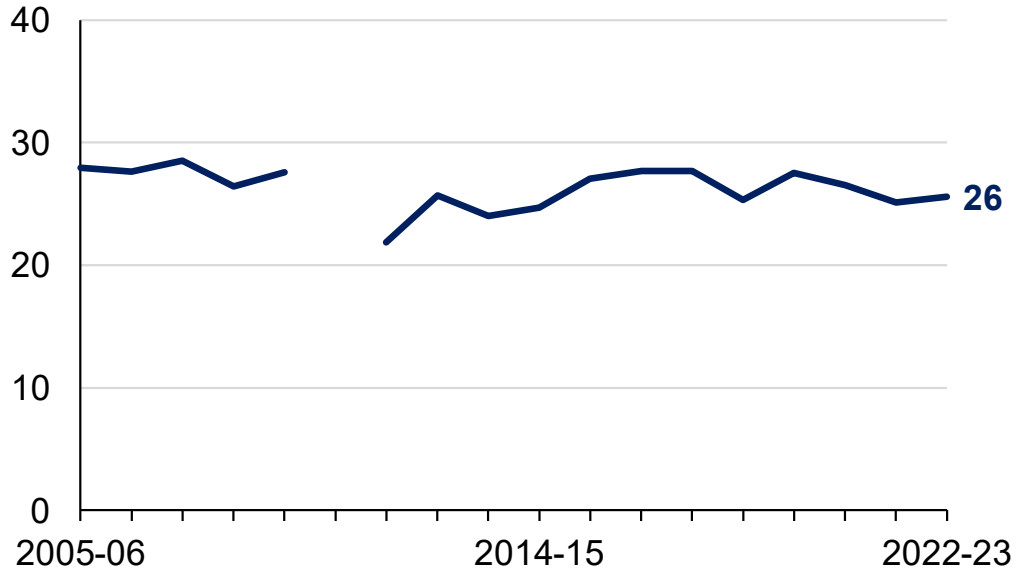
Emissions normalised by net tonne kilometres

As previously mentioned, comparisons of emissions over time and between operators should be treated with caution because usage varies over time and between operators. Normalisation by usage (measured by net tonne kilometres) presents data on a more comparable basis.

In the latest year, emissions per net tonne kilometre was 26 grams of CO_2e. This was up 2% from 25 grams of CO_2e per net tonne kilometre in the previous year. This increase can be attributed to the decrease in emissions (down 5%) being less than the decrease in net tonne kilometres (down 7%).

Figure 3.2 Freight train emissions per net tonne kilometre have remained fairly constant over time

Freight train CO_2e emissions (grams) per net tonne kilometre, Great Britain, annual data, April 2005 to March 2023 (Table 6110)



Note: Data not available for 2010-11

Emissions normalised by vehicle kilometres

In the latest year, emissions per vehicle kilometre for all traction types was 564 grams of CO_2e. This was similar to the previous year (562 grams). There was a decrease in the grams of CO_2e per electric vehicle kilometre in the latest year (down 11%), while the grams of CO_2e per diesel vehicle kilometre increased by 1%. As previously mentioned, this can partly be attributed to the change in the electricity conversion factor, which led to an 18% decrease in electricity emissions, despite electricity consumption decreasing by a smaller amount (down 10%).

4. Freight train emissions by operator

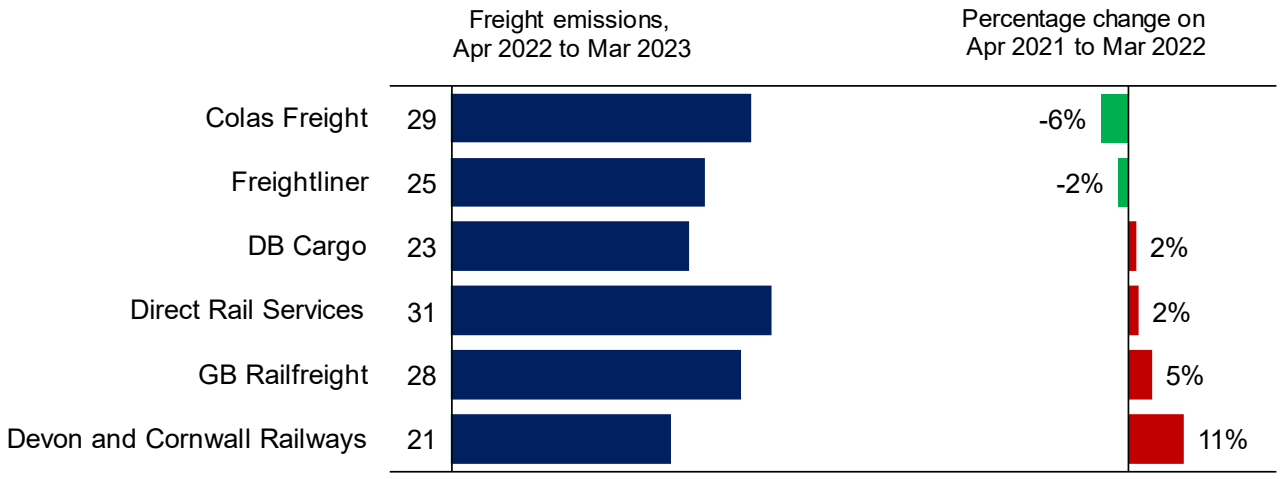
Emissions normalised by net tonne kilometres

For two operators, carbon dioxide equivalent (CO_2e) emissions per net tonne kilometre decreased compared with the previous year. Colas Freight (down 6%) reported the largest decrease, followed by Freightliner (down 2%).

The remaining four operators all increased their emissions per net tonne kilometre. Devon and Cornwall Railways had the largest increase (up 11%). This can be attributed to an increase in diesel consumption relative to the previous year (up 24%).

Figure 4.1 Emissions per net tonne kilometre increased for four operators

Freight train CO_2e emissions (grams) per net tonne kilometre by operator, April 2022 to March 2023, and percentage change compared with April 2021 to March 2022 (Table 6113)



Note: DB Cargo's emissions are an estimate.

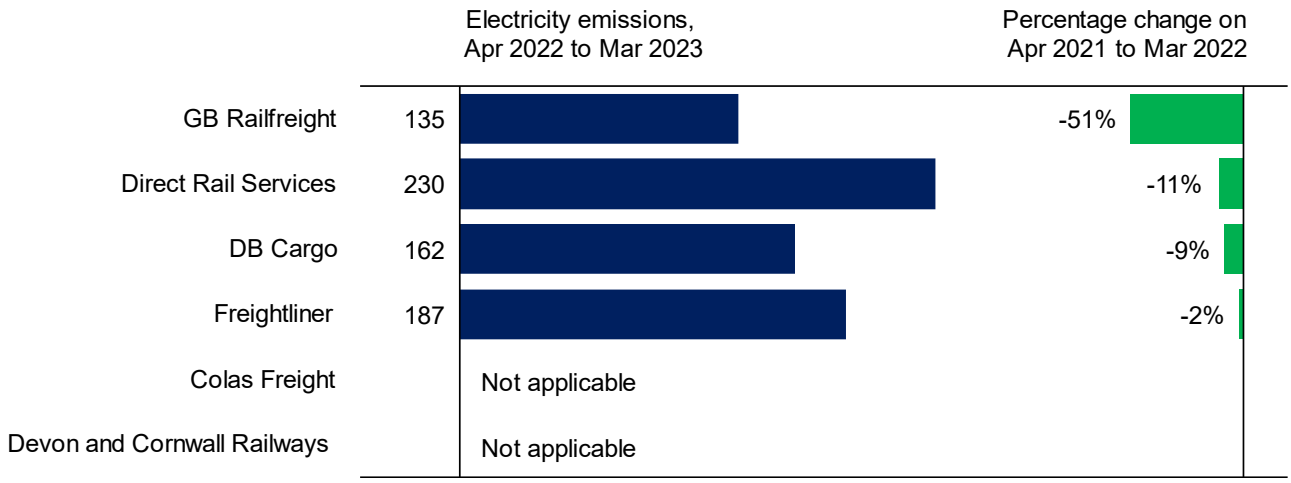
Emissions normalised by vehicle kilometres

Emissions normalised by electric vehicle kilometres

For four operators, electricity emissions per electric vehicle kilometre decreased compared with the previous year. Two operators did not run any electric rolling stock. GB Railfreight had the largest decrease in electricity emissions per electric vehicle kilometre compared with the previous year (down 51%). This can be attributed to a 77% reduction in electricity consumption.

Figure 4.2 Electricity emissions per electric vehicle kilometre decreased for all four operators

Freight train CO_2e emissions (grams) from electricity consumption per electric vehicle kilometre by operator, April 2022 to March 2023, and percentage change with April 2021 to March 2022 (Table 6113)



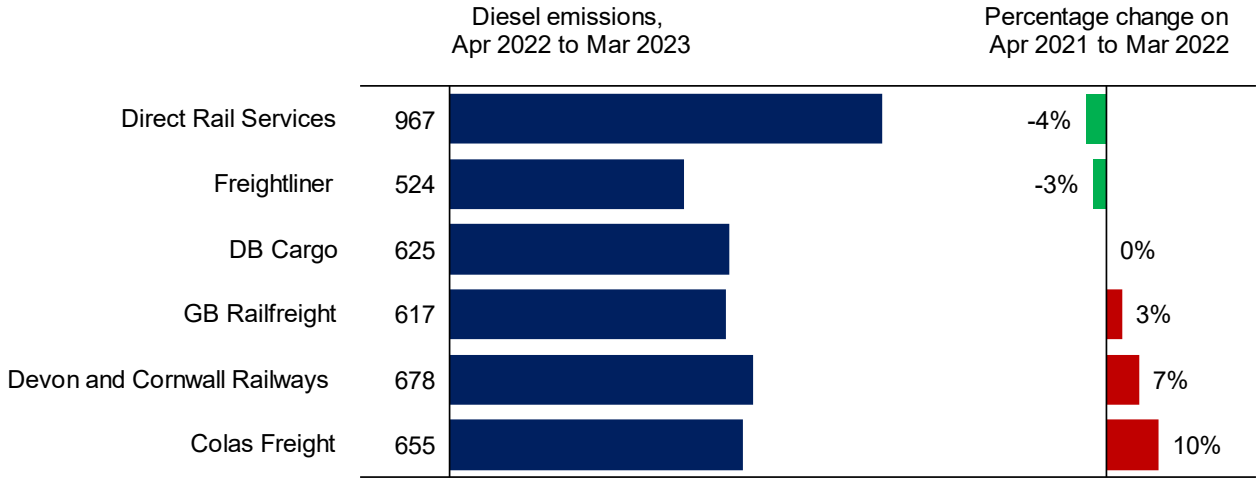
Note: DB Cargo's emissions are an estimate.

Emissions normalised by diesel vehicle kilometres

For two operators, diesel emissions per diesel vehicle kilometre decreased compared with the previous year. For three operators, there was an increase. Direct Rail Services had the largest decrease in diesel emissions per diesel vehicle kilometre compared with the previous year (down 4%). This can be attributed to an increase in their diesel vehicle kilometres (up 13%).

Figure 4.3 Colas Freight had the largest increase in diesel emissions per diesel vehicle kilometre

Freight train CO_2e emissions (grams) from diesel consumption per diesel vehicle kilometre by operator, April 2022 to March 2023, and percentage change compared with April 2021 to March 2022 (Table 6113)



Note: DB Cargo shows no change due to latest year's emissions being an estimate based on their previous year's diesel energy consumption, vehicle kilometres and conversation factor.

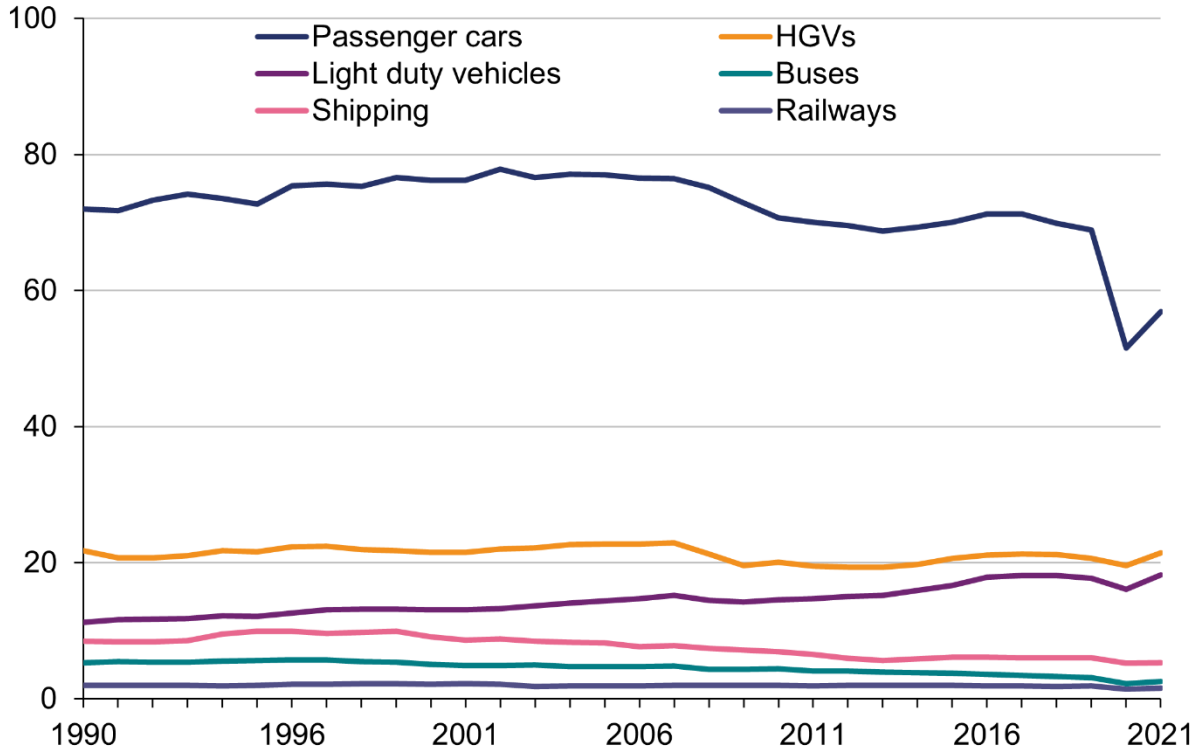
5. Transport emissions in context

This section presents emissions data for other modes of transport to show rail emissions in context. The Department for Energy Security and Net Zero (formerly Department for Business, Energy & Industrial Strategy) publish statistics on greenhouse gas emissions by transport mode. These statistics cover the United Kingdom as a whole, while ORR's statistics only cover Great Britain's rail network.

In 2021, rail emissions accounted for 1.5% of the UK's total emissions from transport, despite accounting for more than 7% of all passenger kilometres travelled. Road transport continues to be the largest source of emissions, with more than 90% of all transport emissions.

Figure 5.1 Emissions from passenger cars represent the majority of all transport emissions

CO_2e emissions (million tonnes) by transport mode, United Kingdom, annual data, 1990 to 2021



Source: Final UK greenhouse gas emissions national statistics: 1990 to 2021

In 2021, UK emissions from the seven greenhouse gases covered by the Kyoto Protocol were estimated to be 427 million tonnes carbon dioxide equivalent. This is nearly half (down 48%) the estimated levels recorded in 1990.

Transport remains the largest emitting sector, accounting for more than a quarter (26%) of all UK emissions. This is followed by energy (20%) and business (18%).

Figure 5.2 A quarter of greenhouse gas emissions came from transport

Proportion of CO_2e greenhouse gas emissions by sector, United Kingdom, 2021

Source: Final UK greenhouse gas emissions national statistics: 1990 to 2021

Network Rail environmental data

Network Rail report their annual energy consumption (electricity, gas and fuel) and the associated emissions. In the year April 2022 to March 2023, Network Rail reported a reduction of 24% in greenhouse gas emissions (excluding traction) against the baseline year April 2018 to March 2019. Network Rail use the environmental sustainability index (ESI) to monitor performance against four key environmental measures: percentage of waste recycled, percentage of waste diverted from landfill, percentage reduction in carbon emissions and percentage reduction in non-traction energy usage.

Network Rail also publish annual emissions and energy use, split by region and separately for 19 of their 20 managed stations. In the year April 2021 to March 2022, total emissions from these stations were 26,236 tonnes from combined electricity and gas consumption. This was 1% higher compared with 26,065 tonnes for the previous year (April 2020 to March 2021).

The text in the paragraph above was revised on 20 December 2024 – see page 18.

6. Annexes

Annex 1 – Definitions

- **Traction energy** refers to rolling stock (railway vehicles, including both powered and unpowered vehicles, such as locomotives, carriages and freight wagons) on the rail network, and the energy used to power passenger and freight train movements. Non-traction emissions are excluded, such as heating and lighting in buildings, depots and stations.
- **Diesel** refers to gas, oil, diesel or biofuel volume (in litres) consumed in train movements.
- **Electricity** measures the amount of electricity consumed (in kWh) in train movements. **Kilowatt hour (kWh)** is a unit of energy by calculating electricity usage - one kWh is the electric energy converted by a one kW appliance used for one hour.
- **Passenger kilometres** are calculated by multiplying the number of passenger journeys on a particular flow by the number of corresponding train kilometres between stations.
- **Net tonne kilometres** measures the amount of freight moved on the railway network, taking into account the weight of the load and distance carried.
- **Vehicle kilometres** measures the distance travelled by an individual vehicle (locomotives, carriages, wagons, etc.) on the rail network. It includes vehicle kilometres travelled on Network Rail infrastructure and other railways such as HS1. For example, a ten vehicle train travelling one kilometre is measured as one train kilometre, but ten vehicle kilometres.
- **Greenhouse gases** are gases in the Earth's atmosphere which trap heat. They allow sunlight to pass through the atmosphere but prevent heat from sunlight leaving the atmosphere. This creates a 'greenhouse effect', where the Sun's energy is trapped, which causes the Earth and in particular the oceans, to warm, the higher the amounts of greenhouse gases in the atmosphere, the warmer the Earth becomes. There are seven greenhouse gases covered under the Kyoto Protocol: carbon dioxide (CO2), methane (NH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF6) and nitrogen trifluoride (NF3).

Further information on each of these measures and other definitions can be found in the quality and methodology report.

Annex 2 – Quality and methodology

Data sources

Energy consumption data has been collected directly from train operators:

- Franchised passenger operators
- Non-franchised (open access) passenger operators
- Eurostar services (UK side)
- Freight operators

Passenger kilometre data is sourced from LENNON (Latest Earnings Networked Nationally Over Night) ticketing and revenue system and supplemented with data from operators who have passenger journeys/kilometres recorded outside of LENNON.

The net tonne kilometres data and vehicle kilometre data, used for the normalised measures, is sourced from Network Rail.

Vehicle kilometre data are sourced from the Track Access Billing System (TABS), which is used to bill train operators. As well as Network Rail infrastructure, it includes vehicle kilometres travelled on HS1, Core Valley Lines, London Underground, and the East London Line. Vehicle kilometres for bimodal trains are either classified as electric or diesel, depending on whether the train ran in diesel or electric mode.

Estimates for missing data

Passenger and freight operators provided ORR with either actual electricity and diesel traction consumption data, or their own estimates. For the year April 2022 to March 2023 the following were estimated by ORR due to operators not providing data:

- Energy consumption for one freight operator (DB Cargo).
- Energy consumption for one passenger operator (London Overground).

In addition, we produce estimates for smaller freight operators that we do not request data from. Further information on how these estimates are produced can be found in the quality and methodology report.

Methodology

Energy consumption data is converted into CO_2e using standard conversion factors from the Department for Energy Security and Net Zero (formerly Department for Business, Energy & Industrial Strategy). The emission conversion factors allow activity data (for example, litres of fuel used or kWh consumed) to be converted into grams of CO_2e.

Revisions

There have been revisions to previously published data:

- Tables 6100, 6105, 6110 and 6115: Some operators supplied revised energy consumption data. This resulted in small revisions to all measures for the year April 2021 to March 2022.

- Two revisions were made to this report on 20 December 2024 to correct the unit for Network Rail emissions data from kilotonnes to tonnes. There were 26,236 tonnes for April 2021 to March 2022 and 26,065 tonnes CO_2e for April 2020 to March 2021 from combined electricity and gas consumption across 19 of the 20 Network Rail managed stations.

Details of previous revisions can be found in the Revisions log.

Further information on data sources, quality, methodology and the historical background, can be found in the quality and methodology report.

How these statistics can and cannot be used

- Monitoring traction electricity and diesel consumption by passenger and freight trains over time
- Monitoring estimated CO_2e emissions from traction energy by passenger and freight trains over time
- Monitoring and comparing normalised CO_2e emissions for passenger and freight trains over time

- Comparing emissions for a specific train type or route (refer to DfT journey emission comparisons data)
- Identifying emissions for heritage or other non-mainline operators
- Calculating emissions for non-traction energy such as stations, buildings or depots
- Identifying expenditure on diesel fuel for passenger operators (refer to rail industry finance)

Annex 3 – List of data tables associated with this release and other related statistics

Data tables

All data tables can be accessed on the ORR data portal free of charge in OpenDocument Spreadsheet (.ods) format. We can also provide data in csv format on request.

All tables associated with this release can be found under the Data tables heading at the bottom of the Rail Emissions page.

- Estimates of normalised passenger carbon dioxide equivalent emissions – Table 6100
- Estimates of normalised passenger carbon dioxide equivalent emissions by operator – Table 6103 **(New)**
- Estimates of passenger energy consumption and carbon dioxide equivalent emissions – Table 6105
- Estimates of passenger energy consumption and carbon dioxide equivalent emissions by operator – Table 6108 **(New)**
- Estimates of normalised freight carbon dioxide equivalent emissions – Table 6110
- Estimates of normalised freight carbon dioxide equivalent emissions by operator – Table 6113 **(New)**
- Estimates of freight energy consumption and carbon dioxide equivalent emissions – Table 6115
- Estimates of freight energy consumption and carbon dioxide equivalent emissions by operator – Table 6118 **(New)**

Other related ORR data

Passenger usage data is published on the Passenger rail usage page on the data portal. This includes passenger kilometres by operator and passenger vehicle kilometres by operator.

Freight usage data is published on the Freight rail usage and performance page on the data portal. This includes the freight vehicle kilometres by operator.

The Rail infrastructure and assets page on the data portal. This includes information on track and route length, including the proportion of the rail network which is electrified.

Other related environmental statistics

The Department for Energy Security and Net Zero (formerly Department for Business, Energy & Industrial Strategy) publish estimates of UK territorial greenhouse gas emissions.

The Department for Environmental, Food & Rural Affairs (Defra) publish data on emissions of air pollutants in the UK. This includes data for transport and railways.

The National Atmospheric Emissions Inventory (NAEI) publish the Greenhouse Gas Inventory. It covers the UK's greenhouse gas emission estimates since 1990, broken down by industry. Rail data is included in the inventory, split into emissions from coal, freight diesel, intercity diesel and regional diesel (gas oil). There is also an interactive map which shows CO_2e emissions by local authority with an option to filter for emissions from diesel railways.

The Office for National Statistics publish UK greenhouse gases and total emissions by industry, This covers the period 1990 to 2020. This data is used in UK Environmental Accounts, which measures the impact of economic activity on the environment.

There is a list of resources relating to historical UK greenhouse gas emissions.

Links to other data sources are available in our new Rail emissions data catalogue.

European comparisons

The United Nations Framework Convention on Climate Change (UNFCCC) publishes national inventory submissions for greenhouse gas emissions.

The European Environment Agency (EEA) publishes data on greenhouse gas emissions for transport from the EU. Railway emissions (which only include emissions from diesel trains) have halved since 1990, but they constitute a small proportion of overall transport emissions.

Annex 4 – ORR's statistical publications

Our statistical practice is regulated by the Office for Statistics Regulation (OSR). OSR sets the standards of trustworthiness, quality and value in the Code of Practice for Statistics that all producers of official statistics should adhere to. You are welcome to contact us directly with any comments about how we meet these standards by emailing rail.stats@orr.gov.uk. Alternatively, you can contact OSR by emailing regulation@statistics.gov.uk or via the OSR website.

Statistical Releases

This publication is part of ORR's 'accredited official statistics', which consist of seven annual publications: **Estimates of station usage; Rail industry finance (UK); Rail fares index; Rail safety statistics; Rail infrastructure and assets; Rail emissions; Regional rail usage**; and four quarterly publications: **Passenger rail performance; Freight rail usage and performance; Passenger rail usage; Passenger rail service complaints.**

ORR also publishes a number of other official statistics, which consist of five annual publications: **Common Safety Indicators; Passenger satisfaction with complaints handling; Train operating company key statistics; Occupational health**; **Rail statistics compendium**; and four quarterly publications: **Signals passed at danger (SPADs); Delay compensation claims; Disabled Persons Railcards (DPRC); Passenger assistance.**

All the above publications are available on the data portal along with a list of publication dates for the next 12 months.

Accredited official statistics

Accredited official statistics are called National Statistics in the Statistics and Registration Service Act 2007. They are official statistics that have been independently reviewed by the Office for Statistics Regulation and found to comply with the standards of trustworthiness, quality and value in the Code of Practice for Statistics.

The majority of our statistical releases were independently reviewed by the OSR in June 2012. They comply with the standards of trustworthiness, quality and value in the Code of Practice for Statistics and are labelled accredited official statistics.

Since our review we have improved the content, presentation and quality of our statistical releases. In addition, in July 2019 we launched our new data portal. Therefore, in late 2019 we worked with the OSR to conduct a compliance check to ensure we are still meeting the standards of the Code. On 4 November 2019, OSR published a letter confirming that ORR's statistics should continue to be accredited official statistics.

OSR found many positive aspects in the way that we produce and present our statistics and welcomed the range of improvements made since the statistics were last assessed.

Estimates of station usage statistics were independently reviewed by OSR in November 2020 and a their accreditation was confirmed on 1 December 2020.

For more information on how we adhere to the Code please see our compliance statements.

If you have any feedback or questions please email rail.stats@orr.gov.uk.

This publication is available at dataportal.orr.gov.uk

Any enquiries regarding this publication should be sent to us at orr.gov.uk/contact-us