FACT SHEET

High-Speed Rail (HSR) and Carbon Emissions

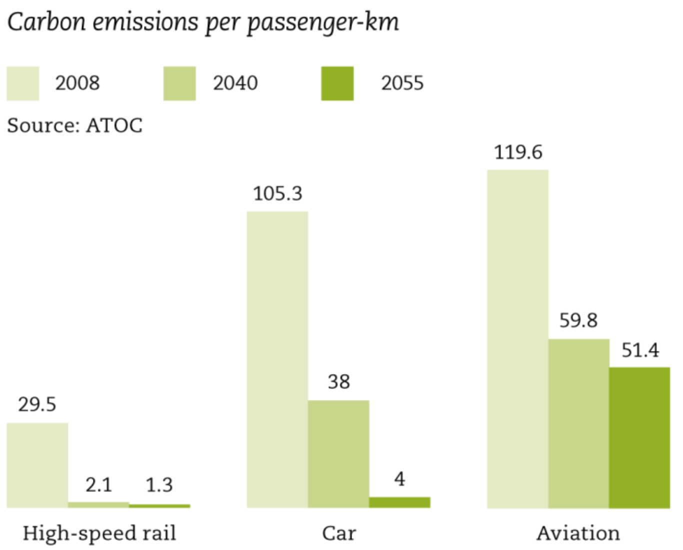
GREENGAUGE21

Evidence Base

A key element of the case for HSR is that it is more environmentally sustainable than other modes of transport. Under the 2008 Climate Change Act legally binding targets mean the UK needs to reduce greenhouse gas emissions by at least 80 per cent by 2050. According to the **Department for Transport (DfT)**[1], in 2008, domestic transport accounted for 21% of the UK's domestic emissions of carbon dioxide (CO_2) – transport clearly has to make its contribution to reducing the UK's overall emissions. HSR can play a vital role in our future low-carbon transport system.

Work carried out in 2009 for Greengauge 21 by the **Association of Train Operating Companies (ATOC)**[2] assessed the carbon emissions of HSR compared with car and air travel. The work adopted assumptions consistent with the King Review of low carbon cars and the work of the Committee on Climate Change on aviation. ATOC found that, even today, HSR has a considerable carbon advantage over car and air travel.

The ATOC research also demonstrated that high speed rail's carbon performance should improve from about 30gCO_2 per passenger km today to as low as 1gCO_2 per passenger km in 2055. This is because HSR uses electric traction and, to meet our carbon reduction targets, the UK will have to substantially reduce the carbon intensity of our electricity supply over the coming decades. The aviation sector may be able to deliver substantial efficiency improvements and the car fleet can switch over to electric vehicles – but these are ambitious targets leaving aside the need for a 10-20% increase in electricity generation[3]. HSR will still have a carbon advantage over other modes of transport used for medium-long distance travel.



Key points

1. High speed rail (HSR) produces only **one-third of the carbon emissions of car travel** and **one-quarter the emissions of an equivalent trip by air**, taking into account the average loadings typically achieved on each mode.

2. The planned **decarbonisation of the electricity supply** will stretch this advantage further over the next 20 – 30 years, even though we expect improved carbon performance from both the road and aviation sectors.

3. Comparison of the actual energy consumption and carbon performance of high-speed trains (300 km/h+) compared with conventional (200km/h – the speed of existing intercity trains) – shows that **high-speed operation results in minimal increase in carbon per passenger** (up to +10%).

4. A national HSR network is forecast to reduce CO_2 emissions by **one million tonnes each year by 2055**. Much of this saving is generated by a shift of passengers from air travel to HSR.

5. A first HSR line, such as the line from London to West Midlands proposed by the Government, will have lower carbon savings because of the lower initial shift of passengers from car to air, with a central estimate of **5 million tonnes of CO_2 over 60 years**.

6. There will also be **carbon emissions from the construction** of any HSR line, estimated at between 0.3 and 2.1 million tonnes of carbon for a London – West Midlands route.

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The significance of these comparative emissions factors is that HSR will deliver a shift from car and air travel to HSR, which will therefore help in reducing the carbon emissions from the transport sector. **Greengauge 21**[4], in the development of our *Fast Forward* strategy for high-speed rail, prepared forecasts of the likely demand on a national HSR network. This demonstrated that 17% of HSR passengers would be transferring from domestic air services and a further 7% from car travel. There would be further second-order impacts from the transfer from classic rail services to HSR: this would free up capacity on the classic network for new commuter, regional or freight services which would further reduce road traffic, although these second order impacts have not been included in the figures below.

Sources of HSR Demand

Source of demand	Million passengers p.a. 2055	Percentage of total HSR passengers
Abstracted from air	29.7	17%
Abstracted from car	12.6	7%
Abstracted from classic rail	101.5	57%
Generated	34.2	19%
Total	178.0	100%

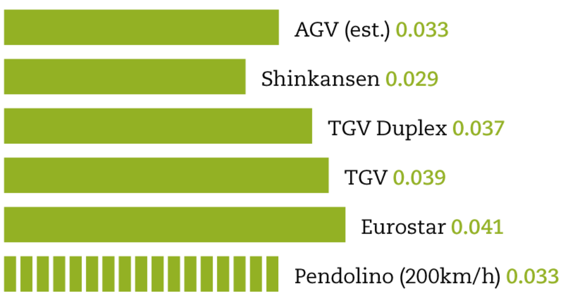
The result of this mode shift would be a reduction of one million tonnes of CO_2 each year by 2055.

ATOC also considered the impacts of operating trains at higher speed than conventional 'classic' trains, because it is often pointed out that, in principle, as the speed of a train increases so does the energy needed to propel it. Actual operating data from high-speed trains operating at 300 km/h and above in the UK, France and Japan was examined. It was found that high-speed trains can be as efficient as today's 200 km/h Pendolino trains operating on the West Coast Main Line.

The good performance of high-speed trains arises from a number of factors:

- High speed railways tend to be high capacity railways. A double-deck, double-unit TGV Duplex train, for example, offers 1090 seats in twenty vehicles compared to the 439 seats that the 9-cars of a Pendolino can offer (a significant capacity advantage that would remain even after most of these have been extended to 11 cars).
- High speed railways have higher load factors than the average of the rail network (Eurostar has a 70% load factor) since they are designed to support point-to-point traffic.
- Considerable effort is expended by train manufacturers in developing aerodynamic train designs that reduce drag.
- Consistency in HSR speed profiles and limited station stops mean that it is not necessary for HSR trains to accelerate and decelerate so frequently.

Energy consumption of high-speed trains
kWh/seat-km



Source: ATOC

Note: Pendolinos are conventional speed trains, operating at 200 km/h on today's railway; all the other train types are high-speed trains operating (or planned to operate) at 300km/h or above in other countries.

The carbon performance of Eurostar trains is even better than the analyses discussed above. Independent research carried out for **Eurostar by Paul Watkiss Associates**[5] shows that a journey between London, Paris and Brussels by Eurostar generates just one tenth of the greenhouse gas carbon dioxide (CO_2) of flying, or even less depending on the assumptions used on the mix of electricity generation. This is better than the ATOC comparisons because of the lower carbon intensity of electricity generation in France than in the UK, but it reflects the position that will be reached in the UK as the renewable and other low-carbon electricity generation systems are expanded.

Comparative emissions between Eurostar and air for passenger journeys Selective (main) air routes to Paris and Brussels for 2008

London □to Paris	kg CO_2 per single passenger trip (2008)	London □to Brussels	kg CO_2 per single passenger trip (2008)
Eurostar – average mix[1]	6.3	Eurostar – average mix[1]	8.4
Eurostar – supplier mix[2]	3.3	Eurostar – supplier mix[2]	4.1
Air: Heathrow – Paris	55.0	Air: Gatwick – Brussels	67.0
Air: Luton – Paris	62.3	Air: Heathrow – Brussels	56.1

The findings of the Greengauge 21 and ATOC analysis are supported by the findings of other respected research organisations.

In March 2010, **GLA Economics**[6] published a report on carbon emissions from short-haul air and high-speed rail travel. The report analyses existing literature, including the ATOC report produced for Greengauge 21. GLA Economics concluded that high-speed rail produces 40-100g of CO_2 per passenger kilometre and aviation 150-350g of CO_2 per passenger kilometre over distances up to 500 kilometres. Both of these ranges are slightly higher than the ATOC estimates, but the difference between the two modes is consistent, suggesting that high-speed rail produces around one-third the CO_2 emissions of short-haul aviation during operation.

In December 2009, the **Committee for Climate Change**[7] published its aviation report which assessed the scope for reducing emissions from air travel, given the Government target for aviation emissions to be no higher than 2005 levels by 2050. The report concluded that fuel efficiency and operational improvements are likely to result in a 30% reduction in carbon emissions per seat km flown and that sustainable biofuels could account for 10% of aviation fuel use in 2050. However, these reductions are insufficient to counter the effects of a 200% forecast increase in demand and so some means of tempering air demand is needed. High-speed rail is assessed as having the potential to deliver significant mode shift that reduces aviation demand by 10% in 2050 by substituting for domestic and short haul flights to Europe.

Taking a wider perspective on the whole transport sector, a 2010 study for the **Stockholm Environment Institute**[8] set out the measures needed to deliver a zero carbon transport sector for the UK by 2050. Car travel would need to be reduced and vehicles would switch to electric and hydrogen fuel cell power (although the substantial increase in renewable power generation this would entail is beyond the scope of the report). The national rail network, including future high-speed rail lines, would be totally electrified. It is not possible to achieve the same decarbonisation for aviation and shipping. While a 56% reduction in carbon emissions from aviation is projected, the SEI Report says that this requires the application of many complementary policy initiatives. The report suggests that a network of high-speed rail services would reduce aviation carbon emissions by 4.9Mt in 2050, a reduction of 8.2% in the projected total emissions from the aviation sector.

Looking in more detailed at the proposed new London – West Midlands high-speed line, the reports by **High Speed Two Ltd**[9] provide a detailed analysis of the operational and embedded carbon effects of HS2.

High-Speed Rail (HSR) and Carbon Emissions

In terms of *operational carbon*, HS2 would have both positive and negative effects on transport emissions. Increases in emissions from the new high speed services would be offset by the reductions in emissions arising from mode shift from air and road and also as a result of the change to classic rail services on the WCML. Overall, the impact of HS2 on operational carbon emissions is judged to be broadly neutral, with a central estimate of a saving of 4.6 million tonnes of CO_2 over 60 years.

Operational carbon impacts of HS2

Change in CO_2 over 60 years ($MtCO_2$)	Central estimate	Low estimate	High estimate
HS2 emissions	+19.7	0	+26.1
Other rail	-0.9	-1.3	+0.5
Car mode shift	-0.2	-0.5	0
Air mode shift	-23.2	-23.2	0
Total	-4.6	-25.0	+26.6

The range of possible results is equivalent to a range of -0.3% to +0.3% of UK transport emissions. The 'high' estimates are based on limited reductions in the carbon intensity of electricity generation and no reduction in flights even with a reduction in air passengers. The 'low' estimates are based on zero carbon electricity generation and a pro-rata reduction in flights.

We also need to consider the *embedded carbon* in a high-speed rail system, which represents the carbon emissions associated with construction of rail infrastructure and trains. Emissions largely arise from the use of high energy bulk materials such as steel and concrete, and high energy intensive construction practices such as tunnel boring. The total embedded carbon of the HS2 scheme is estimated to be 1.2 Mt CO_2, between the range 0.29 Mt CO_2 and 2.12 Mt CO_2.

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Data sources

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