“Close to Carbon Neutral”: How the UK Government Modelled the Carbon of HS2

Four official carbon assessments, 2013–2022: what they estimate, what they assume, and what the record suggests for the carbon case for ALTO

November 2026

8–14 Mt CO2e
Construction emissions, full HS2 network (HS2 Ltd estimate, Oakervee Review 2020)

11–12 Mt CO2e
Operational savings over the first 60 years of operation, full network (same source)

−4 to +3 Mt
Net CO2e over construction plus 60 years: “close to carbon neutral” (Oakervee Review, para. 5.37)

1 — Summary

Across four assessments published between 2013 and 2022, the UK Government and HS2 Ltd never found that HS2 would produce a clear net reduction in greenhouse-gas emissions within the standard 60-year appraisal period. The government-commissioned Oakervee Review (2020) concluded that HS2 appears “close to carbon neutral” and that it is unclear whether its overall effect is positive or negative [4].

Key findings.

1. **Construction carbon is front-loaded and large.** HS2 Ltd’s estimates for the full network ranged from 7.8–13.3 Mt CO2e (2013) to 8–14 Mt CO2e (2019). Phase One alone was estimated at 5.3–6.46 Mt CO2e [1, 2, 4].
2. **Operational savings are of similar size, spread over decades.** The full-network saving was put at about 9.5–10.3 Mt CO2e (2013) and 11–12 Mt CO2e (2019) over 60 years of operation [1, 4].
3. **The sign of the result depends on assumptions.** In the 2013 full-network assessment, the net result over construction plus 60 years ranged from a saving of about 2.5 Mt to an increase of about 3.8 Mt CO2e, depending on construction design and scenario [1].
4. **Every phase assessed on its own shows a net increase.** On an Initiative calculation from the Phase One Environmental Statement, Phase One adds about 2.1–2.6 Mt CO2e over construction plus 60 years. Phase 2a’s own assessment shows a net increase of 1.43 Mt (60 years) and 1.46 Mt (120 years). Crewe–Manchester shows a net increase of about 6.9 Mt over 120 years (Initiative calculation) [2, 3, 6].
5. **The savings rest mainly on taking passengers off domestic flights.** In the 2013 full-network assessment, aviation accounted for 7.80 Mt of the 10.49 Mt modal-shift saving in Scenario A (about 74%, Initiative calculation), largely on routes to Scotland served by the northern phases [1, 4].

The full-network figures were calculated for a network that has since been reduced: the eastern leg to Leeds was dropped in 2021 and the Birmingham–Manchester leg was cancelled in 2023 [10, 11]. This brief has not located a published whole-network carbon reassessment for the reduced scheme.

2 — The official assessments

Four documents carry the government's carbon modelling for HS2. All were prepared by or for HS2 Ltd and published by the Department for Transport. They use different scopes and time horizons, so their totals are not directly additive.

Assessment	Scope	Period	Construction (Mt CO2e)	Stated or derived net result
Temple-ERM for HS2 Ltd, Oct 2013 (Sustainability Statement App. F)	Full network (Phases One + Two)	Construction + 60 yrs	7.8–13.3	−2.5 to +3.8 Mt CO2e, by scenario and Phase Two design (stated)
Phase One Environmental Statement, Vol. 3, Nov 2013	London–West Midlands	Construction 2017–26 + 60 yrs (2026–85)	5.30–6.46	Operation net −2.97 / −3.16 Mt; with construction about +2.1 to +2.6 Mt (Initiative calculation)
Phase 2a Information Paper E27 (v1.3, Feb 2021)	West Midlands–Crewe	Construction + 60 and 120 yrs	1.451	+1.433 Mt (60 yrs); +1.459 Mt (120 yrs) (stated)
Oakervee Review, Feb 2020 (paras 5.30–5.37)	Full network (HS2 Ltd figures)	Construction + 60 yrs	8–14	−3 to −4 Mt (low construction) to +1 to +3 Mt (high construction) (stated)
Crewe–Manchester Environmental Statement, Vol. 3 (M32), Jan 2022	Crewe–Manchester	Construction + to 2050 and 120 yrs	5.022	About +4.8 Mt to 2050; about +6.9 Mt over 120 yrs (Initiative calculation)

Sources: [1], [2], [3], [4], [6]. Negative values are net savings; positive values are net increases. "Stated" figures appear in the source document; "Initiative calculation" figures are the sum of the source's published components.

3 — How the model works

Each assessment builds a carbon footprint from five components. Construction and operation add emissions; modal shift, freight using released capacity, and tree planting are counted as savings.

Component (full network, 60 yrs)	Scenario A (Mt)	Scenario B (Mt)	What drives it
Construction	7.8 to 13.3	7.8 to 13.3	Tunnels, earthworks, viaducts; concrete and steel
Operational emissions	+5.27	+2.15	Train energy; grid carbon intensity
Modal shift: domestic aviation	−7.80	−7.80	Air passengers switching to HS2
Modal shift: long-distance road	−2.63	−0.38	Car fleet carbon intensity over time
Modal shift: classic rail	−0.53	−0.07	Diesel and electric intercity services
Road access to HS2 stations	+0.48	+0.04	Car trips to stations
Freight uptake of released capacity	−3.25	−3.25	Freight paths freed on existing lines
Tree planting	−1.00	−1.00	Sequestration from about 4 million trees
Net operation (excluding construction)	**about −9.5**	**about −10.3**	**Stated totals; rounding in source**

Source: Temple-ERM for HS2 Ltd (2013) [1]. Scenario A uses Economic Case assumptions; Scenario B uses Committee on Climate Change Fourth Carbon Budget assumptions.

3.1 Two scenarios

Scenario A drew on the assumptions in the HS2 Economic Case. Scenario B used the Committee on Climate Change's Fourth Carbon Budget advice, which assumes faster decarbonisation of electricity and road transport. Faster decarbonisation lowers HS2's own operating emissions (5.27 Mt to 2.15 Mt), but it also cuts the road-transport saving from 2.63 Mt to 0.38 Mt, because the cars HS2 replaces are themselves cleaner. Aviation is the one saving that the two scenarios hold constant [1].

3.2 The assessment horizon

The standard appraisal period was 60 years of operation. Later documents (Phase 2a, Crewe–Manchester) also reported 120 years, matching the assumed design life. The 2013 full-network assessment stated that over construction and the first 60 years, savings would be less than emissions, largely because of construction, and that years 61 to 120 could yield net reductions of around 7 Mt CO2e if trends continued. Phase 2a's own figures show little change between 60 and 120 years (1.433 Mt to 1.459 Mt), because operational emissions and beyond-boundary savings rise at about the same rate [1, 3, 6].

3.3 Traded and non-traded emissions

The 2013 assessment noted that most of HS2's operational emissions fall within the EU Emissions Trading System, because they come from power generation. Under a capped trading system, emissions inside the cap are offset elsewhere, while savings from cars (outside the cap) count directly. This accounting choice affects how the operational balance is read but was not converted into a single adjusted figure in the documents reviewed [1].

4 — What the numbers show

4.1 Phase One on its own

Phase One, London to the West Midlands, is the only part now being built. Its 2013 Environmental Statement put construction at 5.30–6.46 Mt CO2e, with a central Scenario A estimate of 5.59 Mt and a Scenario B estimate of 5.30 Mt. Net operational savings over 60 years were 2.97 Mt (Scenario A) and 3.16 Mt (Scenario B). On an Initiative calculation combining those published figures, Phase One adds about 2.6 Mt (Scenario A) and 2.1 Mt (Scenario B) over construction plus 60 years of operation [2].

Phase One's operating assumptions also included freight using capacity released on the West Coast Main Line (2.07 Mt saving) and tree planting (0.5 Mt). Without those two items, the modal-shift saving alone (2.34–3.2 Mt) is less than the operational emissions plus construction in either scenario.

4.2 The full network and the Oakervee conclusion

By 2019, HS2 Ltd's full-network construction estimate had risen to 8–14 Mt CO2e, which Oakervee described as about 0.1% of current UK annual emissions. Operational savings were put at 11–12 Mt over 60 years, including tree planting, modal shift and freight uptake. Oakervee concluded that, at the low end of construction emissions, HS2 would save 3–4 Mt; at the high end it would add 1–3 Mt over construction and 60 years. The Review recommended that carbon reduction effort focus on Phase Two, because the scope for reduction in Phase One was limited [4].

4.3 How the figures were presented in decision documents

The Phase One Full Business Case (April 2020) presented carbon through intensity and scale comparisons rather than the net footprint. It cited 8 g CO2e per passenger-km for

HS2 by 2030, against 22 g for intercity rail, 67 g for inter-urban car and 170 g for domestic aviation. It also stated that building and operating Phase One over 120 years would produce the same carbon as one month of the UK road network [5]. Environmental statements framed construction carbon as a share of national carbon budgets: 0.17% of the third and fourth budgets for Phase One and 2a combined, and 0.13% of the relevant budget for Crewe–Manchester [3, 6].

Both framings are accurate on their own terms. The intensity figures describe a train in operation and do not include construction. The budget-share figures compare a single project with the whole economy. Neither states the net effect over the appraisal period, which is the figure Oakervee described as close to zero.

5 — The assumptions that carry the result

Four assumptions decide whether the official model shows a net saving or a net increase.

Aviation modal shift. Domestic aviation was the largest single saving: 7.80 Mt in both 2013 scenarios. Oakervee cited a forecast 11% fall in domestic flights after HS2, half of it on London–Scotland routes. Those routes depend on the northern phases. With the eastern leg dropped in 2021 and the Manchester leg cancelled in 2023, the full-network aviation saving was calculated for services that the reduced scheme does not provide in the same form [1, 4, 10, 11].

Road-vehicle decarbonisation. Oakervee noted that the carbon benefit of rail over car shrinks as cars electrify. Scenario B, which assumed faster decarbonisation, reduced the road saving by 86% compared with Scenario A (Initiative calculation from 2.63 Mt and 0.38 Mt) [1, 4].

Freight using released capacity. The 3.25 Mt freight saving assumes that paths freed on existing lines are taken up by freight moved off roads. The 2013 assessment gave an upper case of 6.5 Mt if twice as many paths were available. The saving depends on how released capacity is allocated, which is outside HS2 Ltd's control [1].

Construction carbon. HS2 Ltd set a target to cut construction emissions by 50% against the Environmental Statement forecast. Its 2025–26 Environmental Sustainability Progress Report recorded a reduction of 35.0% against that baseline; the 2023–24 report forecast an overall reduction of 32.5% at completion. Oakervee attributed much of the construction carbon to the straight alignments and gentle gradients required for high speed, which require large excavations and concrete [4, 7, 8, 9].

6 — Implications for ALTO

The HS2 record shows that a high-speed railway's carbon case depends on construction carbon, the time horizon, and modal-shift assumptions, more than on the low emissions of trains in service. On the arithmetic set out here, the following questions follow for any carbon claim made for ALTO.

6.1 Key metrics compared

ALTO would be about four and a half times the length of HS2 Phase One. Most of the engineering metrics that drove HS2's construction carbon (tunnel share, cuttings, viaducts) have not been published for ALTO's preferred corridor.

Metric	HS2 Phase One (London–West Midlands)	ALTO (Toronto–Québec City)
Route length	225 km (140 mi) [14]	About 1,000 km [16]

Metric	HS2 Phase One (London–West Midlands)	ALTO (Toronto–Québec City)
Stations	4 new stations [14]	7: Toronto, Peterborough, Ottawa, Montréal, Laval, Trois-Rivières, Québec City [16]
Tunnels	52.4 km (32.5 mi) of twin-bore tunnel; about 23% of route [14, 15]	Not published
Tunnels plus cuttings	About 55% of route [15]	Not published
Viaducts and bridges	52 viaducts, 175 bridges [14]	Not published
Operating speed	Not stated in sources reviewed	300 km/h or more [16]
Cost	£87.7–102.7bn, 2025 prices [18]	C$60–90bn (ALTO) [19]; C$75–113bn (PBO) [17]
Cost per km (Initiative calculation)	£390–456m/km	C$60–90m/km (ALTO); C$75–113m/km (PBO)
Forecast ridership	Not stated in sources reviewed	Up to 24 million per year by 2055 [16]
Construction carbon	5.30–6.46 Mt CO2e [2]	Not published
Construction carbon per km (Initiative calculation)	23.6–28.7 kt CO2e/km	Not published
First services	Between 2036 and 2039 [18]	Construction from 2029; Ottawa–Montréal first [17]

Cost-per-km and carbon-per-km figures are Initiative calculations: published cost or carbon divided by route length. HS2 costs cover the whole remaining programme and are in pounds; ALTO costs are in Canadian dollars; the two are not converted or price-base aligned. "Not published" means no figure was found in ALTO's public material at the date of this brief.

An illustrative scaling, not an estimate. On the arithmetic set out here, a 1,000 km line built at HS2 Phase One's construction-carbon intensity (23.6–28.7 kt CO2e per km) would emit about 24–29 Mt CO2e in construction. Actual figures would depend on ALTO's tunnel share, earthworks, structures and materials, none of which has yet been published. The comparison shows why the tunnel and structure metrics in the table carry most of the carbon question.

6.2 Questions for ALTO's carbon case

- **Is construction carbon included, and over what horizon?** HS2's per-passenger-km figures excluded construction. A whole-life assessment showing construction alongside 60-year and 120-year operation is the comparable basis.
- **Where does the modal shift come from?** HS2's savings depended mainly on domestic aviation. For ALTO, the relevant shares would be air (Toronto–Montréal, Toronto–Ottawa, Montréal–Québec City), car and existing VIA Rail services. Where ALTO has not published a split by source mode, the carbon saving cannot be checked against its ridership forecast.
- **What car fleet is assumed?** HS2's road saving fell by 86% between scenarios when faster vehicle electrification was assumed. An assessment for 2030s–2090s operation in Ontario and Québec would carry the same sensitivity.
- **What does a low-carbon grid change?** Ontario and Québec electricity is already largely low-carbon. That lowers operating emissions, but it also means there is little of the grid-decarbonisation improvement that HS2's long-horizon figures relied on, and it narrows the gap between rail and electric cars.
- **How much tunnelling, rock cutting and viaduct is required?** On HS2, these structures drove construction carbon. Alignment choices across the Canadian Shield, the Rideau system and river crossings would be the equivalent drivers.

- **Is each segment assessed alone?** The federal government has said each ALTO segment will undergo an impact assessment [12]. HS2's phase-by-phase assessments each showed a net increase, while the claimed savings were stated at full-network level. Segment and network results can differ in sign.

Federal impact assessments are subject to the *Strategic Assessment of Climate Change*, which asks proponents to estimate greenhouse-gas emissions and describe how a project fits Canada's 2050 net-zero commitment [13]. That process is the venue in which the questions above can be put on the record.

7 — Status of the figures

Published figures are quoted from the named UK Government and HS2 Ltd documents and can be checked there. Figures marked as Initiative calculations are sums or percentages of those published components, with the inputs named in the text; they are reconstructions, not independent measurements. HS2 Ltd's construction-carbon progress figures are self-reported against its own baseline. Where a document does not publish a figure (for example, a whole-network carbon reassessment for the reduced scheme), the text says so rather than inferring one. No claim is made about why any particular figure was or was not published.

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Note

The "120 years to carbon neutrality" figure that circulates in UK commentary is not stated in the government documents reviewed here [1–6]. The eastern leg to Leeds was dropped in the Integrated Rail Plan, November 2021 [11].

This brief makes no statement about the motives or conduct of any person or organisation.