ALTO HSR CITIZEN RESEARCH INITIATIVE

The Carbon Case for ALTO

Executive summary of the November 2026 lifecycle carbon research

Alto HSR Citizen Research Initiative — November 2026 Update — Second edition, revised. Supersedes the March 2026 edition prepared for the Alto HSR Public Consultation. — citizenresearch.ca

> On the Initiative's own central ridership forecast, ALTO does not repay the carbon spent building it within any appraisal horizon the project will be assessed against. The construction debt of 14.69 Mt CO_2e is still outstanding in 2080, forty years after the first phase opens. Payback falls between 2083 and 2110 depending on where the comparison boundary is drawn. On the lower ridership trajectory it is never repaid.

What this pack contains

Four research notes, reissued in November 2026 as second editions. They are built entirely from international evidence, engineering first principles and published research, because ALTO has published no lifecycle carbon assessment of its own.

Table 1. The four notes in this pack

Note	Covers	Central figure
Model Input 1 — Construction Carbon	Embodied materials, machinery, transport, tunnels, structures, land clearing, cold-climate premium, Leda clay	14.69 Mt CO_2e one-time
Model Input 2 — Operational Carbon	Traction, stations, maintenance, seven cold-climate categories, vegetation, waste, administration, decommissioning	51,944 t CO_2e per year at full network
Model Input 3 — Road Severance	Permanent detour emissions from 350–700 road closures across three vehicle categories	6,844 t CO_2e per year
Consolidated Output — 50-Year Lifecycle Budget	Phased construction against the ridership envelope, at two comparison boundaries	No payback by 2080, central case

This edition rebuilds the March analysis on the project as it is now specified — phased, Ottawa–Montréal first — and on the ridership envelope the Initiative published in May 2026. Appendix A records every change from the first edition and the reason for it.

The finding

A railway spends carbon to build and saves carbon to run. The question is whether the saving ever covers the spending, and when. Building ALTO is estimated to emit 14.69 Mt CO_2e in the central case, with a range of 6.87 to 29.60 Mt. That figure includes two categories ALTO has never acknowledged: a cold-climate design premium derived from the Harbin–Dalian high-speed line, the only comparable

railway operating in deep seasonally frozen ground, and the ground treatment required where approximately 200 km of the Ottawa–Montréal segment crosses Leda clay.

Running ALTO saves carbon only to the extent that its passengers would otherwise have driven or flown. That saving arrives slowly, for three reasons that compound.

Table 2. Why the carbon saving arrives slowly

Reason	Why it delays payback
The railway opens in three phases	Construction carbon is paid at each opening. Phase 1 carries 19% of the route length but 16% of eventual demand.
Ridership ramps	On the central forecast the corridor carries 0.4 million passengers in 2040 and does not reach 12.5 million until 2080.
Trips are shorter than assumed	A demand-weighted average of 430 km, not the 650 km assumed in March. Fewer passenger-kilometres, higher fixed cost per kilometre.

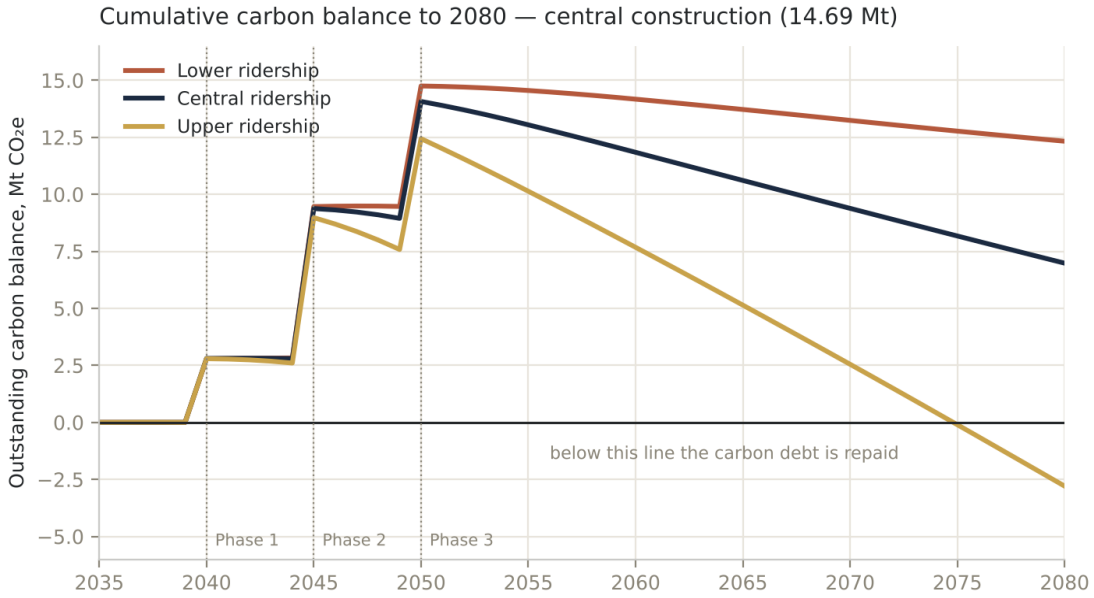


Figure 1. Outstanding carbon balance to 2080. Above the line, the project has not yet repaid the carbon spent building it. Each step is a phase opening. On the central and lower ridership trajectories the line does not reach zero within the period shown.

Table 3. Carbon payback and balance outstanding, by ridership trajectory

Ridership trajectory	Carbon payback	Still owed in 2080
Lower — 6.1M passengers by 2080	Never	12.3 Mt
Central — 12.5M by 2080	2083 to 2110	7.0 Mt
Upper — 25.7M by 2080	2064 to 2075	repaid

Only the upper trajectory repays within the operating life, and it requires 25.7 million annual passengers — above every independent forecast for the corridor, including those of the McGill TRAM group, the Munk School, the C.D. Howe Institute and the federal government's own 2021 business case.

A note on boundaries, for the non-specialist

Comparing a train journey with a car journey sounds simple. It is not, because someone has to decide what counts as part of the journey. That decision is called the boundary, and it changes the answer more than almost anything else in this analysis.

The narrow answer is the tailpipe boundary. It counts only what is emitted while you are travelling — petrol burned in the engine, or electricity drawn from the grid. Nothing else: not the factory that built the car, not the mine that supplied the battery, not the road, not the railway.

The wider answer is the life-cycle boundary. It counts all of that too, spread across everything the asset carries in its lifetime. Building an ordinary car emits roughly 8 tonnes of CO_2 before it is driven a metre, and an electric one nearer 12, because of the battery. Spread over 240,000 km at 1.2 occupants, that adds about 42 g to every passenger-kilometre an electric car ever travels — whatever its electricity costs. Building ALTO adds about 72 g to every passenger-kilometre it carries across fifty years.

Neither boundary is wrong. What is wrong is mixing them: measuring one mode generously and its rival narrowly. An electric car looks almost free at the tailpipe boundary and distinctly less so once its battery is counted. A railway looks clean until the concrete is counted, and expensive once it is. Put a tailpipe car next to a life-cycle railway and you can prove whatever you set out to prove.

> THE RULE THIS PACK FOLLOWS — every mode is measured the same way within the same column. The table and chart that follow report both boundaries side by side, so the reader can see what each choice does rather than having one chosen for them. Where the two boundaries disagree, both answers are given.

The disagreement is not small. At the tailpipe boundary ALTO repays its construction carbon in 2110 on the central ridership case; at the life-cycle boundary, 2083. That is the whole of the “2083 to 2110” range quoted earlier — not uncertainty about ALTO, but a choice about what to count. Both lie beyond any horizon the project will be appraised over, which is why the finding holds either way.

One qualification is owed. ALTO’s figure in the tailpipe column is not strictly a tailpipe figure: it includes station energy, track maintenance, administration, the cold-climate premium and road severance, because those are what the Initiative’s operational research note measures. A car’s tailpipe figure is fuel alone. The tailpipe column therefore still carries a modest bias against ALTO. The life-cycle column is the properly symmetric comparison, and it is the one that favours ALTO.

How the modes compare, and when

A per-passenger-kilometre comparison is only meaningful if every mode is measured to the same boundary. The March edition set ALTO’s fully allocated emissions against tailpipe-only figures for cars and aircraft. This edition reports both boundaries throughout.

Table 4. Emission intensity by mode and comparison boundary, 2050–2080

g CO_2e per passenger-km	Boundary	2050	2065	2080
ALTO rail	operational only	20.5	13.0	11.2
ALTO rail	including amortised construction	92.4	85.0	83.2

g CO_2e per passenger-km	Boundary	2050	2065	2080
Car, fleet average	tailpipe	77.1	55.0	32.9
Car, fleet average	life-cycle	137.6	110.0	82.4
Car, electric only	operational (grid) only	0.6	0.6	0.6
Car, electric only	life-cycle, incl. battery	42.3	42.3	42.3
Short-haul air	operational only	140	140	140
Short-haul air	life-cycle	183	183	183
Memo: Ontario grid, g/kWh	—	5	5	5
Memo: electric share of light fleet	—	29%	49%	70%

Three things follow. ALTO's operational intensity is genuinely low and falls as the grid cleans — about 11 g per passenger-kilometre by 2080. Its full intensity does not, because the construction debt amortises to roughly 72 g and does not improve with the grid. And the car fleet is a moving target: as it electrifies, the saving from moving a passenger out of a car narrows from about 57 g per passenger-kilometre in 2050 to about 22 g in 2080.

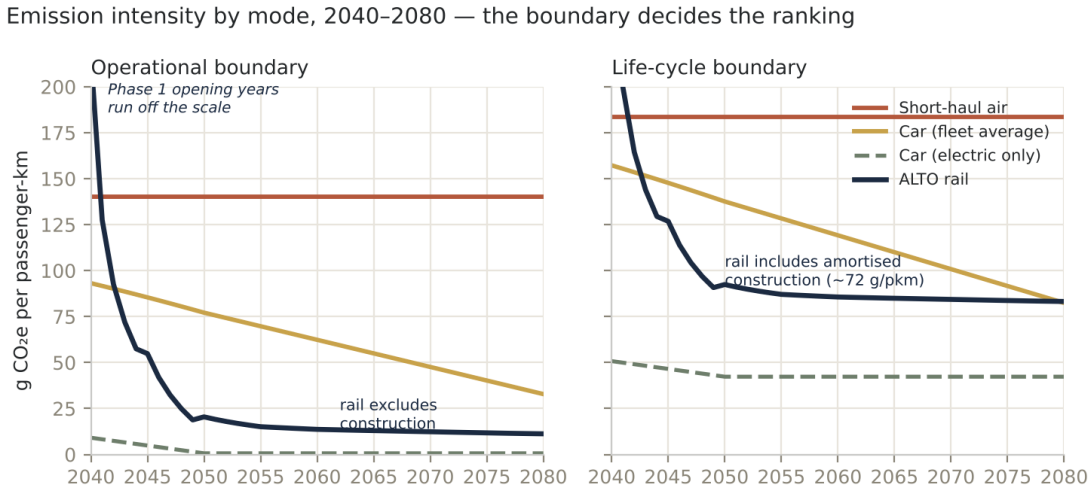


Figure 2. Emission intensity by mode, 2040–2080. On the operational boundary ALTO is the cleanest mode other than an electric car. Once its construction carbon is amortised on the same basis as an electric car's battery, the ranking changes and the margins narrow sharply. Air is held constant: fleet efficiency gains are broadly offset by demand growth, and sustainable aviation fuel is not yet material at scale. That assumption is generous to ALTO, as is the grid path: the IESO's own outlook takes Ontario close to a zero-carbon grid by 2050, and the notes retain a slow-decarbonisation sensitivity in which payback is later still.

The electric vehicle problem

The carbon case for any passenger railway in 2026 depends on what the cars it displaces will be emitting in the 2050s and beyond. The March edition assumed roughly half the light fleet would be electric by 2045, which made the modal-shift saving small and the payback long. That assumption rested on a federal mandate that no longer exists.

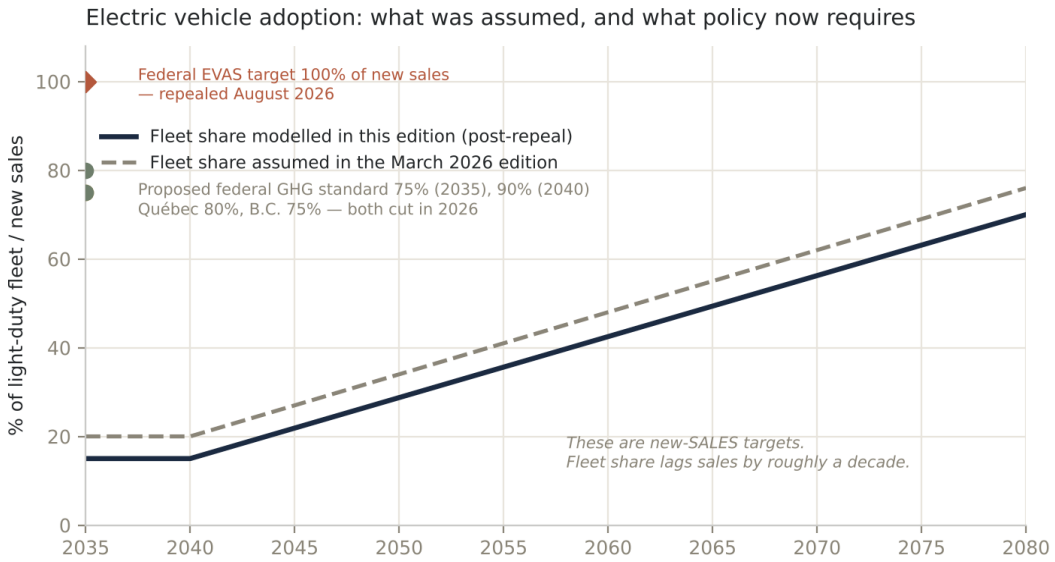


Figure 3. Electric vehicle adoption. The federal Electric Vehicle Availability Standard, which required 100 per cent zero-emission new sales by 2035, was paused in September 2025 and its repeal posted in the Canada Gazette in August 2026 with no replacement in force. Quebec cut its 2035 target to 80 per cent and British Columbia to 75 per cent. The proposed federal greenhouse gas standard is not law. Markers are new-sales targets; the lines are fleet share, which lags sales by roughly a decade.

This edition therefore models a slower trajectory: 15 per cent of the light fleet electric in 2040, rising to 70 per cent in 2080. The effect is to make the cars ALTO displaces dirtier for longer, which shortens its payback. The change works against the Initiative's own conclusion and has been made for that reason.

It also cuts the other way in one place. Road severance — the permanent detours forced on rural households by the 350 to 700 road closures the corridor requires — is driven by internal combustion kilometres. A slower transition raises those emissions. That effect is roughly an order of magnitude smaller than the modal-shift effect, and both are carried in the consolidated budget.

One caveat is owed to the reader. The life-cycle figure for an electric car is held flat at about 42 g per passenger-kilometre, almost all of it battery and vehicle manufacture — emissions that will themselves fall. Holding them constant is generous to ALTO.

Three things this edition concedes

Research that only ever finds in its own favour is not research. Three changes in this edition work against the Initiative's conclusion and have been made for that reason. The comparison boundary in the March edition was asymmetric, and correcting it improves ALTO's standing; the claim that an electric car is cleaner than ALTO at any ridership level has been withdrawn. The claim that Ontario's grid is getting dirtier over ALTO's operating period has also been withdrawn — the deterioration is real but lands before ALTO carries a passenger. And the repeal of the federal electric vehicle mandate means the cars ALTO displaces stay dirtier for longer, which shortens its payback rather than lengthening it.

The central finding survives all three. It is now stated on the Initiative's central ridership case rather than its lowest, and it is stronger for it. Appendix A records each change, the reason for it, and the direction in which it moves the result.

What ALTO claims, and what it has not published

ALTO's Canada's Moment, published in August 2026, states that the network will remove "about 100,000 cars from the road annually" and that the trains will be "100% electric." The first implies a saving of roughly 400 to 500 kt CO_2e a year; this analysis puts the mature annual saving at about 240 kt on the central case — roughly half.

The second claim is true and incomplete. Electric traction on a clean grid is close to carbon-free; it is the building of the railway that carries the carbon cost, and the building is what ALTO has not quantified in public.

As at November 2026, ALTO has published no lifecycle carbon assessment to a recognised standard, no tunnel or viaduct proportion, no embodied carbon estimate for any material, no winter operations energy plan, no acknowledgement of cold-climate subgrade design or of the Leda clay segment, and no electric vehicle counterfactual. The Parliamentary Budget Officer's October 2026 review supplied part of what was missing on cost; nothing equivalent exists on carbon. Until it does, these figures stand as the only published lifecycle carbon analysis of the corridor — offered as a floor for scrutiny, not a substitute for the assessment the project should have produced.

Appendix A Editorial changes from the first edition

The first editions of these notes were published in March 2026 and prepared for the Alto HSR public consultation, which closed on 24 April 2026. This appendix records every change made for the November 2026 second edition. It is reproduced from the accompanying revisions memo, which sets out the reasoning in full.

A.1 Changes that alter the result

Table A1. Changes that alter the result

#	Change	Effect on the finding
1	Construction carbon is allocated by route-kilometre across the three announced opening phases — Montréal–Ottawa around 2040, Ottawa–Toronto around 2045, Montréal–Québec City around 2050 — rather than incurred at a single opening.	Lengthens payback. Debt is front-loaded; ridership is back-loaded.
2	Ridership is taken from Modal Shift Note 3 (May 2026) year by year, including its ramp, replacing flat 4, 8 and 12 million scenarios.	Re-centres the finding. The March high case was the Initiative's own central case.
3	Average trip distance derived at 430 km at maturity, 440 km for the Toronto–Ottawa–Montréal triangle and 190 km in the Phase 1 window, replacing an asserted 650 km.	Lengthens payback. The 650 km figure was generous to ALTO.
4	Grid intensity modelled as a declining trajectory on the IESO 2025 Annual Planning Outlook, replacing three static scenarios.	Shortens payback. The March claim about the grid is withdrawn for the operating period.
5	Electric vehicle fleet trajectory revised to 15 per cent in 2040 rising to 70 per cent in 2080, following the repeal of the federal mandate.	Shortens payback. Displaced cars stay dirtier for longer.
6	Every comparison reported at two boundaries, applying Chester and Horvath life-cycle multipliers and a vehicle-cycle term for electric cars.	Improves ALTO's comparison. The claim that an electric car is cleaner than ALTO at any ridership level is withdrawn.

Changes 4, 5 and 6 work against the Initiative's own conclusion. They have been made notwithstanding, and are identified as such in the body of this summary and in each note.

A.2 Corrections of record

Four internal inconsistencies have been corrected. All four were artefacts of road severance being folded into the model after the surrounding text was written; three sat in callout boxes.

Table A2. Corrections of record

Where	What was wrong	Correction
Output note §1.2	Fixed operational total given as 45,100 t/yr, against 51,944 t/yr in §3.1	Restated at 51,944 t/yr; the difference was the 6,844 t severance line
EV counterfactual box	Cited 30.8–67.3 g/pkm against 31.7–70.0 g/pkm in the body table	Recomputed; the claim it carried has been withdrawn in any case

Where	What was wrong	Correction
Payback paradox box	15,000 t/yr and a 980-year payback, against 8 kt/yr and >500 years in the body	Rewritten on the corrected fixed total
Output vs severance note	~50 per cent electric fleet at 2045, against a trajectory implying 27 per cent	One trajectory now used across both notes
§5 and §7.1	Short-haul flights at 130 g/pkm in one table and 150 g/pkm in another	Reconciled at 140 g/pkm

The displaced-mode weightings in the March edition rounded 95.25 to "≈100" and 70.8 to "≈73". Both rounds raise the displaced-mode intensity and therefore shorten ALTO's payback. They were conservative, in ALTO's favour, and the second edition says so rather than leaving them to look like loose arithmetic.

A.3 What has not changed

The construction carbon estimates are unchanged at 6.87, 14.69 and 29.60 Mt. The cold-climate construction premium and the Leda clay ground treatment penalty are unchanged. The seven cold-climate operational categories are unchanged. The road severance methodology is unchanged apart from the fleet trajectory. The 17 per cent material-transport share is retained, with the reasoning now stated: it was derived for HS2 and has been questioned elsewhere in the Initiative's work as overstating transport carbon for a rail-served corridor, but ALTO's greenfield alignment has no adjacent railhead for most of its length and a high share is defensible for it.

A.4 Status of the March findings

Table A3. Status of the March 2026 findings

March 2026 finding	Status
Construction carbon of 6.87 / 14.69 / 29.60 Mt	Unchanged. Better supported at the upper end by the PBO cost review.
Cold-climate construction and operational premiums	Unchanged.
Leda clay ground treatment penalty	Unchanged.
Road severance as a permanent, non-abatable category	Unchanged. Detour emissions revised upward.
No carbon payback at 4 million passengers	Withdrawn as a headline; replaced by the central-case result, which is stronger.
An electric car is already cleaner than ALTO at any ridership level	Withdrawn. The comparison was drawn at asymmetric boundaries.
Ontario's grid is getting dirtier over the relevant timeframe	Withdrawn for the operating period. Retained for the Phase 1 window.
ALTO has disclosed no lifecycle carbon assessment	Unchanged. Still outstanding as at November 2026.

Appendix B Sources

Sources used across the four notes and this summary, grouped by subject. Where a figure in this pack rests on a single source, that source is named beside the figure in the note from which it comes.

B.1 ALTO and the Government of Canada

- Alto. Canada's Moment: The Economic Opportunity of High-Speed Rail. 20 August 2026. altotrain.ca
- Alto. Discover Alto's Many Benefits. altotrain.ca
- Transport Canada. Full speed ahead: Ottawa–Montreal chosen as starting point for Alto High-Speed Rail. December 2025. canada.ca
- Major Projects Office. Alto High-Speed Rail — referred project record. canada.ca
- Transport Canada. TRAN Committee Appearance Binder, March 2023 — "complete grade separation" on an alignment with more than 1,000 public and private crossings.
- Alto. Evidence of David Cook, VP Systems Engineering, to Kingston City Council, 17 February 2026 — corridor fencing and the intent to limit the number of overpasses built.
- Government of Canada. VIA High Frequency Rail Joint Project Office business case, 2021 (released under Access to Information, November 2025).

B.2 Independent cost and demand review

- Office of the Parliamentary Budget Officer. Cost estimate for the Toronto–Québec City high-speed rail project. 1 October 2026 — $75–113 billion construction, from a reference class of 94 international projects.
- C.D. Howe Institute. Jones, D. and Fariha, T. All Aboard: The Benefits of Faster, More Frequent Passenger Trains between Ontario and Québec. February 2025 — 3.5 per cent social discount rate, 60-year appraisal.
- McGill TRAM. El-Geneidy et al. Stated-preference ridership projection for the corridor. March 2026.
- Munk School of Global Affairs and Public Policy, University of Toronto. Disclosed logit ridership model with induced demand.
- Flyvbjerg, B. Reference-class forecasting and the empirical record of rail demand overstatement.

B.3 Ontario electricity system

- Independent Electricity System Operator. 2025 Annual Planning Outlook — system emissions rising to a peak near 20 Mt in 2029 and falling to 0.7 Mt by 2050.
- Independent Electricity System Operator. Annual Planning Outlook, Capacity Expansion Scenario, Costs and Emissions Module.
- The Atmospheric Fund. 2024 GTHA Carbon Emissions Inventory — grid intensity of 73.8 g CO_2e/kWh in 2024, a 25 per cent rise on the prior year.
- Canada Energy Regulator. Provincial and Territorial Energy Profiles: Ontario.

B.4 High-speed rail lifecycle assessment

- Chester, M. and Horvath, A. Environmental assessment of passenger transportation should include infrastructure and supply chains. Environmental Research Letters, 2009 — life-cycle multipliers of 1.63 for road and 1.31 for air over operational-only emissions.
- Chester, M. and Horvath, A. Life-cycle assessment of high-speed rail: the case of California. Environmental Research Letters, 2010 — 71-year payback at medium occupancy.
- Chang, B. and Kendall, A. Life cycle greenhouse gas assessment of infrastructure construction for California's high-speed rail system. 2011.

— Chang et al. Lifecycle assessment of the Beijing–Shijiazhuang high-speed rail line. 2019; and the Beijing–Tianjin multi-footprint study.

— Lifecycle assessment of the CRH380BL trainset over 20 years of operation, Beijing–Shanghai.

— International Union of Railways. Carbon Footprint of High Speed Rail, 2011; and Carbon Footprint of Railway Infrastructure, 2016.

— HS2 Ltd. Environmental Statement, 2013; Net Zero Carbon Plan; BBV Carbon Reduction Report, 2024; sustainability statement, 2016; and parliamentary written evidence.

— Madrid–Toledo high-speed line lifecycle assessment, 2023.

— Basque Y project — projected never to achieve lifecycle carbon offset.

B.5 Cold-climate rail engineering

— Liu et al. Frost heave and subgrade performance on the Harbin–Dalian Passenger Dedicated Line. Cold Regions Science and Technology, 2016.

— Niu et al. Frost heave monitoring on the Harbin–Dalian high-speed railway, 2017.

— Miao and Niu. Subgrade frost protection in deep seasonally frozen ground, 2020.

— XPS insulation engineering test, DK140 section, Harbin–Dalian line, 2016.

— Canadian Geotechnical Journal, 2015 — frost depth and seasonally frozen ground in eastern Canada.

— Swedish winter railway operations research on heated switch de-icing and energy consumption.

B.6 Geotechnical — Leda clay and the Champlain Sea

— Natural Resources Canada. Surficial Geology and Sensitive Marine Clay database.

— Natural Resources Canada. Quick Clay research programme.

— Dawson, J.W. Champlain Sea whale bone finds, 1883.

B.7 Road severance and vehicle emissions

— Natural Resources Canada. EnerGuide fuel consumption ratings; average electric vehicle efficiency of 6 km/kWh; diesel emission factor of 2.68 kg CO_2 per litre.

— Environment and Climate Change Canada. National Inventory Report — light-duty fleet emission factors.

— Transport Canada. Greenhouse gas data for heavy and medium-duty vehicles, including school buses.

— Ontario Ministry of Transportation. School Bus Handbook; Student Transportation Services of Central Ontario route guidance.

B.8 Electric vehicle policy and lifecycle

— Government of Canada. Electric Vehicle Availability Standard — repeal posted in the Canada Gazette, August 2026, with a 75-day comment period and no replacement standard in force.

— Office of the Prime Minister. One-year pause of the zero-emission vehicle sales mandate, 5 September 2025.

— Osler, Hoskin and Harcourt LLP. Federal and Québec governments to adjust EV sales mandates, October 2025.

— Gouvernement du Québec. Zero-emission vehicle standard, 2035 target reduced to 80 per cent, June 2026.

— Province of British Columbia. Zero-Emission Vehicles Act, 2035 target reduced to 75 per cent, April 2026.

— International Council on Clean Transportation. Life-cycle greenhouse gas emissions from passenger cars, July 2025 — battery electric vehicle manufacturing footprint.

B.9 Carbon valuation and appraisal

— Environment and Climate Change Canada. Social cost of greenhouse gas emissions — 2 per cent near-term Ramsey discount rate; social cost of CO_2 of $261 per tonne for 2023 emissions in 2021 dollars.

— Treasury Board of Canada Secretariat. Canadian Cost-Benefit Analysis Guide: Regulatory Proposals.

— Metrolinx. Business Case Manual, Volume 2: Guidance.

B.10 Emission factors and materials

— C40 Cities. Railway construction carbon database — concrete at 371 kg CO_2 per cubic metre.

— World Steel Association. Structural steel at approximately 1,900 kg CO_2 per tonne.

— Intergovernmental Panel on Climate Change. 2014 Wetlands Supplement, with 2023 updated emission factors.

— Ontario Nature; International Union for Conservation of Nature. Peatland and wetland carbon storage.

B.11 Citizen Research Initiative companion notes

— Modal Shift Note 3: Ridership envelope for the ALTO corridor, 2035–2080. May 2026.

— Modal Shift Note 1: Rail–air substitution. Modal Shift Note 2: Rail–car substitution.

— Alto HSR Road Severance Technical Analysis. March 2026.

— Community Friction and Cost in HSR: CFI methodology and four-year trajectory.

— Engineering Complexity and Community Friction: a multivariate reference-class analysis of HSR cost.

— The full submission library is at citizenresearch.ca/submissions.

Web sources were consulted to 28 October 2026. Figures attributed to ALTO are taken from its own published materials as at that date.