



Intelligence Briefing.

IRU Green Compact Survey Report 2026

**Decarbonising commercial
road transport: progress
and future pathways**

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**Decarbonising commercial
road transport: Progress
and future pathways**

Prepared in collaboration with Trimble

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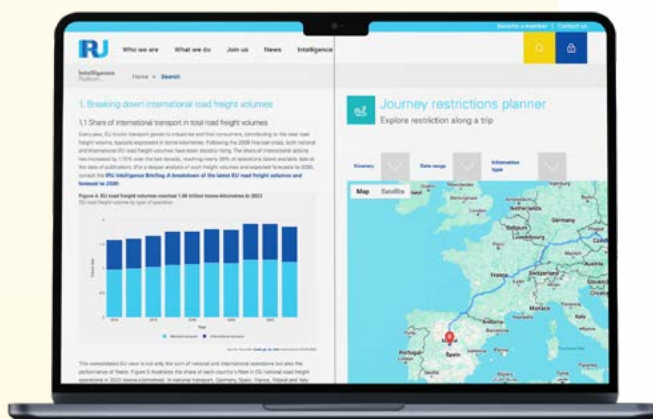
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Continuing to monitor decarbonisation year on year and to voice the concerns of road transport operators in both goods and passenger transport remains essential to building the evidence base that keeps operators' realities at the centre of the debate.

Executive summary

Decarbonisation is being driven more by fuel savings than climate strategy

The IRU Green Compact Report examines the state of commercial road transport decarbonisation and, at its core, reports what transport operators themselves say about it. This 2026 report is the result of close collaboration between IRU and Trimble's Transport & Logistics business segment, and includes the second edition of the annual Green Compact survey, gathering the views of road freight operators in Western Europe, Eastern Europe and Australia. Where other chapters rely on modelling and estimates, the survey tracks what operators have already changed, what they plan to invest in over the next five years, and what is holding them back.

The backdrop to road transport decarbonisation remains demanding. Global greenhouse gas emissions reached about 54.4 GtCO₂e in 2024, a 0.6% rise on 2023 but the smallest yearly increase since 2022. Within that total, transport contributed 8.24 GtCO₂e in 2023, and road transport is the largest source, accounting for 78% of transport emissions. Regulators are responding in very different ways. Brazil combines vehicle programmes with a fuel-side strategy built on biofuels. China pairs tightening standards with generous incentives, producing the fastest uptake of zero-emission commercial vehicles anywhere: new-energy vehicles made up roughly 29% of new heavy-truck sales in 2025. The EU has assembled the most comprehensive framework, combining push measures (HDV CO₂ standards for manufacturers, the Renewable Energy Directive, ETS2, etc) with pull measures such as CO₂-differentiated tolls under the Eurovignette Directive and national incentive programmes. India leans on vehicle standards, biofuel blending and large electric-bus programmes, while the US has moved in the opposite direction, dismantling its federal framework over 2025 and early 2026 and

leaving clean-fuel standards and voluntary commitments as the main remaining drivers.

To support transport operators in this challenge, IRU launched the Green Compact in 2021 to investigate solutions and design pragmatic roadmaps to carbon neutrality by 2050, grounded in a scientific, evidence-based approach and structured around four pillars: efficiencies, alternative fuels, collective mobility and enabling conditions. The annual survey is one of the Green Compact's tools, alongside modelling instruments such as TCO tools, and roundtables that bring operators, shippers, manufacturers and energy providers around the same table.

The report's analytical chapters set out why efficiency acts as a lifeline in a pragmatic transition. Driver training can cut a vehicle's energy consumption by 15% on average; moving from the worst to the best tyres on a long-haul application can deliver up to 30% carbon savings; aerodynamics, lightweighting, modern engines, predictive maintenance and more efficient logistics add further gains, and the Green Compact's 2023 modelling showed a realistic 50% energy reduction from a more efficient transport ecosystem in Europe.

Efficiency alone, however, cannot deliver carbon neutrality: fossil fuels release carbon dioxide, regardless of how efficient transport becomes, so the remaining emissions can only be addressed by changing the energy itself. Renewable diesel's (HVO) carbon emission factor is 88% below that of fossil diesel and can be used with existing engines. Zero-emission vehicles shift the question to the energy system. Nevertheless, these alternative fuels will challenge operators' economic balance and call for a review of how trucks and buses operate today.

What operators reported in the 2026 survey turns this framework into a picture of where the industry actually stands, and the through-line is clear: decarbonisation is being driven more by fuel savings than climate strategy. Action runs well ahead of commitment. Nine in ten European operators already take at least one measure to cut emissions, yet only around four in ten have set a reduction target or can put a figure on what they emit. The measures they reach for first are the ones that pay for themselves: optimising routing, cited by well over half of European operators, along with eco-driving and fuller loads, all of which cost little and cut fuel.

The fact that the levers operators say would move them furthest are financial, with a customer price premium ahead of any regulation or mandate, confirms the pattern: decarbonisation advances where it makes commercial sense. The harder question is what comes next, once those free wins are exhausted and every further step requires capital.

On that question the survey is unambiguous: what moves operators is money, not mandates. Financial levers, a price premium from customers and government incentives rank far above regulation, information or advice in operators' own accounts of what would drive them to act. The same logic runs through the barriers, where cost dominates in every region. Its sharpest sign is the rise of the vehicle's own price as the leading obstacle to alternative fuels, cited by two in three Western European operators and nearly four in five in Eastern Europe, up sharply on 2025 and now ahead of the infrastructure gap that led the previous survey. The binding constraint has shifted from the refuelling network to the upfront cost of the vehicle, a reframing that puts capital, not infrastructure, at the centre of the debate.

That is also why the fuel switch is following the path of least resistance. Renewable diesel leads operators' plans in every region as it works with existing engines and refuelling infrastructure. In Western Europe, the share planning to use it climbs from 29% today to 54% within five years. Australian operators also plan greater use of both renewable diesel (3% currently to 14% planned) and electricity (4% to 13%). A diesel fleet, in other words, can begin to decarbonise through its fuel alone. The move to battery-electric, though real and growing, advances more cautiously and concentrates first where it fits best: among larger operators and on shorter, depot-based routes. Two routes to a lower-emission fleet are running in parallel, and operators are choosing the one with the lower activation energy.

A regional pattern runs through every one of these findings, from commitment and measurement to fuels and fleet age: Western Europe consistently leads, Eastern Europe follows with its own distinct, customer-driven profile, and Australia remains the most committed to diesel. Company size tells a parallel story, separating the operators already investing from those still holding back.

A final theme cuts across all of it: operators know the rules are coming but rarely grasp what they require. Across the major European regulations tested, only around one in eight operators say they understand a given rule well, and understanding is thinnest precisely where the coming cost impact will land hardest, on the carbon price that will raise the cost of diesel from 2028.

Taken together, the 2026 survey delivers a consistent message: operators are willing, the first steps are taken, and the pace of what comes next will be set by who carries the cost of the vehicle, and of the energy that follows the easy wins. ■

Across the major European regulations covered, only around one in eight operators say they understand a given rule well

Chapter 1

Introduction

The Paris Agreement aims to limit the rise in average global temperature to below 2°C above pre-industrial levels, ideally to 1.5°C.

All industries, including road transport, are transitioning. Today, trucks and buses rely on fossil fuels, primarily diesel, to power the transport of goods and passengers on roads. Fossil fuels offer several advantages: they are stable under ambient conditions, easy to distribute, relatively inexpensive and widely available. Shortcomings, such as pollutant emissions, have now been almost completely resolved with advanced exhaust gas treatment and higher fuel quality, at least in advanced economies. However, the use of fossil fuels in combustion engines inherently emits carbon dioxide.

Decarbonisation presents the road transport industry with some of its greatest challenges and opportunities

Decarbonisation presents the road transport industry with some of its greatest challenges and opportunities. The current structure of the industry has evolved gradually since the early 20th century. Over time, new practices and technologies have emerged, reducing vehicles' total cost of ownership (TCO), improving reliability and uptime, and shortening delivery times. However, the rapid change needed to achieve carbon neutrality by 2050 is unprecedented for an industry already grappling with other challenges, such as driver shortages, capacity expansion and digitalisation efforts.

While there is a global commitment to reduce greenhouse gas (GHG) emissions, progress varies worldwide. Other political and economic crises also affect efforts. Some regions have more resources to deploy decarbonisation solutions, while others face greater constraints. Each country tackles decarbonisation from a different starting point, with varying access to carbon-free energy at viable prices and quantities.

IRU, the world road transport organisation, helps transport operators, suppliers and regulators decarbonise with the Green Compact. This report presents the current state of carbon emissions and available decarbonisation solutions for commercial road transport. It provides a snapshot of progress made by transport operators, freight forwarders and fleet-owning shippers. The report also presents concrete and successful decarbonisation strategies from IRU members and examines the road ahead. ■



Chapter 2

Carbon emissions: context

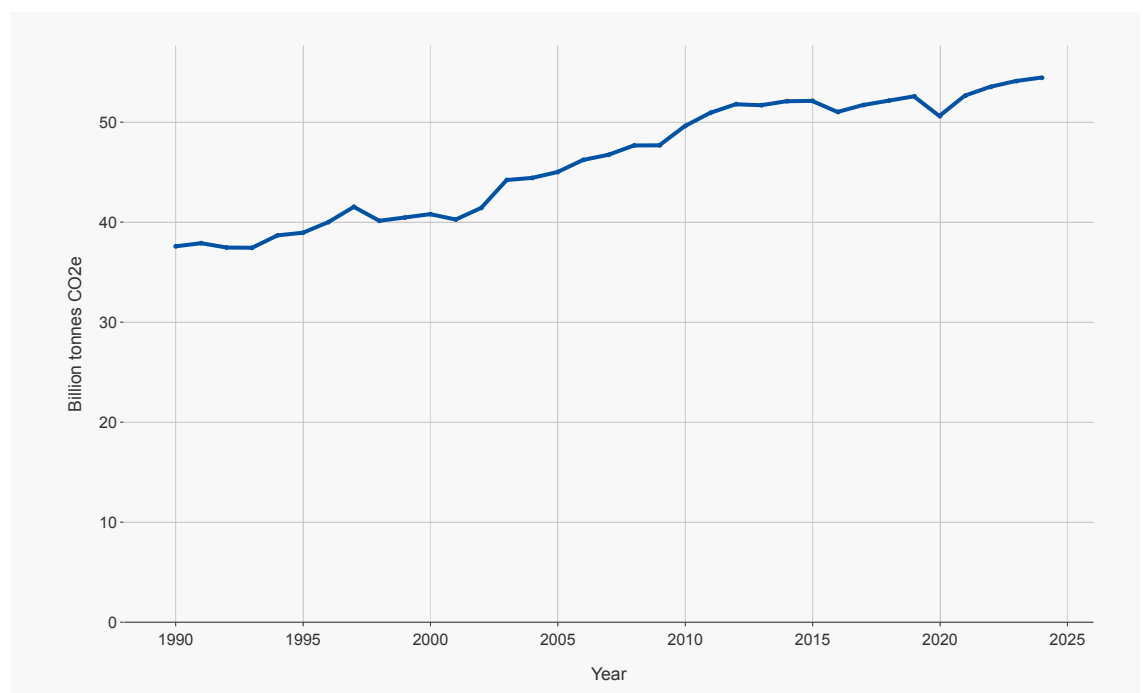
Decarbonisation aims to remove GHG emissions from activities or processes. These include carbon dioxide (CO₂), methane (CH₄), dinitrogen oxide (N₂O) and ozone (O₃), among others (water vapour, etc) which are naturally present in the earth's atmosphere.

However, human activities have been releasing more GHG molecules into the atmosphere, disrupting the climate's balance. About 54.4 GtCO_{2e} of GHG were emitted in total in 2024, a 0.6% rise on 2023, but the smallest yearly increase since 2022, confirming a continued slowdown in global emissions growth.

Figure 1: Global GHG emissions have reached 54 gigatonnes of CO₂ equivalent

Global GHG emissions, 1990-2024

Source: [Jones et al. \(2025\)](#) – with major processing by Our World In Data



What is CO_{2e}?

GHG emissions are typically expressed in CO₂ equivalent (CO_{2e}). This standardised unit accounts for the impact of various GHGs, not just CO₂. Scientists convert the effects of other gases into their CO₂ equivalent, enabling easier comparison of different GHGs.

At the country and regional level, China was the largest emitter in 2024, and Oceania the smallest. The EU and the US reduced their emissions by 38% and 7%, respectively, between 1990 and 2024, while Chinese and Indian emissions rose by 235% and 179%, respectively.

Within global GHG emissions, transport contributed 8.24 GtCO_{2e} in 2023.¹ Road transport was the largest source, accounting for 78% of transport emissions in 2020,² of which passenger transport (including buses) made up roughly two-thirds, and freight, primarily carried by trucks,

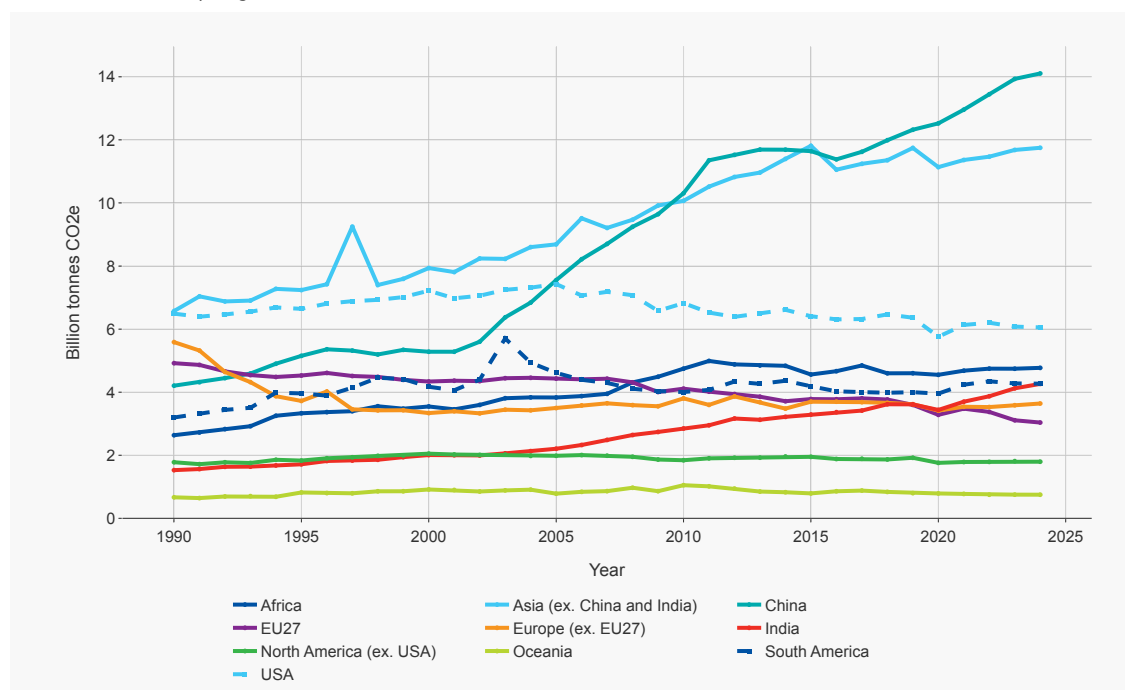
Measuring CO_{2e} emissions

There are three main approaches to measuring CO_{2e} emissions in transport, each widening the boundary of what is counted: tank-to-wheel (TTW), well-to-wheel (WTW), and life-cycle analysis (LCA). TTW covers only vehicle emissions, such as tailpipe emissions from a diesel engine. WTW extends this to fuel-related emissions from extraction, production and distribution – for example, emissions from oil refining or the production of electricity. LCA goes further, adding emissions from the manufacturing of the vehicle itself and building the infrastructure needed to supply its fuel or electricity.

Figure 2: GHG emissions reached 14 gigatonnes in China in 2024

GHG emissions by region, 1990-2024

Source: Jones et al. (2025) – with major processing by Our World In Data



1 <https://ourworldindata.org/grapher/CO2-emissions-transport>

2 SLOCAT, Transport and Climate Change Global Status Report – 3rd edition, 2023

the remaining third. These estimates, based on a tank-to-wheel approach, exclude GHG emissions stemming from the production and distribution of fuel.

These GHG emissions are based on modelling estimates, which may differ significantly from actual values. To better gauge the challenge, it is crucial to isolate emissions from trucks and buses. The Intergovernmental Panel on Climate Change (IPCC) guidelines³ provide a framework for collecting and analysing this data.

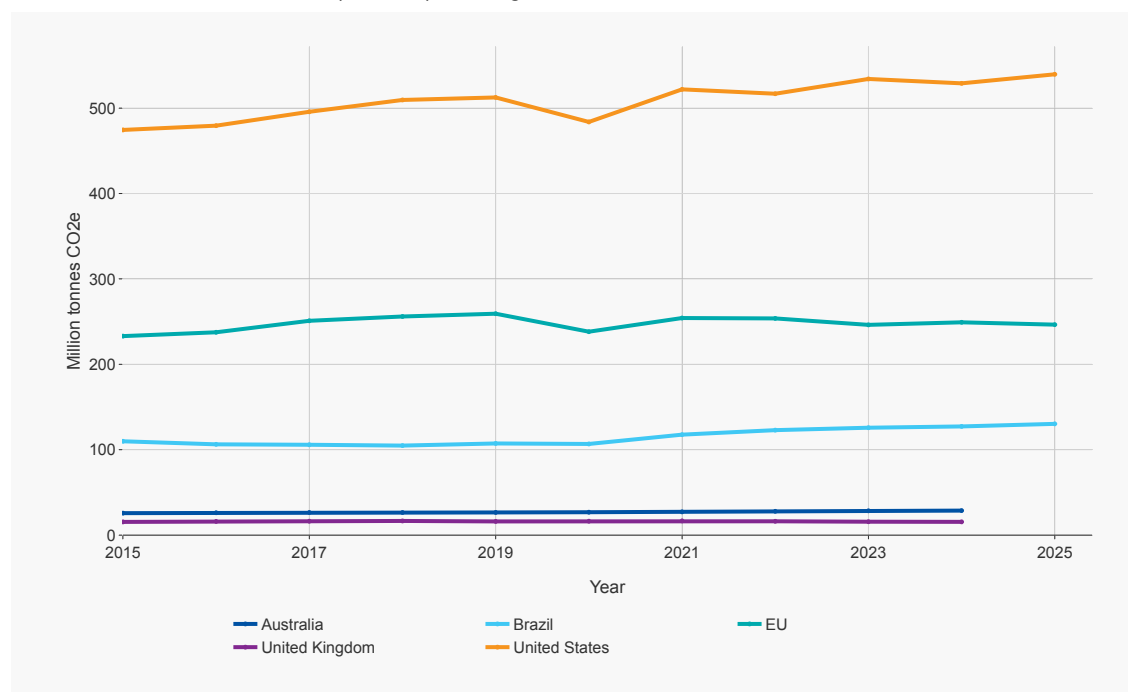
Using this framework, Brazil, the EU and the US now offer a detailed

view of their emissions, specifically for trucks and buses. In 2025, US-registered trucks emitted 0.54 GtCO₂e WTW,⁴ while EU ones emitted 0.25 GtCO₂e WTW,⁵ These absolute figures should be looked at with road transport volumes in mind. The US has approximately twice the road freight volume of the EU. IRU estimates that emissions from Chinese trucks are closer to US figures, due to a sharp increase in China's road freight volume, despite national efforts to transition towards ZEVs. Brazil, on the other hand, produces around half the truck emissions of the EU despite comparable road freight volumes, thanks to widespread biofuel use. ■

Brazil generates around half the truck emissions of the EU, despite comparable road freight volumes

Figure 3: Truck GHG emissions

Annual truck GHG emissions by country and region



Source: IRU estimates and national statistics for US, EU, UK, Australia and Brazil

3 https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf

4 <https://climateprogramportal.org/wp-content/uploads/2025/02/Fast-Facts-US-Transportation-Sector-GHG-Emissions-1990-2022.pdf>

5 <https://www.eea.europa.eu/en/datahub/datahubitem-view/3b7fe76c-524a-439a-bfd2-a6e4046302a2?activeAccordion=1095700>

Chapter 3

Decarbonisation regulatory approach by region

Countries have pledged to reduce their carbon emissions to limit global warming to 1.5°C, requiring an 84% reduction from 2019 figures.⁶ These pledges require efforts from all sectors, including commercial road transport. However, while most of these pledges mention transport, only a third include an emissions reduction target for the sector.⁷

National and regional authorities are working to find the right balance of measures and regulations to incentivise industries to decarbonise. Regulations can be divided into push (penalising CO₂ emissions) and pull measures (incentivising decarbonisation efforts).

The next sections detail the approach taken for commercial road transport in Brazil, China, the EU, India and the US (see Table 1).

3.1 Brazil

Brazil has placed decarbonisation high on its agenda, pledging to cut net GHG emissions by 59–67% below 2005 levels by 2035, and to reach net-zero emissions by 2050. Transport is the largest source of Brazil's energy-related CO₂ emissions, and freight transport is overwhelmingly road-based, accounting for around 60% of the country's freight volumes.⁸

To bend the curve, the federal government has built a set of regulations around both vehicles and fuels. Given the size of Brazil's market, notably relative to its neighbouring countries, its approach can define the broader South American decarbonisation strategies.

On the vehicle side, the push comes from two instruments. The first, PROCONVE, is Brazil's long-standing vehicle-emissions programme, run by the national environment

council (CONAMA). Its latest phase for heavy vehicles, PROCONVE P8, is equivalent to Europe's Euro VI: it caps pollutants and has applied to all new trucks and buses sold since January 2023. The second, the MOVER programme (the Green Mobility and Innovation law of 2024, which replaced Rota 2030), is closer to a CO₂ and efficiency standard. It makes energy-efficiency, technology and labelling requirements mandatory for new vehicles, on a well-to-wheel basis, supported with fiscal levers (lower industrial-products tax (IPI) for compliant vehicles and higher rates for the others), alongside up to BRL 19.3 billion in innovation credits through 2028.

The heart of Brazil's strategy, though, is on the energy side. Brazil is already a significant producer of biofuel (FAME). Brazilian trucks leverage this technology to lower their

Brazil's road transport decarbonisation strategy centres on biofuels, combining carbon intensity targets with increasingly ambitious biodiesel and ethanol blending requirements

⁶ https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_FullVolume.pdf Table SPM. 1

⁷ <https://www.itf-oecd.org/ndc-tracker/en>

⁸ https://www.epe.gov.br/sites-en/publicacoes-dados-abertos/publicacoes/PublicacoesArquivos/publicacao-237/Atlas2021_EN_2022_02_04.pdf



Workers update a fuel price board at a petrol station in Marília, São Paulo, Brazil, 16 April 2026

carbon intensity. RenovaBio, Brazil's national public policy designed to expand the use of clean biofuels and cut carbon emissions in the transport sector, sets annual carbon intensity reduction targets for fuel distributors that meet them by retiring tradeable decarbonisation credits issued to certified biofuel producers. Brazil also has the Future Fuel Law (Combustível do Futuro, 2024), which raises the biofuel content of road fuels directly. Since August 2025, diesel must contain 15% biodiesel (B15) and gasoline 30% ethanol (E30), with the law allowing these blends to rise to B25 and E35 as technical conditions permit, and opening the door to green diesel, sustainable aviation fuel and biomethane.

On the pull side, the focus is increasingly on zero-emission vehicles. The federal development bank, BNDES, is the main financing channel. In late 2025, a USD 500

million programme backed by the World Bank and Caixa began funding a national credit line to replace diesel city buses with electric ones, and to upgrade depots and grids accordingly. Several cities, São Paulo notably, have passed laws requiring their bus fleets to phase out fossil fuel emissions over the coming years, giving operators a firm reason to switch.

At the same time, Brazil is using industrial policy to build a domestic zero-emission-vehicle industry: the import-tax exemption that electric vehicles once enjoyed is being phased out, with tariffs climbing back to 35% by 2026–27, on the expectation that manufacturers will produce locally rather than import. MOVER's tax reductions for efficient and flex-fuel models add a further financial incentive for buyers to invest in more efficient powertrains.

3.2 China

China is currently the world's largest GHG emitter. It aims to peak emissions before 2030 and achieve carbon neutrality by 2060. The latest reports suggest that Chinese emissions might have already peaked in 2025, with emissions in transport falling by 3%,⁹ leveraging a mix of vehicle standards and generous incentives that have produced the fastest uptake of zero-emission commercial vehicles anywhere.

On the push side, China regulates trucks and buses on two tracks. Fuel-consumption limits (the GB 30510 series) cap how much fuel a new vehicle model may use and tighten with each phase. The latest, Phase IV, has applied to new vehicle type-approvals since July 2025 and is 10% stricter than its predecessor, Phase III. There is also the China VI emissions standard, in force since 2023, which is similar to the EU's Euro VI requirements.

However, the real driver behind ZEV registrations is on the pull

side, anchored by the New Energy Vehicle (NEV) policy in place since 2009. Buyers of electric trucks and buses are exempt from purchase tax (fully through 2025, then at half rate in 2026–2027) and successive "trade-in" schemes pay operators up to RMB 140,000 to scrap an old diesel truck and buy a NEV, a programme renewed again for 2026. In June 2026, Beijing went further, setting its first explicit target for commercial road transport: 40% of new heavy trucks (12 tonnes and above) sold should be NEVs by 2030, backed by "zero-carbon" freight corridors and a national charging and battery-swapping network.

Battery swapping is itself a distinctively Chinese lever: dedicated heavy truck swap stations have spread quickly, supported by a new national safety standard. They allow trucks to exchange a depleted pack for a charged one in minutes. As a result, NEVs made up roughly 29% of China's new heavy truck sales in 2025, peaking at nearly 54% in December.

China aims for new energy vehicles to account for 40% of new heavy-truck sales by 2030

Workers assemble new energy vehicles at a Geely Remote production facility in Jinzhong, Shanxi Province, China, 28 August 2026



9 <https://www.carbonbrief.org/analysis-chinas-CO2-emissions-have-now-been-flat-or-falling-for-21-months/>

3.3 European Union

The EU has made decarbonisation a priority in recent years. By 2024, the EU had reduced its GHG emissions by 38% compared to its 1990 baseline,¹⁰ keeping the bloc largely on track to meet its interim target of a 55% reduction by 2030 before achieving carbon neutrality in 2050. Commercial road transport is, however, going in the opposite direction. With road freight volumes doubling during this period, operational efficiency has limited GHG emissions increases to 28%, a growing number that could add more pressure on the sector to decarbonise.

The European Commission has several regulations addressing the trucking and bus sector. As EU truck manufacturers export their products and technologies, the EU approach to decarbonisation influences not only bordering countries but other regions as well.

The EU has created a set of regulations acting as push measures, impacting vehicle production and energy systems, pushing transport operators away from fossil fuel-based powertrains. The two foundation texts on the vehicle side are the Euro Norms and CO₂ standards for trucks and buses. Euro Norms do not regulate CO₂ emissions directly but mitigate other pollutants, some of them belonging to the GHG family, such as methane (CH₄) and dinitrogen oxide (N₂O).

The latest Euro 7 regulation now also regulates battery durability and battery health inspection for newer vehicles. CO₂ standards regulate vehicle manufacturers' sales mix, assessing CO₂ sales performance by looking at the CO₂ performance of the vehicles sold. Vehicle manufacturers must report on the type of vehicle sold and their

emissions based on modelling. VECTO, a calculation tool, has been designed to provide a common and transparent tool for all manufacturers.

Emissions are assessed based on vehicle characteristics and mission profiles. After setting a baseline for each manufacturer (2019–2020 sales), each manufacturer has a time-based set of targets to meet on CO₂ reduction, incentivising them to move their offer towards ZEVs. This approach allows for the acceleration of ZEV technology development, but it does not address the enabling conditions required to use such vehicles, which is being done by the Alternative Fuels Infrastructure Regulation (AFIR).

AFIR requires countries to deploy a minimum number of public electric charging stations and hydrogen refuelling stations along the Trans-European Transport Network (TEN-T). AFIR is part of the set of regulations targeting the energy system, with the Renewable Energy Directive requiring, among other things, the decarbonisation of fossil fuels by mixing with renewable fuels and the decarbonisation of electricity production, and the Energy Taxation Directive, aiming to harmonise energy taxation at the EU level. The last significant piece of legislation is called the Emissions Trading System 2 (ETS2), which will set a carbon price for road transport fuel starting 2028, a price which can be traded on a stock exchange-like system.

For transport operators, push measures have been set on tolls (Eurovignette), setting up fee differentiation based on VECTO results for trucks, with more CO₂-intense vehicles paying higher toll rates than ZEVs.

Overall EU emissions have fallen, but commercial road transport emissions have risen by 28%, despite road freight volumes doubling

¹⁰ <https://www.eea.europa.eu/en/datahub/datahubitem-view/3b7fe76c-524a-439a-bfd2-a6e4046302a2?activeAccordion=1095998>

Hydrogen refuelling station in Milan, Italy, 30 June 2025



The EU is also working on pull measures. The same Eurovignette revision has significantly reduced toll rates for ZEVs, making them more cost-effective. CountEmissionsEU sets a common method for operators and shippers that report their CO₂ emissions, so that carbon reduction can be built into procurement decisions. Revenues from ETS2 will be channelled into the Social Climate Fund, which will help smaller businesses access decarbonisation solutions. The EU is also adapting

its current policies, such as the revision of the Weights and Dimensions Directive, to partially compensate for ZEV limitations.

At the national level, EU countries are introducing pull measures for transport operators to invest in and use low- and zero-emission vehicles, such as purchase subsidies, tax reductions linked to vehicles, and financial help schemes to build private charging stations.

3.4 India

India has set out a long-term climate path while insisting on room to grow. Its 2022 pledge is to cut the emissions intensity of its economy by at least 45% by 2030 (from 2005 levels) and to reach net-zero by 2070. As elsewhere, transport runs against the trend: it accounts for about 14% of India's GHG emissions, with medium and heavy trucks making up roughly 44% of that, despite accounting for only 3% of vehicles on the road.

With one of the world's largest and fastest-growing commercial vehicle markets, and with freight being overwhelmingly carried by road, India's choices for trucks and buses matter well beyond its borders.

To bend the curve, the government leans on vehicle standards, fuel policy and direct support for electrification, with a strong emphasis on manufacturing at home.

On the vehicle side, the push has two instruments. Bharat Stage VI, India's equivalent of Euro VI, was rolled out nationwide in April 2020 and tightened in April 2023 with a second phase adding real-driving-emissions and on-road conformity testing. Like the Euro Norms, it caps pollutants rather than CO₂. Fuel economy is handled separately by the Bureau of Energy Efficiency, whose fuel-consumption standards for heavy vehicles have applied since 2018. A much tighter second phase (30% more stringent and extended to cover buses and lighter commercial vehicles) is proposed to phase in between 2027 and 2032. But it still remains at the draft stage.

On the energy side, India's headline achievement is biofuels: it reached 20% ethanol blending in petrol (E20) in 2025, roughly five years ahead of the original target. The parallel biodiesel programme (a 20% blend target) has moved far more slowly.

Just like in China, the real driver of change sits on the pull side, and on buses in particular. Building on the earlier FAME schemes, the PM E-DRIVE programme (2024, around INR 10,900 crore, or USD 1.3 billion) channels the largest single share of its budget into electric buses, funding the purchase of some 14,000 buses for major cities, and for the first time has allocated money to incentivise electric trucks, tied to the scrapping of old diesel vehicles.

A companion scheme, PM e-Bus Sewa, uses a payment-security mechanism to underwrite around 38,000 electric buses in smaller cities through the end of the decade. Underpinning all of this is an industrial ambition: through "Make in India" manufacturing incentives and preferential tax treatment for electric vehicles, the country is trying to build its buses, trucks and batteries at home.

Medium and heavy trucks account for roughly 44% of India's transport emissions



Electric bus and auto rickshaw on National Highway 44 in Bengaluru, India, 18 November 2025

3.5 United States

The US stands apart from the other regions in this chapter: its federal direction reversed in 2025 and early 2026. It notified its withdrawal from the Paris Agreement on 27 January 2025; the withdrawal took effect on 27 January 2026, beginning the dismantling of the federal framework for road transport decarbonisation and leaving individual states to lead the effort.

At the federal level, the push measures have been undone. The Environmental Protection Agency's (EPA) Phase 3 GHG standards, adopted in 2024 to cut CO₂ from new trucks by up to 60% for vocational vehicles and 40% for new tractors by 2032, were put under reconsideration in March 2025. In February 2026 the EPA went to the root of its authority, rescinding the 2009 "endangerment finding" that underpinned federal GHG rules for vehicles and repealing the vehicle CO₂ standards built on it. Legal challenges from both environmental groups and parts of industry mean the final position may take years to settle.

California has historically gone further than federal-level requirements, using a special Clean Air Act waiver to set its own rules: Advanced Clean Trucks, requiring rising shares of zero-emission truck sales; Advanced Clean Fleets, pushing large fleets to buy them; and a Heavy-Duty Omnibus rule on NO_x. Several states have adopted California's truck rules and signed a memorandum of understanding targeting 100% zero-emission sales of new medium- and heavy-duty vehicles by 2050. In 2025, that structure was cut down: Congress used the Congressional Review Act to revoke California's federal waivers

for Advanced Clean Trucks, Advanced Clean Cars II and the Heavy-Duty Omnibus, and the President signed the resolutions on 12 June 2025. California had already paused the Advanced Clean Fleets waiver earlier in the year. Without their waivers, these rules cannot be enforced, though California disputes the move's legality and litigation continues; a voluntary "Clean Truck Partnership" between the state and manufacturers has survived as a softer commitment.

One state lever remains untouched because it does not need a federal waiver: California's Low Carbon Fuel Standard, which sets declining carbon-intensity targets for transport fuels and lets clean-fuel producers sell credits to suppliers that fall short. Amendments that took effect in 2025 tightened the trajectory to a 30% cut in carbon intensity by 2030 and 90% by 2045, a mechanism that is close in spirit to the EU's fuel-side measures and to Brazil's RenovaBio.

On the pull side, the main federal incentive has also been withdrawn. The One Big Beautiful Bill Act of July 2025 cut short two Inflation Reduction Act tax credits. The clean commercial vehicle credit ended for vehicles acquired after 30 September 2025. That came roughly seven years earlier than originally legislated. The charging and refuelling infrastructure credit lasted nine months longer. It ended for property placed in service after 30 June 2026. The net effect is that the US has swung from a federal-plus-state blend of push and pull measures to federal deregulation, with California's toolkit curtailed and clean fuel standards and voluntary commitments left as the main remaining drivers.

The US reversed its federal approach to road transport decarbonisation in 2025 and early 2026, dismantling key policies and shifting leadership to states

The table below maps where each region stands, and brings out both the gap in pace, four regions advancing while the US retreats, and where each applies its pressure.

Some target the manufacturers that build the vehicles, others the suppliers that provide the fuel, or the operators that run the fleets. ■

Table 1. Summary of regional decarbonisation frameworks

Region	Direction	Push measures	Pull measures	Key programmes and detail
Brazil	Advancing, fuel-led	<ul style="list-style-type: none"> • PROCONVE P8 (pollutants) • MOVER (efficiency and CO₂ emissions) 	<ul style="list-style-type: none"> • Biofuel mandates • BNDES finance • BEV bus credit lines 	<ul style="list-style-type: none"> • B15 diesel / E30 petrol blends rising to B25 / E35 • RenovaBio credits • Electric bus programme • Local-industry tariffs to 35%
China	Advancing fastest	<ul style="list-style-type: none"> • GB 30510 fuel limits (Phase IV) • China VI standard 	<ul style="list-style-type: none"> • NEV purchase-tax exemption • Trade-in grants • 2030 NEV truck target 	<ul style="list-style-type: none"> • Financial subsidies to scrap-and-replace diesel for electric trucks • 40% of new heavy trucks to be NEVs by 2030 • Battery-swapping network
EU	Advancing comprehensive	<ul style="list-style-type: none"> • CO₂ standards • Euro 7 • ETS2 in 2028 • CO₂-based tolls (Eurovignette Directive) 	<ul style="list-style-type: none"> • Toll reductions for ZEVs • CountEmissionsEU • Social Climate Fund • National subsidies 	<ul style="list-style-type: none"> • AFIR charging/infrastructure network • Renewable Energy Directive • Weights and dimensions revision for ZEVs
India	Advancing, bus-led	<ul style="list-style-type: none"> • Bharat Stage VI • Fuel-economy standards (Phase 2 draft) 	<ul style="list-style-type: none"> • PM E-DRIVE • PM e-Bus Sewa • 'Make in India' incentives 	<ul style="list-style-type: none"> • E20 petrol reached 2025 • Financial subsidies for electric-bus • Electric-truck incentives tied to scrappage
US	Reversal at federal level	Federal standards repealed 2025-26	Commercial vehicle credit ended September 2025; charging credit ended June 2026	Left to states' own initiatives <ul style="list-style-type: none"> • California's LCFS (fuel-side) survives

Chapter 4

The IRU Green Compact

IRU launched the Green Compact in 2021 to identify solutions and develop pragmatic roadmaps to achieve carbon neutrality in road transport by 2050

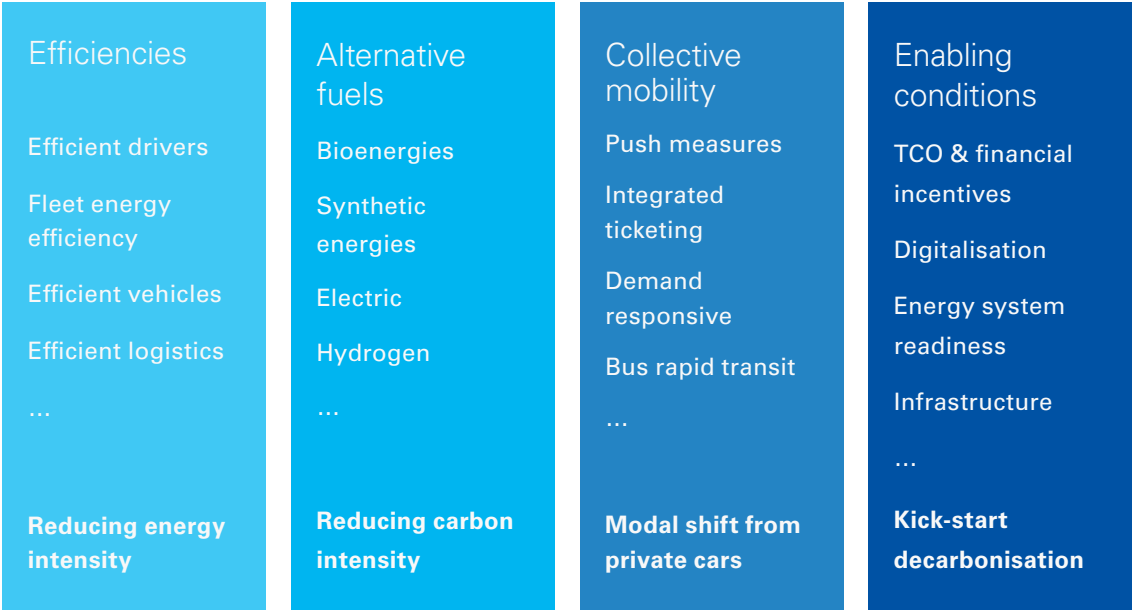
The environment is one of IRU’s core focus areas, with its importance steadily increasing in recent years. As a commitment to address the decarbonisation challenge, IRU launched the Green Compact in 2021 to investigate solutions and design pragmatic roadmaps to reach carbon neutrality by 2050.

As the pace of changes required by decarbonisation is unprecedented for the road transport industry, clarity and robustness are mandatory to meet operators’ needs. This is why the Green Compact is grounded in a scientific, evidence-based approach, applied to the analysis of transport operations, the investigation of decarbonisation levers, and the forecasting of market potential – always with a focus on economic sustainability.

The Green Compact research is based on four pillars: efficiencies, alternative fuels, collective mobility, and enabling conditions.

The “efficiencies” pillar covers all best practices and technologies to reduce the energy intensity of commercial road transport, or the amount of energy needed to move people (energy per passenger-kilometre) and goods (energy per tonne-kilometre). Efficiencies can come from more efficient drivers, with eco-driving, feedback technologies, semi and full autonomous driving and drivers’ readiness to take advantage of new powertrains. They also come from more efficient vehicles, not only for new models but also for the running fleet, involving efforts to reduce tyre rolling resistance, aerodynamic drag, frictions and vehicle kerb weight.

The Green Compact pillars



Finally, efficiencies can be found with logistics and its interactions with road transport. Available solutions include eco-trucks, load consolidation, and advanced routing software.

Alternative fuels include all energy sources that trucks and buses can use to power their journeys, provided they have a lower well-to-wheel carbon emission factor than diesel. The Green Compact focuses on electric vehicles, hydrogen powertrains, biofuels, biogas, and synthetic fuels. IRU research particularly emphasises energy availability, impacts on transport operations and energy prices, while also considering each country's decarbonisation potential.

Collective mobility is a Green Compact pillar specific to buses, coaches and taxis, as it groups all practices and technologies to increase their occupancy ratio by incentivising a modal shift from private cars, as buses have a lower carbon intensity per passenger-kilometre. The pillar also studies the effectiveness of regulatory push and pull measures in reducing car use.

Finally, the enabling conditions pillar groups research and monitoring efforts on the enabling conditions to power the transition. It includes work on TCO comparison, green financial schemes available to transport operators, grid and energy systems' readiness to power greener trucks and buses as well as efforts to leverage the digitalisation of road transport to facilitate energy improvements and greater cooperation between companies.

A few other decarbonisation levers fall outside the scope of the Green Compact, such as carbon capture and offsetting. Carbon capture involves capturing carbon dioxide either at emission points like tailpipes (point-source capture) or directly from the atmosphere (direct air capture). Offsetting is a strategy to compensate for one's own GHG emissions by supporting indirect emissions reductions elsewhere.

The Green Compact is developing several tools to work on pragmatic ways to reduce carbon emissions while meeting transport demand. The first set of tools is the product of constant research efforts which are creating modelling tools looking at carbon emissions from both micro (vehicles' usage) and macro levels (industry energy systems). Building on this modelling base, IRU disseminates data and guidance to help transport operators and stakeholders decarbonise, providing proven guidance and status information for improved decision-making. This survey is part of this second set of tools.

Finally, IRU has activated its strong network to facilitate talks between stakeholders, harmonising efforts and fostering greater cooperation in the transport ecosystem. IRU has been organising Green Compact roundtables for two years, addressing the needs of operators, shippers, manufacturers, energy providers, and suppliers seeking greater visibility on decarbonisation. ■



IRU combines modelling, practical guidance and industry cooperation to help road transport operators and stakeholders make informed decarbonisation decisions

Chapter 5

Best practices and technical levers to decarbonise

Operators can cut carbon emissions through greater efficiency and by switching to alternative fuels with a lower carbon intensity

Trucks and buses rely largely on fossil fuels to move goods and passengers by road. These fuels offer real advantages: they are stable at ambient conditions, easy to distribute, low in cost and widely available on the market. Their main drawback, pollutant emissions, has been substantially reduced in advanced economies thanks to advanced exhaust-gas treatment and higher fuel quality. However, the burning of carbon-based fossil fuels in combustion engines inherently releases carbon dioxide.

Industry stakeholders nonetheless have several levers to cut these emissions. Because carbon emissions are directly linked to fuel consumption, operators can reduce consumption through efficiency gains, with better-trained drivers, more efficient vehicles and smarter logistics. They can also address emissions at the source by switching to alternative fuels which have a lower carbon intensity.



5.1 Efficiencies

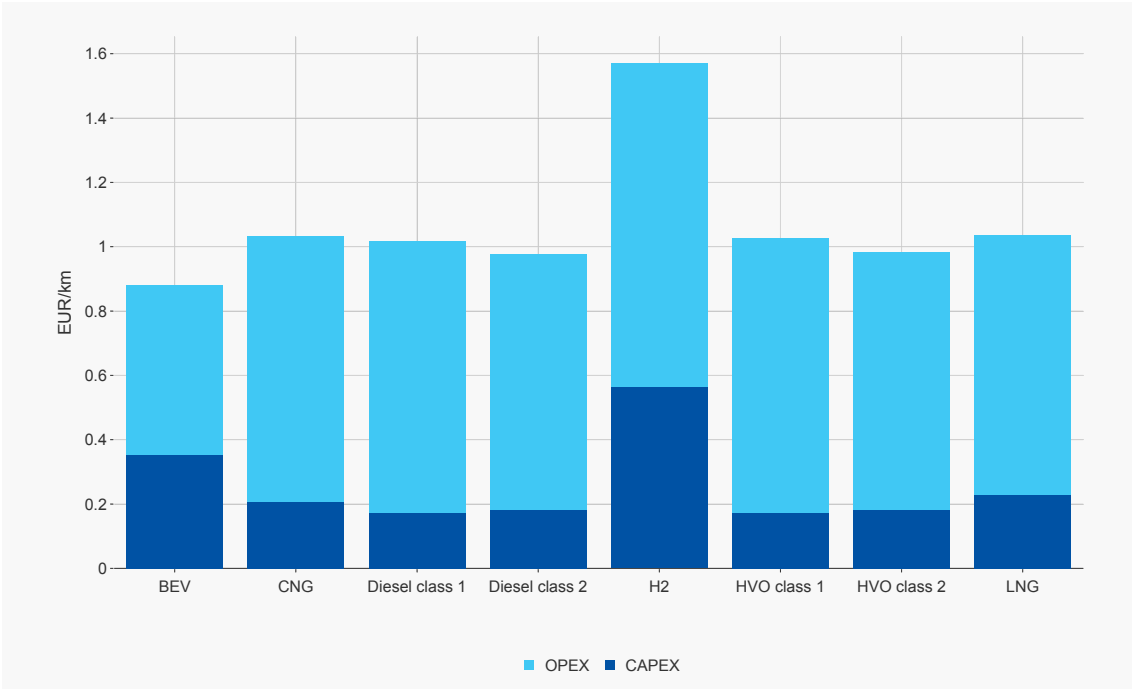
The most significant outcome of the Green Compact was to show that a pragmatic approach to decarbonisation, in an industry constrained by freight rates and capacity, is to leverage efficiencies to lower energy consumption, easing the switch to alternative fuels by compensating extra energy costs and operational limitations.

But efficiency alone is not enough. Economic experience shows a rebound effect: when efficiency lowers the effective cost per unit of transport, part of the savings is offset by higher demand rather than translating fully into lower consumption. Efficiency therefore reduces energy use per tonne-kilometre, but does not on its own guarantee a fall in absolute emissions.

Meeting the decarbonisation challenge will therefore also require alternative fuels. Many alternative powertrains still carry a higher total cost of ownership (TCO) than diesel. Vehicle prices, residual values, energy prices and energy consumption drive the gap. These vehicles also need new charging or refuelling infrastructure. The German scenario in Figure 4 shows a different picture. Under its policy and operating assumptions, battery-electric trucks cost EUR 0.88 per kilometre. This is where efficiency proves decisive: by cutting energy consumption or the number of vehicles needed to meet transport demand, it mitigates the expected rise in TCO and makes the transition affordable.

Efficiency can mitigate rising TCO by reducing energy consumption and the number of vehicles needed to meet transport demand

Figure 4: Cost structure by powertrain for 13-tonne payload in Germany
Long-haul use; capital and operating costs



Source: IRU Intelligence - Alternative vs traditional truck powertrains in the EU: Total cost of ownership 2024

5.1.1 Efficient drivers: the human side of decarbonisation

Driver training can reduce a vehicle’s energy consumption by around 15% on average, while the penalty from an untrained driver is open-ended

Drivers are the backbone of road transport. Until autonomous vehicles become mainstream, it is impossible to move vehicles and goods without them. Drivers are also a powerful decarbonisation lever. Through eco-driving, drivers play a key role in reducing energy consumption, for both diesel and alternative fuel trucks alike.

Energy consumption depends on many parameters, notably vehicle speed and acceleration, over which professional drivers have a direct influence. They are the ones who vary speed based on their reading of the road, traffic regulations, and weather and traffic conditions, and who decide whether idling is necessary. Even skilled load positioning and securing can affect energy consumption.

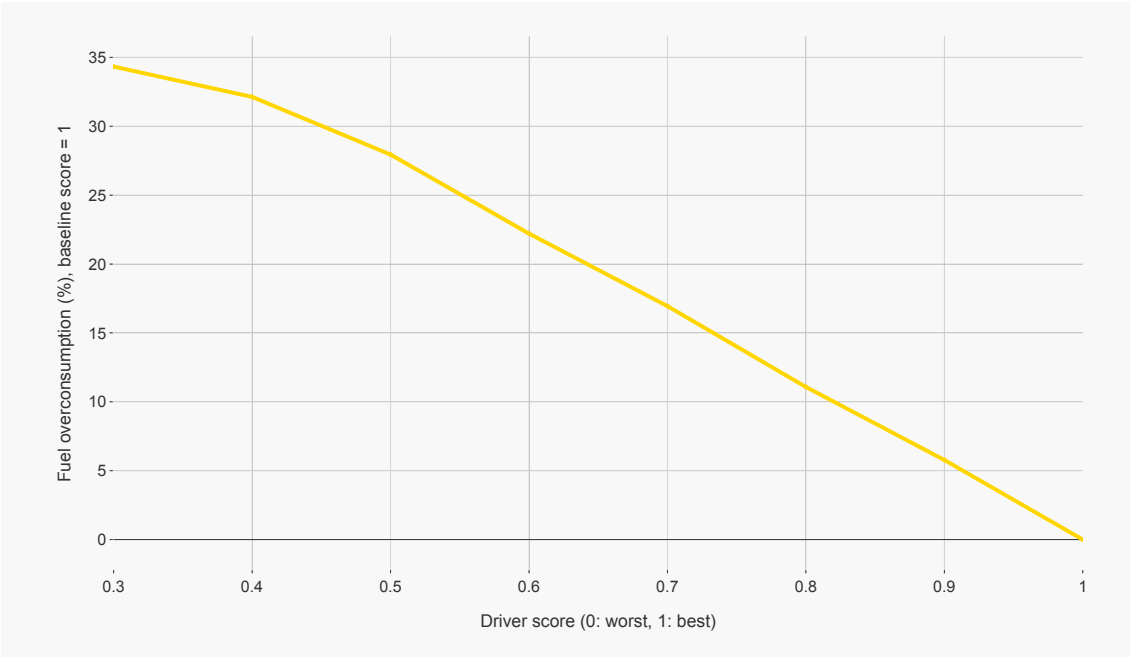
Driver education and feedback loops are therefore essential to minimise drivers’ impact on

energy consumption. Training can reduce a vehicle’s energy consumption by around 15% on average, while the penalty from an untrained driver is open-ended.

For any given trip, there is also a lower limit on fuel consumption. This is the theoretical optimum, the minimum physically possible for a given vehicle configuration and route profile. Every driver pushes consumption above this optimum through their driving style, as aggressive acceleration and braking waste energy through inertia, and excessive use of cruise control on hilly routes leads to energy waste. Proper training narrows the gap between real and optimal consumption by teaching drivers to match the powertrain to the conditions on the road, keeping the engine in its most efficient operating range and therefore delivering efficiency gains. A professional driver

Figure 5: More efficient driving skills can significantly reduce fuel overconsumption
Impact of driving skills on fuel consumption for 15-tonne payload of articulated vehicle (long-haul use)

Source: IRU estimates based on AFEM



also checks the vehicle's condition before departure, setting it up for optimal consumption and avoiding energy-intensive accessories. Finally, professional drivers can adapt their route to traffic conditions, where the fleet manager allows it.

From a TCO perspective, driver training is a win-win, delivering gains on both cost and CO₂ emissions: a more efficient driver lowers not only fuel consumption but also maintenance costs, for a relatively small investment compared with other decarbonisation technologies.

On-board technologies can help drivers lower their energy consumption. Solutions based on telematics can provide instructive feedback to drivers, either during or after the journey. Such telematics work only on vehicles fitted with this electronic network (Euro IV vehicles and newer). Smartphone applications – using speed, GPS and the device's accelerometer – are also a powerful tool for driving feedback, not least because they can compensate for the absence of vehicle sensors.

More advanced systems can help drivers go further. Modern predictive cruise control selects the optimal gear ratio for the vehicle's payload and speed together with GPS and on-board topographic maps that anticipate the road ahead. Autonomous vehicles take this further, replacing driver inputs such as accelerating, braking and steering to bring fuel consumption closer to optimal levels. The Society of Automotive Engineers defines several levels of autonomy. From Level 4, trucks and buses can operate without a driver within a defined domain (for instance on highways), while Level 5, the highest, removes the need for a driver entirely.

This opens new possibilities for decarbonisation, such as running vehicles at night when lighter traffic can help reduce energy consumption. However, autonomous systems are expected to have a higher CAPEX, and their OPEX must be assessed carefully to determine the economic viability of the technology.

After reviewing the scientific literature in 2023, IRU Green Compact research found that the most effective training combines theory with real-world practice, repeated twice a year to sustain driver performance. Fleets must find ways to keep drivers engaged over the long run so the benefits of eco-driving last. Training does more than build eco-driving skills; it also prepares drivers to compensate for the limitations of new powertrains, for instance, developing the energy-management skills to choose the right charging strategy or make the best use of energy-recovery systems.

Driver training also reduces maintenance costs, making it a cost-effective decarbonisation measure



5.1.2 Efficient vehicles: Decarbonising the fleet

While the transition to zero-emission vehicles takes time, modern diesel vehicles and retrofitting can improve fleet efficiency and reduce carbon emissions

Current policies are encouraging transport operators to switch to zero-emission powertrains. This will take decades. Operators need to gather the financial means, manufacturers need to produce enough zero-emission vehicles, and energy providers need to build the necessary generation capacity and grid upgrades.

In the meantime, modern diesel vehicles and technical retrofitting solutions can make the existing fleet more fuel efficient, thereby reducing its carbon footprint. Vehicles convert fuel into mechanical energy to move forward, and the laws of thermodynamics dictate that this conversion generates losses: the basis of the concept of vehicle efficiency. Efficiency covers not only the engine itself but also losses across the vehicle's other components.

Vehicle efficiency can be improved by acting on the forces that resist a vehicle's motion. As it moves, a vehicle must overcome rolling resistance, aerodynamic drag, gradient (climbing) resistance, inertia during acceleration, and internal powertrain friction. A more efficient vehicle therefore has energy-efficient tyres (lower rolling resistance), improved aerodynamics (smaller frontal area and lower drag coefficient), reduced kerb weight (through lightweighting, removing unnecessary parts, and using advanced materials and designs), and reduced powertrain friction (through advanced lubricants and better maintenance).

One key aspect for operators to enhance fleet efficiency is to invest in new vehicles, despite the potential heavy price of doing so.



New vehicles are taking advantage of the progress manufacturers have made in lowering fuel consumption with higher engine efficiency, better cab aerodynamics and the use of new advanced driver-assistance systems (ADAS) to help drivers lower fuel consumption. But many other technologies are available to cut energy and fuel consumption, ranging from simple to complex and from relatively inexpensive to costly.

Tyres

Among the technical solutions for retrofitting the existing fleet, the easiest way to make a vehicle more efficient is through its tyres. Tyres are the link between the vehicle and the road, passing forces back and forth between the two. Made of viscoelastic rubber, they deform under load to absorb impact and to generate the forces that guide the vehicle. This viscoelastic behaviour, together with

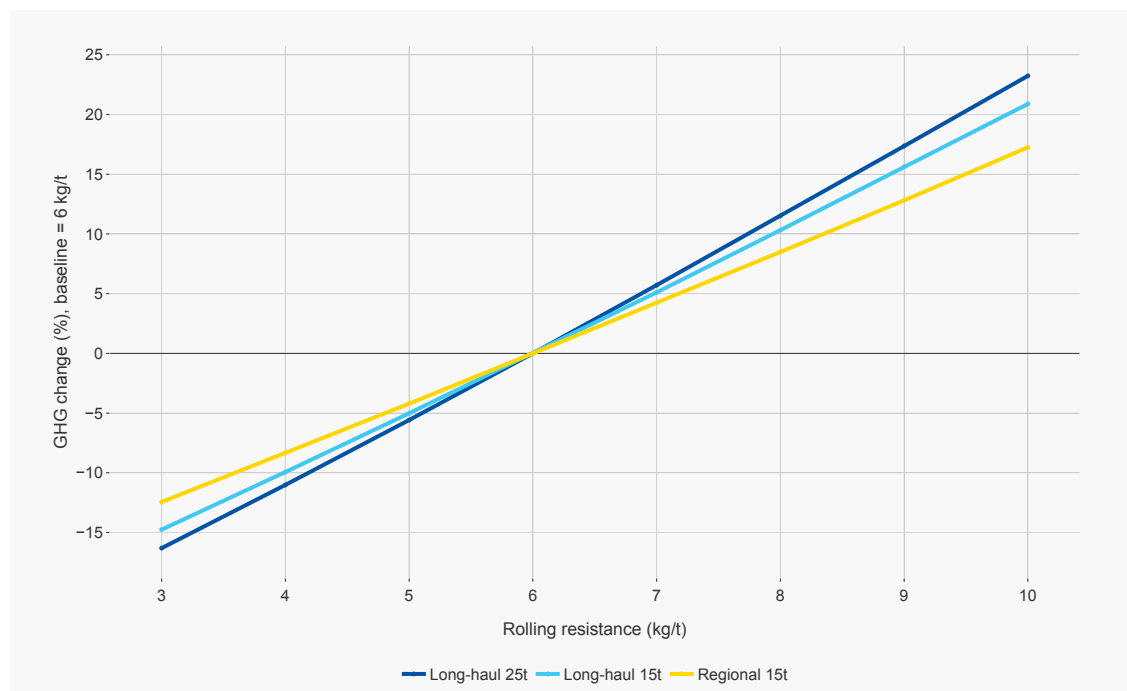
other design parameters, leads to thermal losses, which manifest as rolling resistance, the force resisting the tyre's motion. Rolling resistance depends on the tyre's structure, materials, air pressure and axle load.

Tyres historically used a diagonal (bias-ply) construction, valued for its ease of production and robustness but at the expense of rolling resistance and durability; they are still in use today in parts of Asia and Africa. Radial construction is the modern standard, offering lower rolling resistance and greater durability, at the expense of higher production costs. Correct tyre pressure and good maintenance keep rolling resistance low. Across today's heavy-duty tyre market, rolling resistance varies widely, from around 3 kg/tonne for the best tyres to about 10 kg/tonne for a diagonal tyre. On a long-haul application, moving from the worst to the best can deliver up to 30% savings in carbon emissions.

For long-haul operations, switching from high- to low-rolling-resistance tyres can cut carbon emissions by up to 30%

Figure 6: Low-rolling-resistance tyres help to increase GHG savings

Impact of tyres' rolling resistance on GHG emissions – articulated vehicle by payload and use



Source: IRU estimates based on AFEM

Operators should nonetheless treat any headline saving with caution and assess the potential for their own operations, since GHG savings and fuel consumption depend heavily on payload and usage.

Once again, TCO should be carefully considered, as tyre costs are not only based on rolling resistance but also on durability, which is sensitive to vehicle usage and road surface. It should be noted that tyre retrofitting is the simplest way to increase vehicle efficiency, as low rolling resistance tyres have the same dimensions as regular ones and can be mounted on the same wheels without any technical modifications.

and its drag coefficient, defining how easily it moves through the air. Aerodynamics can be improved in two ways: by reducing the frontal area (width and height), at the cost of payload capacity, or by lowering the drag coefficient.

Manufacturers have several tools to reduce drag, using aero devices that guide the air more smoothly around the vehicle. These include roof deflectors bridging the cab and trailer, side skirts, wheel covers and digital (camera) mirrors.

Drivers can also influence drag by removing unnecessary accessories such as extra lamps or decorations and correctly setting up spoilers and skirts to ease airflow. They can also reduce drag by trimming their top speed by a few percent: as aerodynamic drag rises with the square of speed, a small reduction has a greater-than-proportional effect.



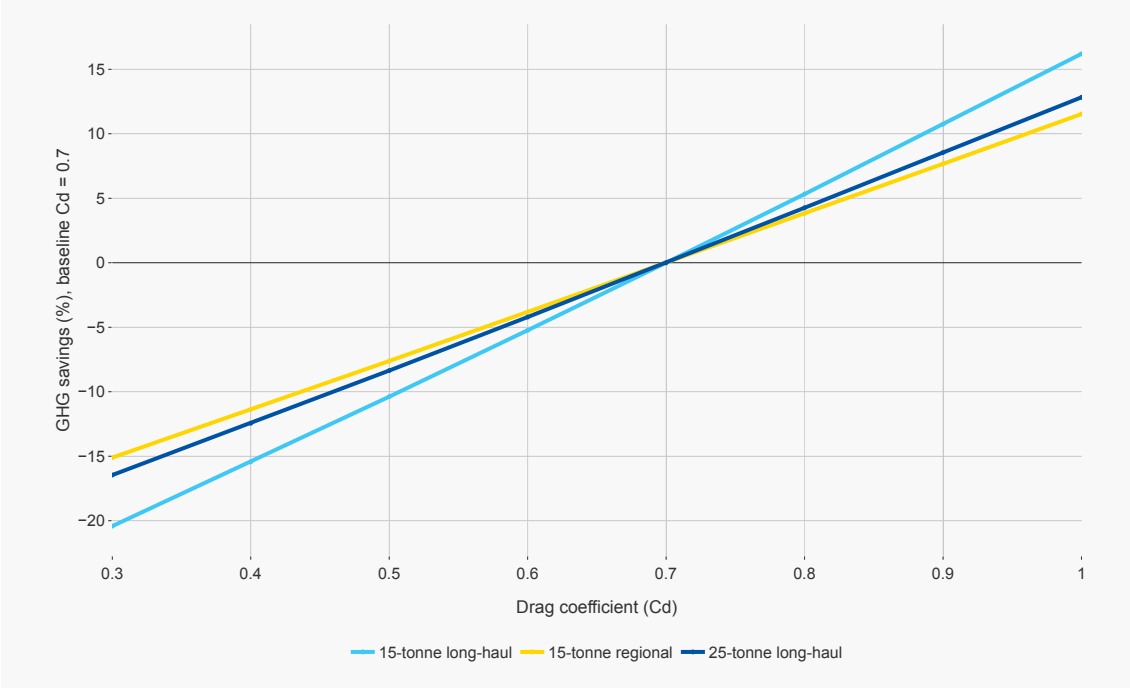
Small reductions in vehicle speed can significantly reduce aerodynamic drag, which rises with the square of speed

Aerodynamics

A vehicle’s aerodynamic performance is defined by its frontal area exposed to airflow

Figure 7: A reduced drag coefficient results in significant GHG savings
Impact of drag coefficient on GHG emissions for articulated vehicles by use type

Source: IRU estimates based on AFEM



It is now common practice in Europe for drivers to cap their top speed at 85km/h rather than the 90km/h speed-limiter setting. The type of trailer and load placement matter as well. For example, box trailers have a lower drag than flatbed (deck) trailers.

As with rolling resistance, the carbon savings from aero devices depend on payload and usage, with the largest savings on long-haul operations, particularly at lower payloads.

Lightweighting

For commercial vehicles, lightweighting means reducing the ratio of vehicle mass to the payload it can carry. It starts with selecting the right vehicle – trailers in particular – for the transport operation, and maximising the vehicle combination's payload ratio. It continues by removing unnecessary equipment:

where market conditions allow, operators can go further and strip out items such as the spare wheel and tools, relying instead on effective, reliable breakdown services.

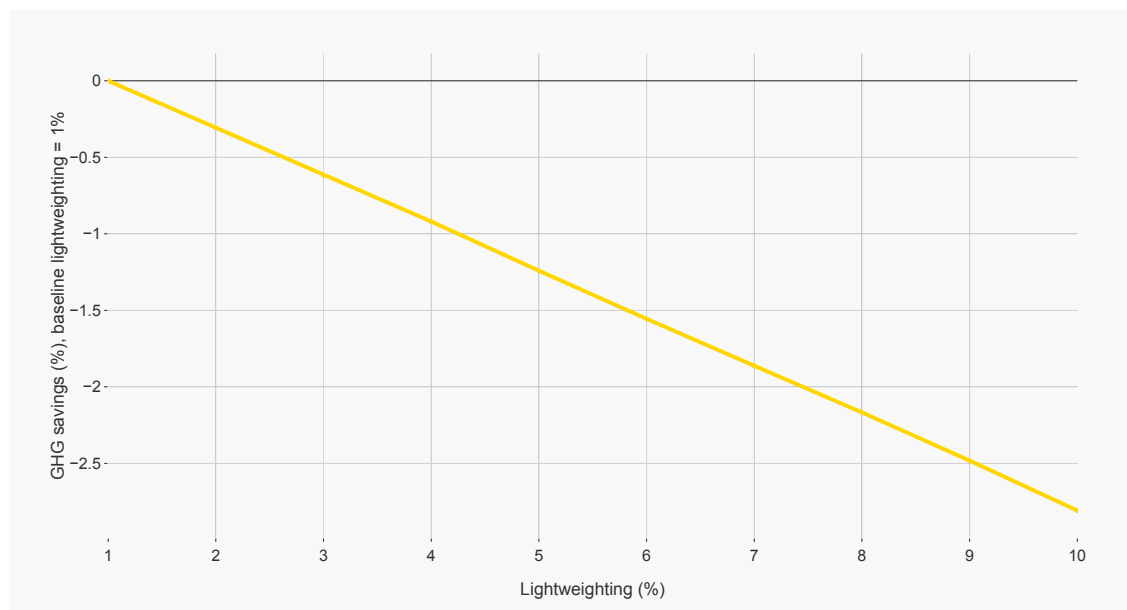
At the extreme, lightweighting involves the use of advanced materials, though caution is needed, as saving weight can come at the expense of reliability, cost and lifespan.

With frequent speed changes, such as in urban delivery operations, lightweighting has the greatest impact, as it reduces the energy lost to inertia during acceleration. For most operations, its benefit often shows up as extra payload capacity (and so fewer trips) rather than lower fuel per trip.

Overall, however, its GHG savings are more limited than those from aerodynamic and tyre improvements.

Figure 8: Increasing lightweighting from 1% to 10% reduces modelled GHG emissions by about 2.8%

AFEM simulation, articulated vehicle with 15-tonne payload, regional use



Source: IRU estimates based on AFEM

Advances in engine technology have pushed diesel brake thermal efficiency to around 53%, compared with roughly 40% for the previous standard

Engine technology

Modern diesel vehicles continue to improve, manufacturers are still optimising internal combustion engines, and newer models bring efficiency gains to the market. Advances in turbocharging, cooling systems, piston design, high-pressure injection and exhaust-gas after-treatment have pushed today's combustion engines to levels of efficiency that would have seemed unimaginable not long ago.

The current diesel record stands at around 53%¹¹ brake thermal efficiency, against roughly 40% for the previous standard. For example, Scania's new Super 11 engine lowers fuel consumption by 7% compared with the previous Scania 9-litre engine.¹²

Fleet maintenance

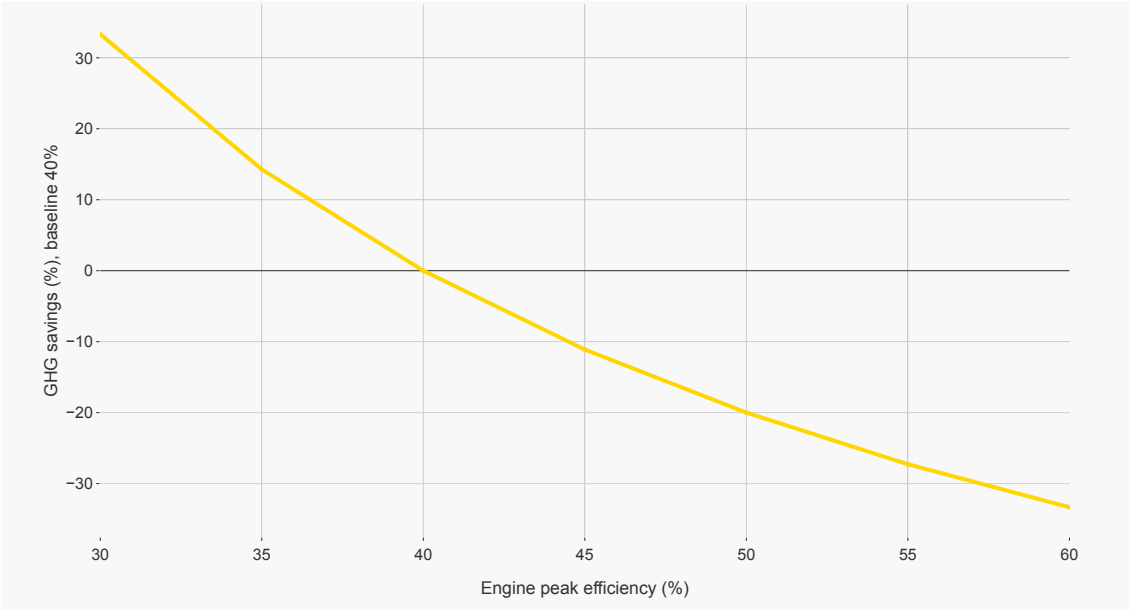
Predictive maintenance and breakdown anticipation are another way to maintain a vehicle at the

top of its efficiency. Predictive maintenance can be facilitated by sensors, measuring oil quality, brake pad thickness and tyre tread wear. Machine learning and digital twins are other solutions available for assessing a vehicle's overall efficiency and triggering repairs when needed.

These individual gains are not simply additive, as the forces resisting a vehicle's motion interact within its overall energy balance, the effects of each lever overlap rather than stack. Adding up the individual best-versus-worst gains described above would imply a reduction of more than 100%, which is physically impossible. Once vehicle dynamics are taken into account, the combined reduction comes to around 75%. Even this is not realistic in every region. EU and US fleets, for instance, are already relatively advanced, yet significant gains remain achievable: results from the 2023 IRU Green Compact research showed that a more efficient European fleet can reduce energy consumption by 20%.

Figure 9: Improved energy efficiency can increase GHG savings by reducing fuel consumption
AFEM simulation, articulated vehicle with 15-tonne payload, long-haul use

Source: IRU estimates based on AFEM



11 https://en.weichaipower.com/media_center/news/202404/t20240420_104523.html
12 <https://www.scania.com/group/en/home/newsroom/press-releases/press-release-detail-page.html/5056197-scania-unveils-the-super-11-engine---a-lighter--more-efficient-solution-for-high-performance-transport>

5.1.3 Efficient logistics: reducing transport energy intensity

Trucks have a simple but powerful property: they can carry more than their own weight. As a result, a fully loaded truck spends more of its energy moving goods than moving the vehicle itself. The heavier the truck, the more pronounced this becomes. A van burns less fuel per kilometre than a standard articulated truck, but the articulated truck consumes less fuel per tonne-kilometre of goods carried. Carbon emissions follow the same pattern: carbon intensity (CO₂ per tonne-kilometre) falls as payload rises.

Efficient logistics within the IRU Green Compact encapsulates all practices and technologies that focus on decreasing the energy intensity and carbon intensity of road transport, in other words, everything that reduces kWh/tkm and CO₂/tkm.

Maximising payload and vehicle utilisation

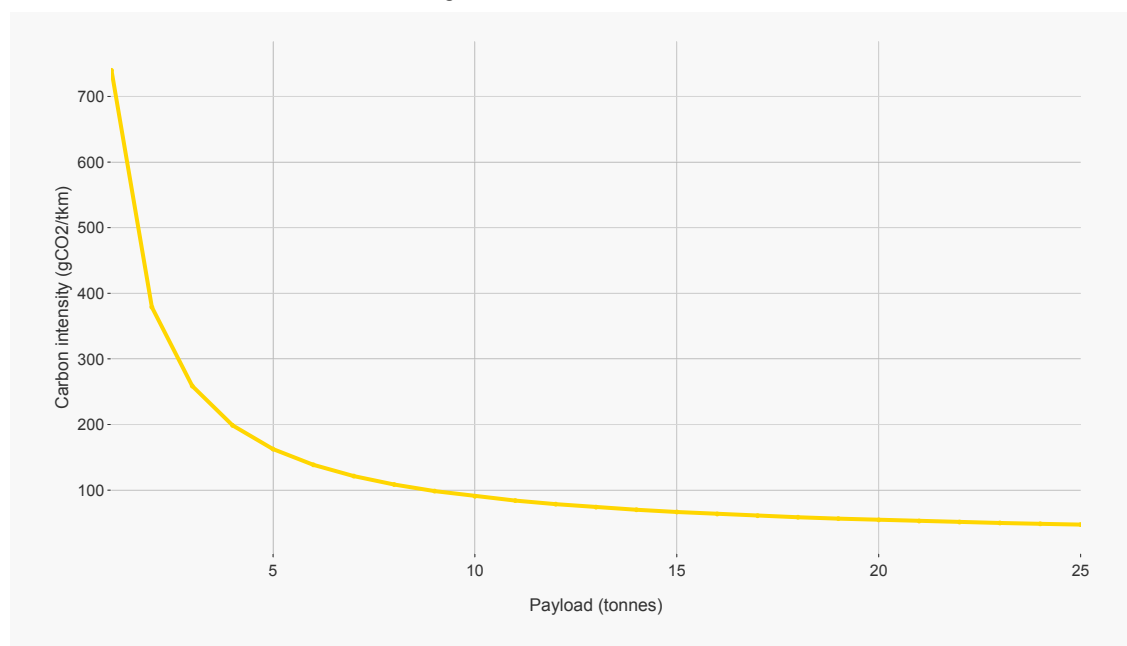
Reducing the energy intensity of road freight starts with the vehicle itself. Lowering a vehicle's energy consumption has already been covered in the section on efficient vehicles. The efficient logistics pillar focuses instead on how to reduce energy consumption per tonne-kilometre. From a vehicle perspective, this depends on the payload-to-kerb-weight ratio, the load factor, and the extent of empty running.

As noted earlier, trucks can carry more than they weigh, and the heavier and longer the truck, the better its payload-over-kerb-weight (POK) ratio. A typical EU rigid truck has a kerb weight of 8 tonnes and

Fully loaded trucks use more of their energy moving goods rather than the vehicle itself, reducing carbon emissions per tonne-kilometre

Figure 10: Simply increasing the payload from 5 to 10 tonnes is estimated to reduce carbon intensity by nearly 44%

AFEM simulation, articulated vehicle, long-haul



Source: IRU estimates based on AFEM

In the EU, EMS combinations can cut energy intensity by around 10%, while duo-trailers can achieve reductions of around 20%

a payload of 10 tonnes, giving it a POK of 1.25, while a typical EU articulated vehicle has a kerb weight of 15 tonnes and a payload of 25 tonnes, giving it a POK of 1.67. At one extreme, a van has a kerb weight of 2 tonnes for a payload of 1.5 tonnes (POK below 1), meaning more energy goes into moving the vehicle than the goods. At the other extreme, ecotrucks have even higher POK values (up to 2 for duo-trailers) and combine them with more loading volume, which helps for goods limited by space rather than weight.

Ecotrucks such as the European Modular System (EMS) in the EU or Australia’s road trains are powerful tools to reduce transport energy intensity, and thus carbon intensity. In the EU, two EMS combinations can replace three standard articulated vehicles, cutting energy intensity by around 10% at full load; duo-trailers (sometimes

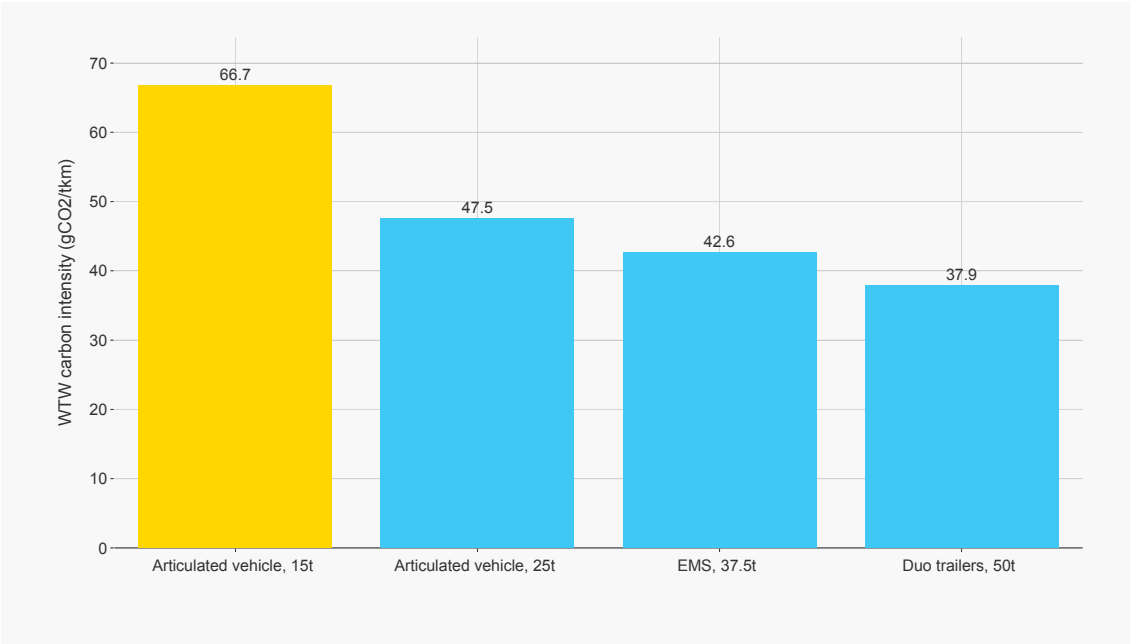
called SuperEcoCombis) reach around a 20% reduction compared with a standard articulated truck.¹³

Vehicles rarely run full, so the load factor describes how well they are loaded. It is the ratio between a truck’s actual payload (the mass of goods loaded) and its maximum available payload. The average load factor is typically well below 100% as most goods are low-density, filling the trailer’s volume before reaching its weight limit.

Shippers often determine load factors, particularly for Full Truck Load (FTL) services. For dense, weight-limited freight, the simplest lever is reducing the weight of packaging and transport equipment (pallets, boxes) while keeping products adequately protected. For volume-limited freight, reducing packaging volume achieves the same by fitting more goods into

Figure 11: The carbon emission intensity of a duo trailer is roughly half that of a regular 15-tonne articulated vehicle
Carbon emission intensity by vehicle

Source: IRU estimates based on AFEM



13 AFEM simulation, long-haul, articulated vehicles with 15-tonne payload.



the same space. A more complex approach is to modify delivery schedules and consolidate goods with other shippers to improve truck occupancy. Although shippers generally set load-factor requirements, transport operators can consolidate Less Than Truckload (LTL) shipments when delivery times allow and routing creates a viable business case.

Route and load management

Another way to improve energy efficiency is to reduce empty runs. This is a delicate task. It depends on many stakeholders and variables, but it raises energy efficiency per unit of goods transported. Goods consolidation and LTL freight marketplaces can bring more transparency into the fragmented market and help reduce empty running, as does better digital integration of trucks to harmonise the flow of goods, vehicles and drivers.

Empty running makes up more than 20% of all freight movements by road in Europe, but cannot be eliminated entirely, as supply chains need flexibility, and some slack is required to keep trucks moving.

Advanced routing is another lever, planning journeys more carefully before vehicles hit the road. By weighing gradient, wind and likely congestion, algorithms can build less energy-intensive itineraries. Night driving, for instance, often means lighter traffic and more stable environmental conditions, and so lower fuel consumption, though this must be balanced against the attractiveness of night work for drivers.

Pre-routing should be complemented by live routing, with software detecting congestion and redirecting trucks to alternative routes that suit their dimensions and use less energy than crawling through traffic.

Pre-routing should be complemented by live routing, with software detecting congestion and redirecting trucks to alternative routes

Transport contracts can help too, by offering wider delivery windows or real-time delivery booking, giving operators more freedom to choose routes, or by pooling equipment between shippers. Finally, vehicle-to-everything (V2X) communication and digital tools add a further layer of optimisation, using clearer communication between vehicles and stakeholders to synchronise transport planning and execution through real-time visibility and cut energy intensity further.

keeping road for the first and last mile. It does, however, require a high level of cooperation between operators, all while maintaining high service levels for shippers.

Modal interfaces (transfer points between modes) are critical to moving goods smoothly. Particular attention is needed for the handling of trailers and containers, because maritime, rail and road evolve at different technological paces: rail wagons, for instance, stay in service far longer than trucks.

Intermodal and collaborative transport

Technologies are not the only levers for the transition to a carbon-neutral industry. Transport practices can also cut carbon emissions by improving operational efficiency. Intermodal transport supports decarbonisation by using the most suitable mode for each leg of the journey, shifting long hauls to rail or waterborne transport, when less carbon-intensive per tonne-kilometre than road, while

Another practice supporting decarbonisation is trailer swapping, where a network of operators with tractor units work together to move each other's trailers. Swapping first limits drivers' working area, making the profession more attractive; second, it facilitates the deployment of alternative fuels, because a tractor stays within reach of familiar refuelling or charging points, making it more compatible with the limited operating range of zero-emission vehicles (ZEVs).

Trailer swapping can support decarbonisation by keeping trucks within range of charging or refuelling infrastructure, while making drivers' working conditions more attractive



Negative practices

Best practices should be promoted, but negative practices must also be curbed. As noted earlier, technological developments in vehicles can make logistics more efficient, yet practices such as speeding and overweighting stand in the way of their deployment. Speeding directly raises fuel consumption and emissions. Overweighting is objectionable on different grounds: it is illegal and unsafe, damages infrastructure and distorts fair competition. Both, moreover, break the legal weight and speed assumptions that manufacturers design around, undermining the standardisation and optimisation of their products. Operators therefore need to comply with the rules, and these practices need to be discouraged.

Another negative practice is long waiting times at border crossings or at loading bays, which encourage

engine idling and needless emissions. Border-crossing facilitation tools such as TIR and its digital version eTIR are effective ways to cut emissions without investing in new technology. And according to case studies by Trimble time-slot-management can reduce the waiting time for trucks at dock and yard by 40%. As fleets electrify, the stakes will grow. Long border waits could require dedicated charging or hydrogen refuelling infrastructure – a major investment, especially where local grids are weak.

Finally, making the most of current and future technologies generally requires greater education and communication among road transport stakeholders. The professionalisation of road transport is needed to spread best practices and support decarbonisation.

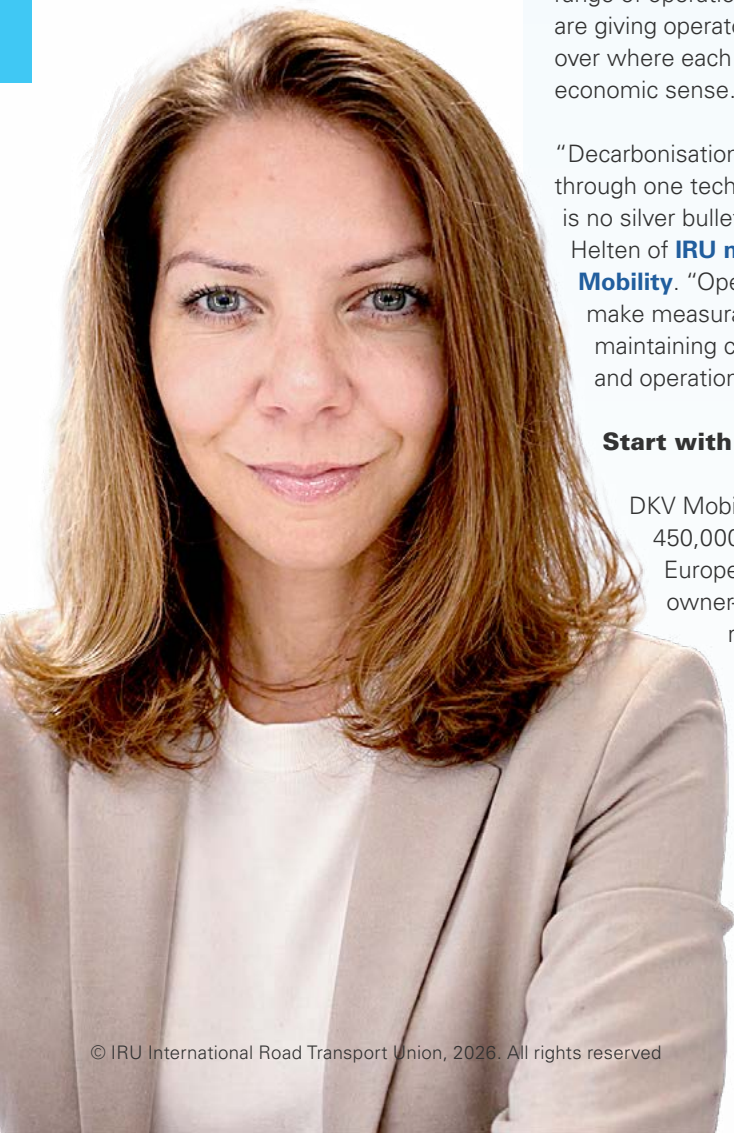
As fleets electrify, the stakes will grow. Long border waits could require dedicated charging or hydrogen refuelling infrastructure



How to sequence decarbonisation in road transport

Decarbonising road transport involves a range of approaches and technologies. What do you do first? And how do you ensure that each step works commercially? We asked DKV Mobility.

Malika Helten
Head of Product
Management Fuel,
DKV Mobility



Decarbonisation options are multiplying.

Existing fleets can become more efficient through route optimisation, telematics and eco-driving. HVO and biomethane can reduce lifecycle emissions without necessarily requiring new vehicles. Battery-electric trucks are becoming viable for a growing range of operations. And digital tools are giving operators more visibility over where each technology makes economic sense.

“Decarbonisation is not achieved through one technology alone. There is no silver bullet,” said Malika Helten of **IRU member DKV Mobility**. “Operators need to make measurable changes while maintaining commercial viability and operational reliability.”

Start with the operation

DKV Mobility serves around 450,000 customers across Europe, ranging from owner-drivers and small regional operators to large international transport companies. Its approach to decarbonisation is tailored to each customer's specific needs.

“The most common mistake is to start with the vehicle instead of with data, operations and energy management,” said Christian Gehring. “Successful fleet decarbonisation begins with understanding how vehicles move today and how energy will be supplied tomorrow.”

DKV Mobility's recommended sequence starts with optimising existing operations through telematics, route analysis and digital tools.

Efficiency has more to give

IRU's Green Compact survey found that route optimisation and reducing empty runs are among the most widely used efficiency measures.

That makes sense: they often require far less capital investment than replacing vehicles.

When working with customers, DKV Mobility first looks at practical operational factors: the countries and routes served, how flexible drivers can be with detours, what fuels are already in use, where refuelling hotspots are located and what cost-saving opportunities exist around VAT and excise-duty refunds.

Digital tools can then help operators understand where unnecessary mileage, inefficient routing or poor energy use are occurring.

The same principle becomes even more important as fleets electrify.

Electric needs the right energy system

For electric vehicles, a key dividing line is increasingly the charging ecosystem.

“Large-scale electrification often depends on the availability of grid capacity at depots and logistics hubs,” said Christian Gehring. “Fleets with a high level of electrification benefit significantly from having access to a variety of charging solutions.”

A strong business case combines depot or workplace charging with reliable public charging along the route. Operators that manage that mix effectively can reduce total cost of ownership significantly.

Data, data, data

Data can make electrification decisions much more precise.

By combining telematics and transaction data, operators can compare route profiles, mileage, dwell times, energy consumption and charging costs.

“In practice, this shows operators exactly which vehicles and routes are ready for electrification,” said Christian Gehring. “Instead of asking, ‘Should we go electric?’, operators can ask, ‘Which vehicles and routes

can be electrified profitably today?’ That reduces investment risk and accelerates adoption.”

For long-haul and cross-border transport, predictability remains critical. Operators need confidence that charging will be available where and when it is needed, with sufficient power and minimal waiting times.

“Once operators can plan an electric route with the same confidence they plan a diesel route today, the transition will accelerate significantly,” said Christian Gehring.

Smaller operators can start small

The transition is more difficult for smaller fleets without large internal data teams.

But Christian Gehring argues that many already possess much of the information needed to make an initial assessment.

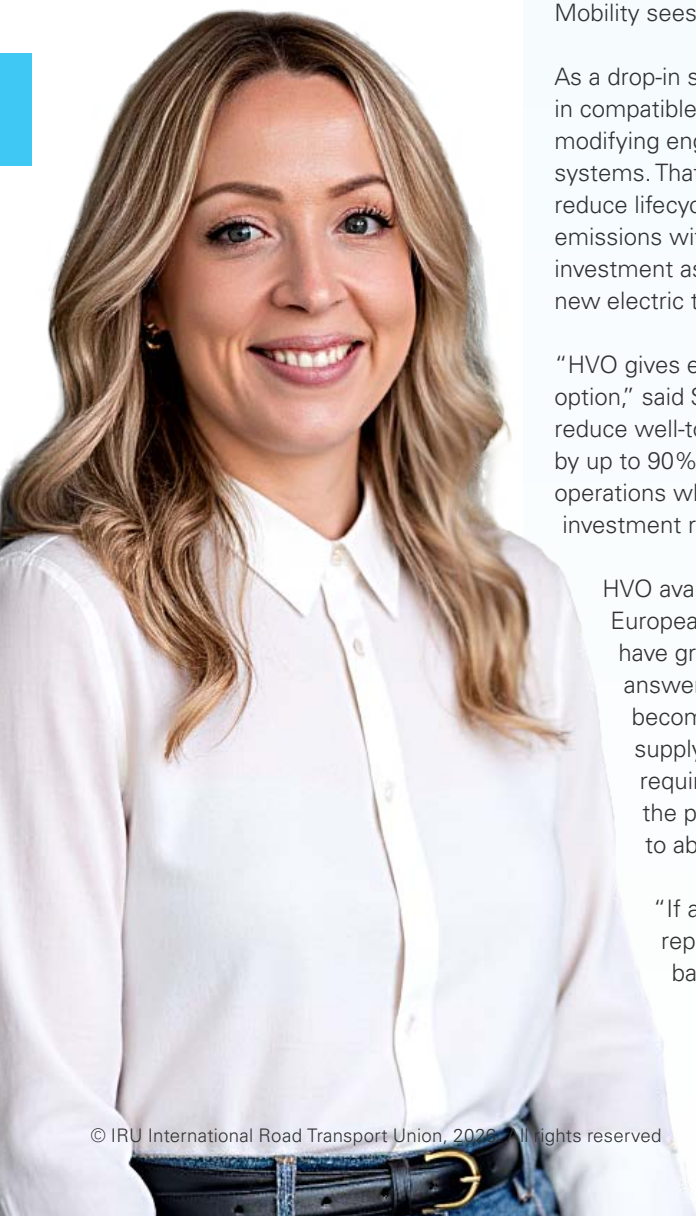
Vehicle mileage, route profiles, dwell times, fuel costs and depot locations can be enough to identify promising use cases.

Christian Gehring
Director Product & Consulting
@home @work e-Mobility,
DKV Mobility



Sabrina Schulz

Product Manager Fuel,
DKV Mobility



"Rather than trying to assess the entire fleet, start with a small group of vehicles with predictable daily routes and regular depot returns," said Christian Gehring.

"The key is to start with a pilot, measure the real operating costs and build the business case on your own operational data," Christian Gehring added. "Electrification does not require perfect data from day one."

HVO: an easier first move

IRU's survey found HVO to be the most widely adopted alternative fuel. DKV Mobility sees several reasons why.

As a drop-in solution, HVO can be used in compatible diesel vehicles without modifying engines or fuel-distribution systems. That allows operators to reduce lifecycle greenhouse gas emissions without the upfront investment associated with buying a new electric truck.

"HVO gives existing fleets a ready-made option," said Sabrina Schulz. "It can reduce well-to-wheel CO_{2e} emissions by up to 90%, effectively decarbonising operations while avoiding the capital investment required for a new vehicle."

HVO availability has improved as European production and imports have grown. But it is not the right answer everywhere. HVO can become less attractive where supply is unreliable, refuelling requires significant detours or the price premium is difficult to absorb.

"If an operator is already replacing a vehicle and a battery-electric option

works technically and commercially, we would assess electric from the outset," said Sabrina Schulz.

Different fuels for different fleets

The same logic applies to biomethane and hydrogen.

DKV Mobility's network currently includes 150 bio-CNG stations across six countries, while its HVO100 network spans 4,982 stations across 21 countries. Bio-CNG can therefore make sense for operators that already run compatible gas vehicles and have suitable refuelling locations along their routes.

Hydrogen remains more uncertain.

"There are developments in freight, but for most operators, hydrogen is still difficult to plan around and not yet a mainstream solution," said Sabrina Schulz.

Vehicle availability, reliable low-emission hydrogen supply and cost all remain significant questions. DKV Mobility sees potential in specific use cases with dedicated refuelling arrangements, but believes operators need greater certainty.

All options on the table

That leads back to the central point: the future is unlikely to be built around one fuel.

An operator might use HVO for existing diesel vehicles, biomethane where suitable gas infrastructure exists, and electric vehicles on routes where charging and the economics already work.

"We certainly do not recommend the same energy mix to every customer," said Sabrina Schulz. "The right combination depends on the fleet and its daily operations."

Fleet replacement takes time, meaning renewable fuels are likely to remain relevant even as electric vehicles take a growing share of new purchases.

"Overall, we expect several solutions to co-exist, with operators choosing what works best for their routes and budgets," said Sabrina Schulz.

For DKV Mobility, the role of service providers is therefore to help operators determine what to do first, what comes next and where each option makes commercial sense. ■



About DKV Mobility

Servicing some 450,000 active customers in more than 50 service countries across Europe with around 3,000 employees, DKV Mobility is the leading business-to-business platform for international mobility services with a history of purpose-driven growth for over 90 years.

They offer access to one of the largest energy-agnostic acceptance networks in Europe, including about 76,000 conventional fuel service stations, around 1,200,000 public and semi-public EV charge points and some 26,000 alternative fuel service stations.

Moreover, DKV Mobility is a leading provider of toll payment solutions in Europe, while also offering mobility solutions, including vehicle services at around 39,000 vehicle service stations and innovative digital solutions.

In 2025, DKV Mobility generated a transaction volume of EUR 20 billion and revenue of EUR 860 million.

5.2 Collective mobility

Cars are the most common form of passenger transport in advanced economies, with a modal share of 86% in the US and 69% in the EU for passenger movements, reaching as high as 90% in Germany and France (based on passenger kilometres done on road). As for trucks and buses, cars’ powertrains are mostly dependent on fossil fuels to power their movement, releasing GHG into the atmosphere. Despite progress in engine technologies and car efficiency, the amount of carbon emissions per passenger kilometre means cars account for the largest share of GHG emission within transport, reaching about 57% both¹⁴ in the US and the EU.

Similar to the principle of efficient logistics, buses and coaches reduce GHG intensity per passenger journey by sharing energy consumption across multiple passengers.

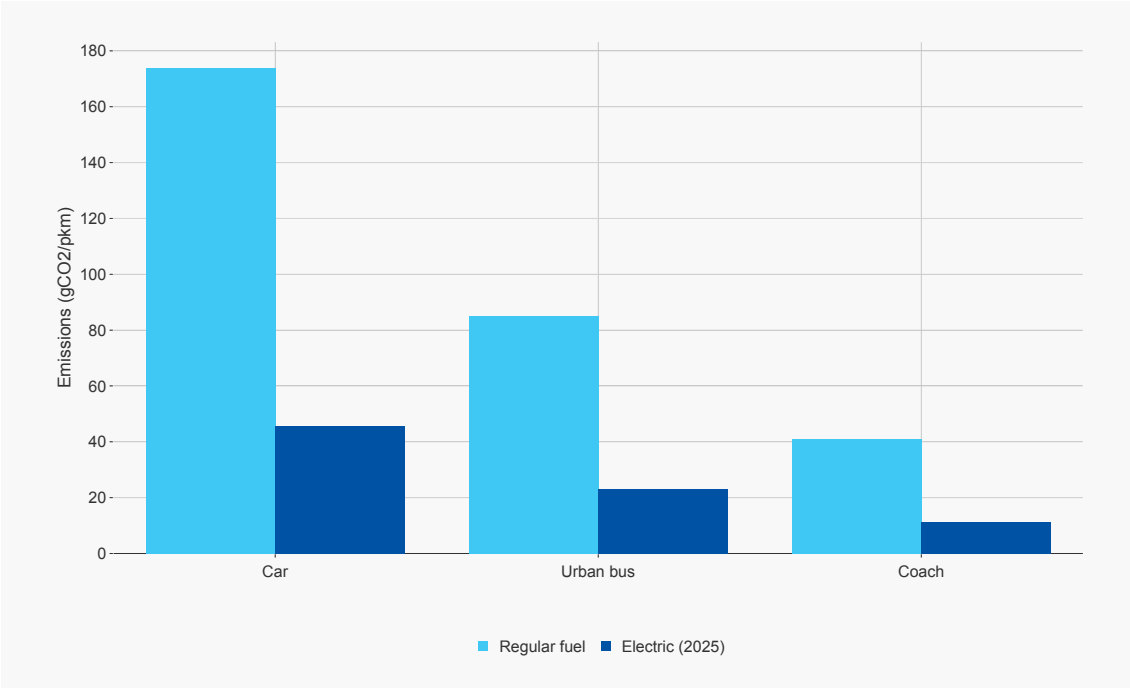
Engine efficiency differences and vehicle mass per passenger are key factors in reducing emissions. For example, a fully loaded 1.8-tonne car with 5 passengers (75kg each) moves 440kg per passenger, while a fully loaded 12-tonne coach with 55 passengers moves only 295kg per passenger. Consequently, buses and coaches produce lower carbon emissions per passenger kilometre than cars, regardless of the powertrain energy source.

Modal shifts from private cars to buses and coaches favour carbon emissions reduction. It shall be noted that it could increase transport demand for buses, in pair with energy consumption, creating a greater challenge for commercial road transport, but with a powerful decarbonisation output for passenger transport.

Buses and coaches produce far less carbon emissions per passenger-kilometre than cars, regardless of the energy source powering the vehicle

Figure 12: Buses and coaches help reduce GHG emissions per passenger-kilometre regardless of powertrain type
Emissions by type of vehicle and fuel

Source: IRU estimates based on AFEM



14 <https://www.epa.gov/ghgemissions/transportation-sector-emissions> & <https://www.eea.europa.eu/en/datahub/datahubitem-view/3b7fe76c-524a-439a-bfd2-a6e4046302a2>

However, private cars are the dominant form of transport for a reason. Passengers generally find them more convenient than buses, as they are easy to use, generally faster and more flexible in terms of timing, for a slightly higher perceived price. Modal shift can only happen if buses and coaches succeed in being both more economical and more convenient.

There are two approaches to reach such goals, involving push and pull measures. Push measures discourage the use of cars, pushing passengers towards other modes of transport. Pull measures make road passenger transport more attractive, pulling people away from car use towards buses and coaches. One approach needs to be complemented by the other to create social acceptance and drive long-term results.

In detail, push measures target cars' convenience and operational costs. Convenience includes many parameters such as trip start and end locations (parking in the case of cars), average travel speed, comfort, etc. Push measures generally leveraged by authorities target parking availability (dedicated spaces) and costs, freedom to use cars on public roads (single lanes instead of two, lower priority at intersections...), congestion tolls, emissions-based access restrictions, and other sorts of fees such as ownership fees. Obviously, leveraging push measures only is unpopular as they just increase transport burden.

Pull measures are used to increase buses' convenience and decrease operational costs to better position this mode of transport compared to cars. The goal is to improve five aspects: (1) service quality, (2) infrastructure, (3) accessibility, (4) modal integration, and (5) public awareness.

Improving service quality and infrastructure are the most common pull measures to make buses more attractive to users. Possible measures include greater punctuality and bus frequency, real-time information, clear communication on travel information and ticket prices, and modern, safe, and clean vehicles, shelters and waiting areas, and dedicated bus lanes in metropolitan areas. Recent developments have also brought bus users flexible routing options and demand-responsive transport to enhance stop networks in a cost-effective manner for transport operators.

Accessibility has been a strength of buses and coaches for people with disabilities and reduced mobility compared to other modes. Pull measures on accessibility are also helping other vulnerable groups to safely use buses, such as children, people with little or no IT skills, and non-locals or tourists who do not speak the local language. Research has shown that English translations work wonders to increase city bus occupancy.

Shifting passengers from cars to buses requires both push measures that discourage car use and pull measures that make buses more attractive



Another set of proven pull measures concerns modal integration: the integration of buses in a broader scheme of transport including other modes. Relay parking facilitates the modal shift from cars to buses, as do bus stations close to rail stations and airports.

Another effective tool to favour bus usage is harmonised timetables between transport modes and companies, increasing convenience for users who need to connect different lines. Coupled with real-time information and knowing that connections will wait for them, this increases people's confidence in collective mobility. E-ticketing is

a key enabler for easier modal shift, especially when integrated between all local transport companies.

Lastly, public awareness is key to taking advantage of efficient bus and coach networks. As people using cars might not be aware of collective mobility's ease and safety of use, marketing campaigns can disseminate information and allow test rides for people to form an opinion. From neat IT services and flexible fare payment services to social media campaigns: many marketing solutions exist for operators to attract people to their services.

5.3 Alternative fuels: crucial step towards carbon neutrality

Fossil fuels release CO₂ regardless of how efficient road transport becomes

Transport operators have relied on diesel for over a century. The transition to alternative fuels is a significant challenge, given the pace of change now expected: new technologies are more complex to operate, while customers continue to expect the costs and operational flexibility they are used to.

Alternative fuels are indispensable to carbon neutrality. Fossil fuels release carbon dioxide regardless of how efficient road transport becomes, so efficiency alone cannot close the gap. Only renewable and low-carbon energy can bring the sector's carbon intensity close to zero over the long term.

In this report, alternative fuels are all energy sources usable by truck and bus powertrains with a lower carbon emission factor (CEF) than diesel, measured well-to-wheel. Some fossil fuels qualify, such as natural gas (fossil methane), whose advantage

over diesel is modest and depends on engine efficiency and methane leakage. These are not long-term decarbonisation solutions, but they can act as stepping stones to biogas (renewable methane), which uses the same vehicles and refuelling infrastructure. Other alternatives range from well-established biofuels to more disruptive energy carriers such as electricity and hydrogen, whose emissions depend entirely on how they are produced.

No single option suits every operation. Payload, range, duty cycle, infrastructure access and cost determine what is viable for a given fleet, which is why the IRU Green Compact alternative fuels pillar examines each fuel's characteristics, availability and performance, and why IRU provides tools such as the Alternative Fuels and Efficiency Model to help operators compare them. Uncertainty among operators remains high, as the survey results in this report show.

5.3.1 Lowering carbon emission factor to decarbonise

The carbon emission factor (CEF) expresses the greenhouse gas emissions associated with a unit of energy delivered to and used by a vehicle, in gCO₂e per megajoule or, for liquid fuels, in kgCO₂e per litre. A well-to-wheel carbon emission factor is the sum of well-to-tank emissions, resulting from extraction, processing and distribution, and tank-to-wheel emissions, released when the energy is used. Lowering greenhouse gas emissions therefore means lowering carbon emission factors: either by reducing the well-to-tank carbon intensity of the fuels used today, or by switching to lower-carbon energy.

Diesel has a well-to-wheel carbon emission factor of between 3 and 4 kgCO₂e per litre, depending on crude origin, flaring intensity and refinery efficiency. The European reference value corresponds to about 3.4 kgCO₂e per litre¹⁵. Of this, 2.6 kgCO₂e per litre is fixed by the chemistry of combustion¹⁶ and is released at the tailpipe. The remaining 0.8 kgCO₂e per litre is upstream, just under a quarter of the total, and in theory the ceiling of what the fuel supply-side could deliver for carbon reduction.

This GHG reduction potential is limited but powerful, as it implies the involvement of fewer stakeholders (energy providers) in the process. It requires no change to vehicles, fuels or operations, so every truck and bus already on the road benefits immediately, at no capital cost to operators. However, it cannot be captured in full, since extraction, refining, distribution and fugitive emissions cannot be eliminated entirely. But reducing upstream methane venting, flaring and leakage,

and increasing the renewable content of supplied fuel, both lower the well-to-tank share, and both are being driven by legislation rather than by operators' own investment.

Fuel quality standards play a different but complementary role. Diesel meeting EN 590 enables modern, more efficient combustion engines and their emission control systems, reducing consumption per kilometre and so emissions per tonne-kilometre. The standard's 7% cap on biodiesel content does, however, limit how much renewable energy conventional diesel can carry.

One point is worth making before turning to individual fuels: the 2.6 kg of CO₂ per litre leaves the tailpipe whichever liquid hydrocarbon is burned, renewable ones included. What changes is the origin of the carbon. When recently captured from the atmosphere rather than extracted from the ground, it is accounted as near-zero, which is how renewable fuels reduce emissions without changing what happens inside the engine.

Renewable fuels

For compression-ignition engines, renewable liquid fuels come in two families: biodiesels, made from biomass, and synthetic diesels, made from hydrogen and captured CO₂.

Several generations of biodiesel coexist on the market. The first draws on food crops, sugar and starch feedstocks such as sugarcane and corn, converted mainly into bioethanol, and edible oils such as rapeseed and soybean, converted into biodiesel. The second uses

Renewable fuels still release CO₂ at the tailpipe, but their carbon comes from recently captured atmospheric CO₂ rather than fossil sources

¹⁵ Consistent with the fossil fuel comparator of 94 gCO₂e/MJ in Annex V of the Renewable Energy Directive; see also the JRC JEC Well-to-Wheels analysis.

¹⁶ Density at 0.835 kg/L, carbon content 86% by mass.

Biofuels can reduce emissions without redesigning engines or rebuilding refuelling infrastructure, making them an immediately available option for operators

non-food sources: lignocellulosic biomass, woody crops, agricultural residues, and energy crops grown on marginal land unsuitable for food production. The label is applied inconsistently, sometimes to the advanced processes involved, sometimes merely to the use of non-food inputs in conventional processing. This ambiguity is a common source of confusion. Hydrotreated vegetable oil (HVO) illustrates it: the production route is sophisticated, but the feedstock is first-generation. Cost keeps trucks and buses on first-generation biodiesel.

Two products dominate. FAME (fatty acid methyl ester), obtained by transesterification, is the most widespread; its lower energy density (38 against 43 MJ/kg) raises fuel consumption over the same distance. HVO, obtained by hydrogenating the same feedstocks, costs more to produce but matches diesel's energy density and carries the lower carbon emission factor of the two: 11.3 gCO₂e per megajoule,

against 23.6 for FAME and 95.1 for fossil diesel, i.e. reductions of 88% and 75% respectively¹⁷. Per litre, that is roughly 0.4 kgCO₂e for HVO and 0.8 for FAME, against 3.4 for diesel, though litre-for-litre comparisons understate FAME's consumption penalty. HVO currently sells at about a 10% premium to diesel in most European markets, a gap that would close with aligned excise duty treatment.

Neither fuel asks much of the vehicle. HVO requires no engine modification and is fully miscible with diesel; FAME also blends, but its fatty content calls for adapted fuel filters. Blends are designated "B-X" in the EU, X being the percentage of biodiesel: B5 is a 5% blend, B100 pure biodiesel.

That proximity to fossil diesel is the main attraction: emissions fall without redesigning engines or rebuilding the refuelling network, which makes biofuels an immediately available option for operators. The constraints lie elsewhere.



¹⁷ <https://www.eionet.europa.eu/etcs/etc-cm/products/etc-cm-report-2025-02>

The climate benefit depends heavily on feedstock: counting indirect land-use change, the savings from biodiesel and HVO supplied in the EU in 2023 fall from 77.6% to 53.6%, while demand for food crops adds pressure on prices and supply. Waste and residue feedstocks such as used cooking oil and animal fats avoid that trade-off, but volumes are small and are expected to go primarily to sustainable aviation fuel.

Synthetic fuels (also called e-fuels or e-diesel) are drop-in replacements usable in a conventional diesel powertrain, produced by combining renewable hydrogen with captured CO₂; both inputs must be low-carbon for the fuel to approach carbon neutrality. Their weakness is efficiency: capturing CO₂, producing hydrogen by electrolysis, processing hydrogen with CO₂, then burning the result in a combustion engine leaves a full-cycle efficiency typically below 25%, so a given quantity of renewable electricity carries far fewer tonne-kilometres this way than through other pathways. Volumes remain marginal, and expected prices are five to ten times those of diesel today. Where renewable electricity becomes abundant and very cheap, however, the appeal is considerable: synthetic diesel would displace fossil diesel without changing either the vehicle or the fuel supply chain.

Methane offers a lower carbon emission factor than diesel whatever its origin. In EU life-cycle terms, compressed natural gas is rated at 69.3 gCO_{2e} per megajoule and liquefied natural gas at 74.5, against 95.1 for diesel, or reductions of about 27% and 22%. Renewable methane goes considerably further: biomethane is rated at 20.9 gCO_{2e} per megajoule, and manure-based biogas at –29.1, a negative value reflecting the methane it captures that would otherwise have reached the atmosphere.

Against the fossil gas it replaces, biogas cuts emissions by 91.6%.

These are fuel figures, not vehicle figures. Most gas trucks and buses use spark-ignition engines, which are less efficient than diesel engines, so part of the advantage is absorbed by higher energy consumption per kilometre. Methane does not ignite under compression alone, so the mainstream gas powertrain is spark-ignited and cannot revert to diesel, a loss of fuel flexibility that weighs on operators. The exception is high-pressure direct injection (HPDI), in which a small diesel pilot ignites liquefied gas in a compression-ignition engine, preserving diesel-like efficiency at the cost of carrying both fuels.

The rest of the vehicle changes little. Diesel tanks give way to cylindrical pressure vessels for compressed gas, or to cryogenic tanks holding liquefied gas at around –162 °C, and purchase prices stay close to diesel equivalents. What must be built lies around the vehicle: a refuelling network, and maintenance staff trained on gas systems, without which operators will not develop confidence in the technology.

Methane emissions themselves require attention, since methane warms the atmosphere far more than carbon dioxide over the short term. Engine methane slip, the unburned fuel leaving the exhaust, and leakage along the supply chain can erode the advantage the fuel was chosen for.

Zero-emission vehicles

A zero-emission vehicle (ZEV) emits neither carbon dioxide nor pollutants from its exhaust, so its carbon emission factor consists entirely of well-to-tank emissions. Battery electric vehicles, catenary and induction road systems,

Synthetic fuels can replace diesel without changing vehicles, but full-cycle efficiency is typically below 25% and current prices remain five to ten times higher

Where electricity remains coal-dominated, decarbonising the grid is a precondition for realising the full emission benefits of electric vehicles

and fuel cell electric vehicles. EU law is slightly broader than the term suggests: a zero-emission heavy-duty vehicle is one without a combustion engine, or with a combustion engine emitting no more than 1 gCO₂ per kWh, which allows hydrogen combustion to qualify.

Whatever the technology, the consequence is the same: the vehicle's emissions are decided by the local energy system rather than by the vehicle, so fleet decisions now require an understanding of how electricity or hydrogen is produced in each country of operation. Moreover, electricity and hydrogen require a new powertrain, new infrastructure and new skills, which is what makes them the most disruptive part of the transition. In today's world, ZEVs cost considerably more to buy, so their economic interest rests on recovering higher capital expenditure through lower operating expenditure, which depends above all on energy prices.

Battery electric vehicles are the most widespread zero-emission option on the market. The diesel driveline gives way to a charging inlet, a battery pack, high-power electronics and an electric driveline with a dedicated transmission. The battery pack is the heaviest, costliest and most complex component. Chemistries follow the passenger car market: nickel-manganese-cobalt cells are progressively giving way to lithium iron phosphate, which is cheaper, longer-lived and tolerates deeper discharge (around 95% of nominal capacity is usable, against roughly 80%) at the cost of greater weight for the same energy stored. Charging uses the Combined Charging System up to 500 kW, in its European version 2 or North American version 1, and the Megawatt Charging System above that. Motors either replace the diesel engine or move into the drive axle, which removes the gearbox and offsets part of the battery weight.

For a road tractor, the two figures that matter to operators are a purchase price, more than two and a half times that of a diesel equivalent, and about four tonnes of additional mass for 500km of range. Some countries' weights and dimensions rules allow zero-emission vehicles two extra tonnes of maximum authorised weight, so the payload penalty is reduced but not removed. Trailers are being electrified too, with their own battery and driveline. These are not zero-emission vehicles in themselves but energy-recovery devices: behind a diesel tractor they cut fuel consumption and emissions, behind an electric one they extend range.

The decarbonisation potential of an electric fleet is set by the electricity that charges it, since well-to-tank is all that remains. A road tractor's electric variant emits less than its diesel counterpart as long as the electricity used is below roughly 730 gCO_{2e} per kWh. Where generation remains coal-dominated, the benefit is small or absent until the mix changes, which makes grid decarbonisation a precondition rather than a parallel effort.

Generation is only half the question. Distribution is a bottleneck everywhere: charging points at the powers heavy vehicles need require grid reinforcement that must be planned years ahead, and grid operators can only plan it against a credible forecast of how many electric trucks and buses will be on the road. Modelling and forecasting are therefore practical tools for the sector, not academic exercises.

Hydrogen's carbon emission factor is set almost entirely by how it is made, and the spread is extreme. Steam reforming of natural gas, which supplies most hydrogen today, is rated at 104.3 gCO_{2e} per megajoule, or 12.5 kgCO_{2e} per kilogram of hydrogen, and higher per unit of energy than diesel at 95.1.

Coal-based hydrogen reaches 234.4 gCO₂e per megajoule, or some 28 kg per kilogram. Adding carbon capture and storage to coal brings it down to 52.7, though the technology is not yet deployed at scale. Electrolysis powered by renewable electricity is rated at 9.1 gCO₂e per megajoule, roughly 1.1 kg per kilogram of hydrogen, near zero, but not zero.

Electrolysis is only as clean as its electricity. Producing a kilogram of hydrogen takes on the order of 48 kWh, so above a grid intensity of about 260 gCO₂e per kWh, electrolytic hydrogen is more carbon-intensive than hydrogen from natural gas. Cost runs the other way: hydrogen from natural gas is currently several times cheaper than the electrolytic route, which is why almost all supply remains fossil. Water use is a further consideration, as nine litres is needed per kilogram of hydrogen by chemistry alone, and more in practice once purification is accounted for.

To date, two powertrains can use hydrogen. In a fuel cell electric vehicle, a fuel cell combines hydrogen with oxygen to produce electricity and water, driving an electric motor; a battery buffers the load variations the fuel cell handles poorly. Well-to-wheel efficiency is around 35% using renewable hydrogen, better than hydrogen combustion, and refuelling takes about as long as diesel. Against that, it is among the most expensive options available. Tanks and fuel cell systems are costly, and current prices are several times those of a diesel truck, while the stack has a finite life, in the order of 25,000 hours, after which its replacement is an expensive operation involving precious metals such as platinum.

Hydrogen combustion engines are the newer arrival on the truck market, and their appeal is industrial. Hydrogen can be burned in a compression-ignition engine,

mixed with the intake air and ignited by a small diesel pilot injection, or in an adapted spark-ignition gas engine. Either way, existing engine plants can build them, no precious metals are required, and maintenance and refuelling stay close to practices workshops already know, which shortens the training and adaptation operators face. The drawbacks are storage and efficiency. Hydrogen is the smallest molecule there is, so tanks are expensive and sealing is a permanent trade-off against cost, with losses that matter most for vehicles standing idle for long periods; cryogenic storage adds boil-off. Well-to-wheel efficiency using renewable hydrogen is around 30%. Combustion also produces nitrogen oxides, so exhaust after-treatment is still required. In exchange, these engines tolerate lower hydrogen purity than fuel cells.

Set side by side, energy efficiency differs considerably among powertrains, despite the same renewable electricity: a battery electric vehicle delivers the largest share of it to the wheel, around 85%, a fuel cell vehicle around 35%, a hydrogen combustion engine around 30%, and synthetic diesel less than 25%. ■

From the same renewable electricity, around 85% reaches the wheels in a battery electric vehicle, compared with 35% for hydrogen fuel cells



Waiting for electric truck parity could leave operators behind

Anders Rousing

Vice President, Group
Operational Sustainability,
DSV

Electric trucks are slowly getting cheaper, ranges are improving and the technology is ready to scale in many instances. DSV's Anders Rousing explains why operators should start learning now – even before the business case is fully here.

For IRU member DSV, the transition to battery-electric trucks is increasingly about where they work, how they are operated and how quickly operators can build the experience needed to use them efficiently.

"We cannot have a market that is just waiting for magic to happen," said Anders Rousing, DSV's Global Road Sustainability Vice President. "You need to step into it now to get the lessons."

DSV's road decarbonisation strategy is guided by its 2030 science-based targets, including a 50% reduction in Scope 1 and 2 emissions and a 30% reduction in Scope 3 emissions from a 2019 baseline.

Its roadmap covers vehicles, charging infrastructure, customers and the commercial models needed for deployment to work.

Technology moving fast

Anders Rousing sees a clear progression in battery-electric trucks.

Early models offered ranges of around 200–250km. Current models are reaching 400–500km or more, while efficiency is improving and prices are slowly falling. DSV expects the next generation, around 2027–2028, to push this further as production scales and competition increases.

"The technology is there," he said. "It is really about looking at how we start scaling it."

Nevertheless, vehicle price remains a major obstacle, particularly for small and medium-sized operators.

That is where DSV believes its scale can help.

The company aggregates demand when negotiating with manufacturers, allowing subcontractors to benefit from conditions they would struggle to secure when buying only one or two trucks.

DSV is also investing in charging infrastructure at its own sites, reducing the need for operators to finance both a more expensive vehicle and the required charging infrastructure themselves.

Anders Rousing cautions against treating customer willingness as uniform. DSV sees some customers for whom decarbonisation is already a business requirement, others that are beginning to experiment, and another group that is not yet ready to pay more.

Finding the right use case

For Anders Rousing, one of the biggest mistakes is to treat a battery-electric truck as a direct one-for-one replacement for diesel.

“The right use case is key,” he said.

Operators need to understand where the vehicle can achieve high utilisation, how charging fits into daily operations and where the technology reaches its “sweet spot”.

“If you wait until the TCO flips and then start learning how to operate this new technology, you are going to have a very steep learning curve,” said Anders Rousing.

DSV is applying the same logic across several technologies, including battery-electric, biogas, hydrogen and HVO, using operating data and

business cases rather than relying on a single solution.

No universal tipping point

Anders Rousing does not expect electric trucks to reach TCO parity everywhere in Europe at once.

Vehicle prices, charging costs, grid capacity, road taxes, energy prices and the impact of ETS2 will create different conditions from one market to another.

But once the economics turn in one market, he expects adoption to accelerate rapidly.

“As soon as you start seeing the TCO flip in some markets, this is going to move very fast,” he said.

DSV currently has more than 400 heavy-duty electric trucks operating in Europe. Those deployments are cutting emissions today while building the knowledge operators will need tomorrow.

“It shouldn’t be a waiting game,” he said. “You need the use cases and the data to understand how to operate this technology.” ■



About DSV

At DSV, our purpose is to keep customers’ supply chains flowing. We move millions of shipments for our customers every year, ensuring reliable and efficient transport and logistics services by air, sea, road and rail around a world in constant change. Our vision is to create long-term, sustainable growth and value for our customers, employees, shareholders and society.

Close to 150,000 employees in over 90 countries work diligently to deliver great customer experiences and high-quality services. Our commitment to sustainable business practices is a central element of our overall business strategy.



Chapter 6

Enabling conditions

No green energy solution currently meets all three conditions for deployment at scale: availability, operational viability and a sustainable business case

Road transport has always been organised around two variables: cost and flexibility. Operators build truck and bus journeys to keep the first as low as possible and the second as high as possible. Both are already under pressure: costs from the inflation of vehicle and energy prices, flexibility from the driver shortage and the resulting challenge on transport capacity. Decarbonisation adds a third variable to the equation.

The levers described in the previous chapter are, for the most part, technically available today. Whether an operator can actually deploy them depends on conditions that sit outside the vehicle, and largely outside the operator's control. This chapter groups those conditions into three questions, which all have to be answered positively at the same time for a solution to be deployable at scale:

- Is the energy there? Enough volume has to be produced, and a distribution network has to exist to bring it to the vehicle.
- Can the operation still run? The vehicle has to cover the same duty cycles, carry the same payload and fit the same schedules.
- Does the business case close? The total cost of ownership has to stay compatible with freight rates that customers are willing to pay.

Answering one or two is not enough. An energy that is abundant and cheap but requires a network that does not exist will not move goods; a drop-in fuel that changes nothing operationally but is capped at a fraction of the sector's needs will not decarbonise it. The inventory that follows shows that, to date, no green energy answers all three questions positively, in any region of the world.

Temsa MD9 bus at a public transport charging station in Gothenburg, Sweden, 21 September 2023



6.1 Energy availability: is the green energy there?

Every energy reviewed in this section is measured against the same reference: what commercial road transport actually consumes. Trucks and buses worldwide burn roughly 800 billion litres of diesel a year, of which about 80 billion litres in the European Union alone.

Production figures mean little without that comparison: the sector's energy demand is on such a scale that a capacity which looks substantial in absolute terms can still cover only a marginal share of the fleet's needs. It matters all the more

because most of the alternatives below are not reserved for road transport: aviation, shipping and passenger cars compete for the same molecules and the same electrons.

Two questions are asked of each energy: how much is available against that need, and whether a network exists to bring it to the vehicle. The two are independent: biofuels have a network and no volume, electricity has volume and no network. An energy only becomes deployable when both questions are answered.

Even substantial energy production can cover only a marginal share of road transport needs when compared with the sector's total demand

6.1.1 Electricity

Battery electric vehicles are the most disruptive option to implement, because uptime depends not only on producing the energy but on building a dedicated distribution network from scratch.

On production, electric powertrains are far more efficient than combustion, but moving cargo and people still requires a large amount of energy. If the entire global fleet ran on electricity today, it would draw about 3,700 TWh a year, or some 13% of world electricity consumption, close to eight times what all of the world's

data centres consumed in 2025 (485 TWh, or 1.7% of global electricity, according to the IEA), and around four times the 950 TWh they are projected to reach in 2030. Road transport would not be claiming that power in isolation: it would be competing for the same new generation and the same grid connections as a data centre industry growing at 17% a year on the back of AI, with more capital behind it and shorter lead times.¹⁸

For a more granular picture at EU level, the DRM tool estimates the electricity that an electric fleet

¹⁸ Electricity equivalent based on a diesel truck at 30 L/100 km compared with an equivalent electric truck at 140 kWh/100 km over the same duty cycle. Set against global electricity consumption of 28,200 TWh in 2025 (IEA, Electricity 2026), this represents 13.2%. Data centre consumption: 485 TWh in 2025, growing 17% that year and projected to reach 950 TWh in 2030 (IEA, Key Questions on Energy and AI).

transiting through each EU country would mobilise, by virtually replaying goods movements with electric trucks instead of diesel trucks (buses are excluded from these estimates).

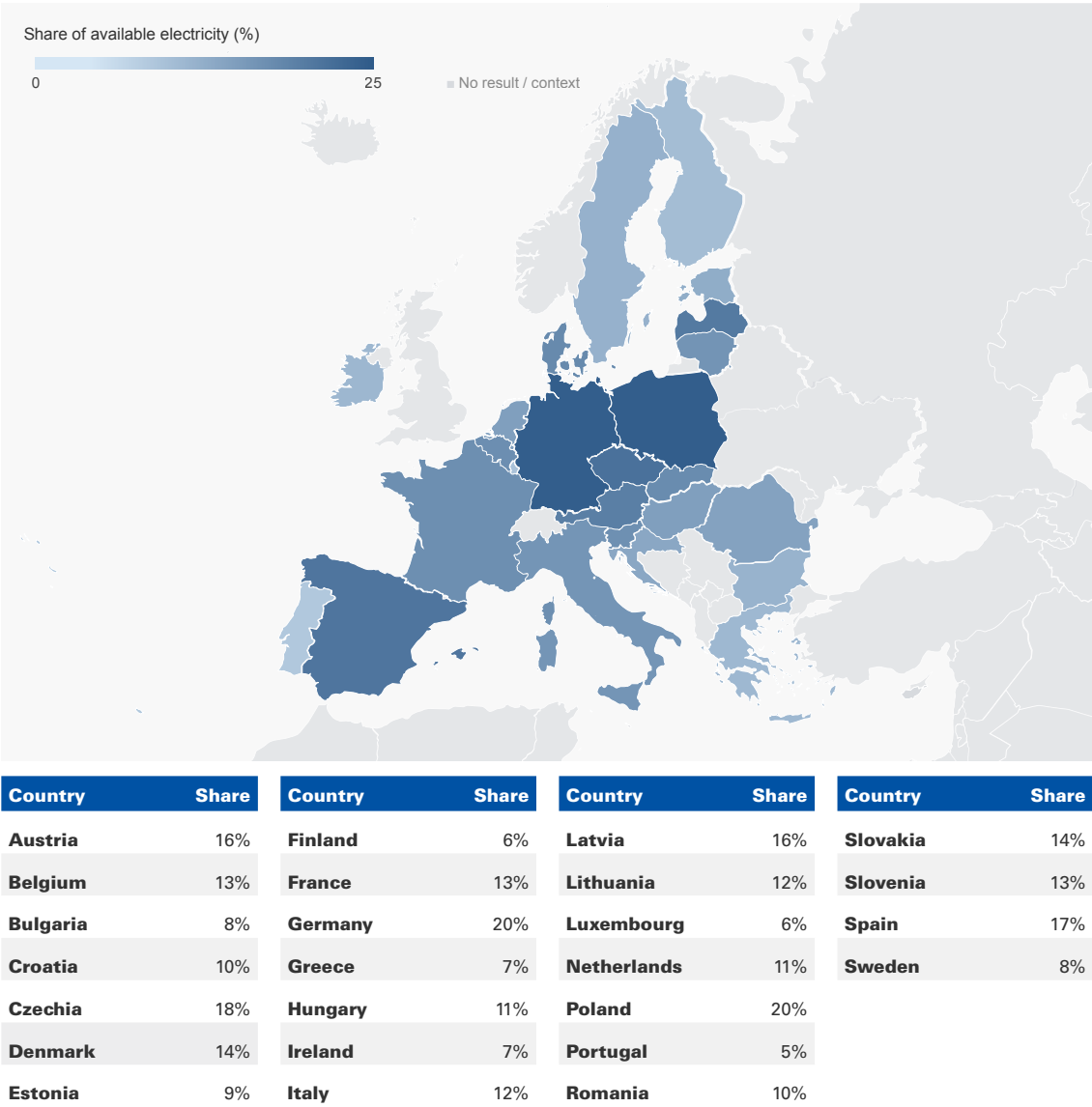
The demand on national systems is substantial. Powering truck transit alone would take about a fifth of the electricity available in Germany and in Poland. There is no established ideal threshold for truck electricity

consumption, but a lower share indicates a more reliable and steady supply for truck and bus operations.

When looking at the distribution of this produced electricity, the gap is wider still. In November 2025,¹⁹ Europe counted 1225 public charging stations spread over 370 locations (EAFO, April 2026) suitable for trucks and buses, but only a third of them offered at least

Figure 13: Trucks’ share of available electricity
Electricity needed for a fully electric EU truck fleet, 2024

Source: IRU estimates, 2024



19 <https://alternative-fuels-observatory.ec.europa.eu/general-information/news/heavy-duty-electric-truck-charging-infrastructure-europe-eafo-data-update>

DRM – Decarbonisation Roadmap Maker

DRM is an IRU in-house tool that models road transport movement as an energy model. It incorporates a road transport demand forecast, distributed among vehicles, goods and usages, to estimate the energy consumed by trucks. DRM then tests all possible combinations of efficiency and alternative fuel solutions, constrained by market capacity, and selects the option that meets a given CO₂ reduction curve while minimising the fleet's TCO.

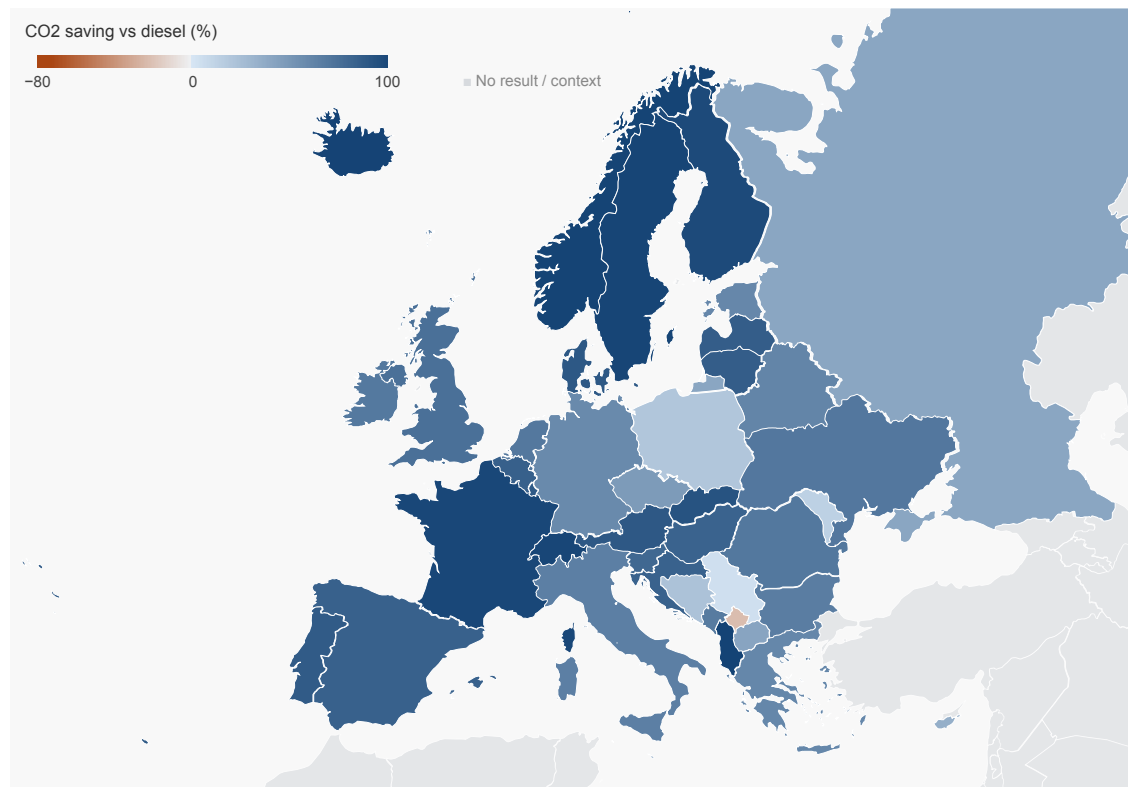
one point at 350 kW or above, the minimal power a truck needs to recharge meaningfully within a driver's 45-minute break. Latest IRU estimates put the requirement closer to 50,000 high-power public or shared charging points, a range ACEA also arrives at, supported by an even greater number of private depot chargers. IRU monitors operational charging stations, and readers can access a detailed mapping at [this link](#).

Volume is not the whole story: the added production also has to lower the carbon intensity of electricity, otherwise electrification displaces emissions rather than removing them. Comparing, with AFEM, a diesel truck consuming 30 L/100 km with an equivalent electric truck consuming 140 kWh/100 km on the same duty cycle, the carbon saved differs sharply between countries. In Poland, six electric trucks are needed

The emissions benefits of electric vehicles depend on the electricity mix: an electric vehicle is only as clean as the grid that powers it

Figure 14: Europe

CO₂ saving, latest available grid year



Source: IRU estimates, latest available grid year by country

to save as much CO₂ as a single electric truck in Switzerland. The same comparison sets a break-even point at around 730 gCO₂e/kWh: above that grid carbon intensity, an electric truck emits more than the diesel one it replaces.

Most countries sit comfortably below it, but the threshold is still exceeded where power generation remains dominated by fossil energies: an electric vehicle is only as clean as the grid it plugs into.

Figure 15: Asia
CO₂ saving, latest available grid year

Source: IRU estimates, latest available grid year by country

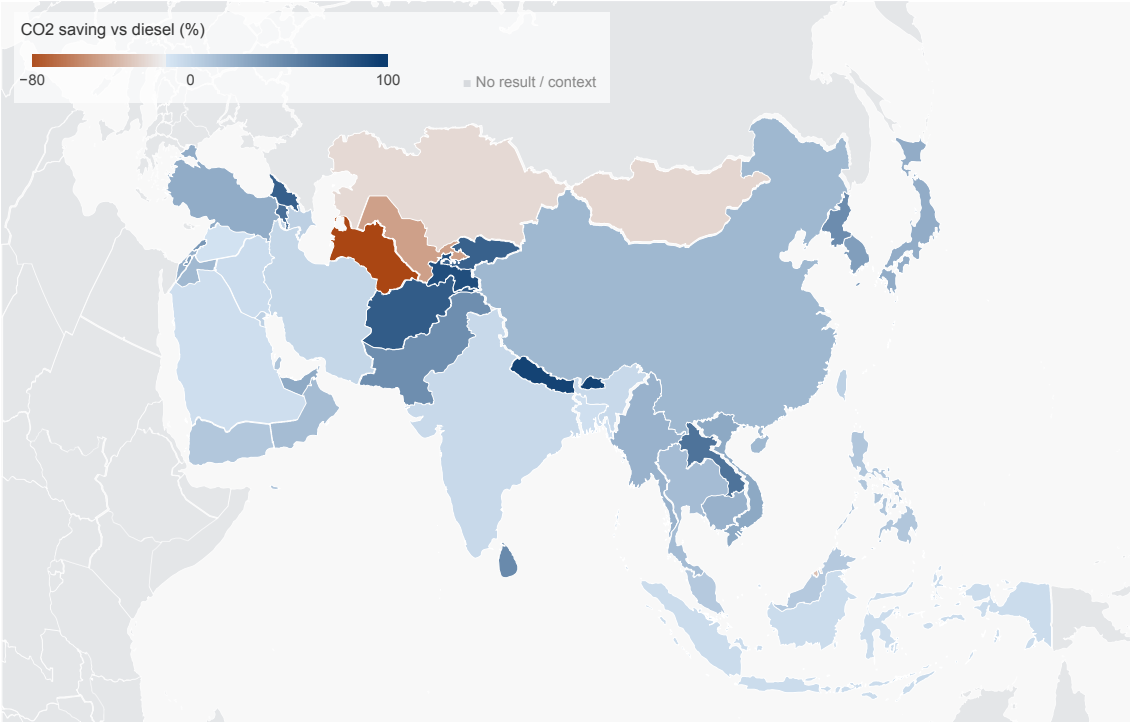
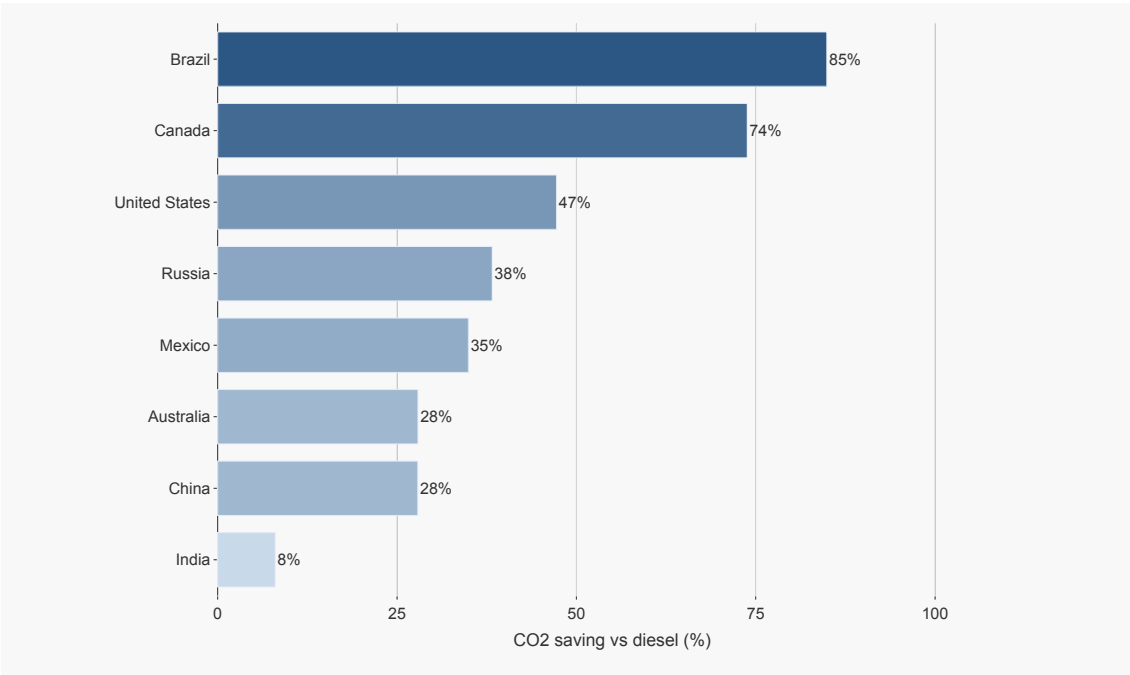


Figure 16: CO₂ savings of battery-electric trucks versus diesel, 2025
Latest grid carbon intensity (OWID/Ember, lifecycle, 2025)

Source: IRU estimates, latest available grid year by country



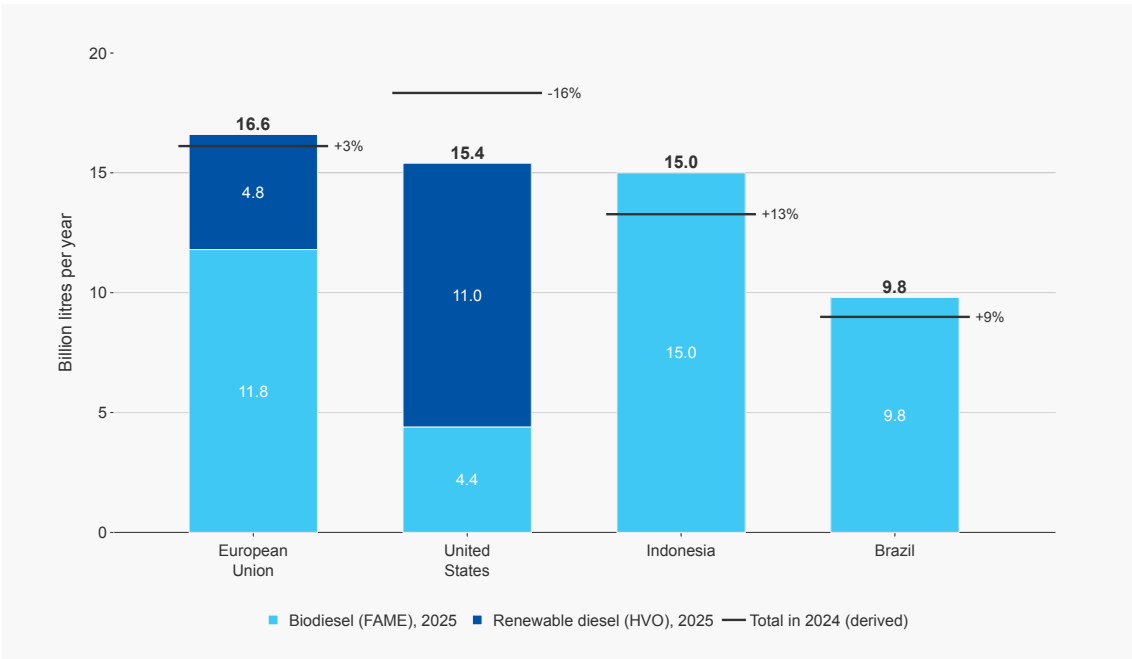
6.1.2 Biofuels (FAME and HVO)

Biofuels offer a strong reduction per litre (around 88% between HVO and diesel in the EU) but a limited effect on total transport emissions, because supply is capped by feedstock. The four largest producing markets turned out 56.9 billion litres of biodiesel and renewable diesel in 2025, the same volume as 2024. The US output fell 16% to 15.4 billion litres, with FAME down 31% and HVO down 9%, as federal tax credit support for the sector was restructured, while Indonesia grew 13% as its blending mandate moved to B40, with Brazil also recording a 9% increase and the EU +3%, enough for the EU to overtake the US as the

largest producer. Brazilian growth is continuing, up 9.4% over the first seven months of 2026. However that output is shared with cars, vans, shipping and aviation. Set against the 800 billion litres of diesel burned by trucks and buses worldwide, and the 80 billion litres consumed by the EU fleet alone, diesel-substitute biofuel covers under a tenth of the sector’s needs before a single litre is allocated to another mode. The IRU Green Compact EU 2023 roadmap puts EU production potential at 30 billion litres by 2050, roughly double today’s output, and still to be shared with other industries.²⁰

Biofuels can cut emissions substantially per litre, but current diesel-substitute supply covers less than a tenth of global truck and bus demand

Figure 17: Diesel-substitute biofuel output covers under a tenth of what trucks and buses burn
Biodiesel (FAME) and renewable diesel (HVO) production in the four largest producing markets, 2025



Source: USDA Foreign Agricultural Service (GAIN), US Energy Information Administration and ANP; 2025 production. See footnote 20

20 Biodiesel (FAME) and renewable diesel (HVO) production, 2025. **European Union and Indonesia:** USDA Foreign Agricultural Service, GAIN Biofuels Annual — European Union E42026-0052 (17 July 2026; 2025 estimate, 2024 revised), Indonesia ID2026-0033 (14 August 2026). **United States:** US Energy Information Administration, Monthly Energy Review, Tables 10.4a and 10.4b; litres derived from published barrels (1 barrel = 42 US gallons, 1 US gallon = 3.78541 L). **Brazil:** ANP, Produção Nacional de Biodiesel B100. **Other markets** (latest available, mostly forecasts): GAIN Biofuels Annual for China CH2025-0151, Thailand TH2024-0032, Malaysia MY2025-0017, Argentina AR2026-0013, Canada CA2025-0045 and India IN2025-0031.

Of all the energies reviewed, biofuels are the only one requiring no new infrastructure, with supply remaining the main constraint

The absence of HVO from the Indonesian and Brazilian bars is not a technical limit, and this is where enabling conditions become visible. Indonesia's mandate admits only FAME as the bio-component, and the fund that pays the price gap is indexed on the FAME-diesel spread, so a domestic HVO producer has neither an eligible market nor price support, while the export route is closing, as the EU caps and phases out palm-oil-based renewable diesel as a high land-use-change-risk feedstock. Brazil does produce renewable diesel molecules, but as co-processed "R diesel," a mixed fossil and biogenic refinery stream that these statistics exclude from HVO, with 1.6 billion litres of capacity today and 10.6 billion announced for 2027. Capacity is being built in both countries: three Pertamina (Indonesia) hydrotreating projects would add about 1.4 billion litres a year by 2027, and Brasil BioFuels has 0.64 billion litres coming on stream in Manaus.

The pattern reaches Europe too. Spain is building substantial HVO capacity (Repsol reached 450,000 tonnes a year across Cartagena and Puertollano in May 2026, and Moeve's 500,000-tonne Huelva plant starts up the same year, close to 1.2 billion litres between them) on feedstocks that are overwhelmingly used cooking oil and animal fats. Spanish and EU rules cap biofuels from those feedstocks at 1.7% of transport energy, limiting how much of that output the domestic obligation can absorb, while volumes exported earn no Spanish certificate at all. There is no tax advantage to compensate: since the biofuel zero rate lapsed at the end of 2012, HVO has been classified as gasóleo and carries the same excise as fossil diesel, charged per litre rather than per unit of energy. In all three cases the refiners, the technology and the feedstock exist. What limits supply is how the instruments are written.

Moeve fuel tanker truck in Granada, Spain, March 2025



Distribution is the opposite story. Because biofuels are a one-for-one diesel replacement, they travel through the existing fuel supply chain and can be stored in existing depot tanks. No new network is needed. Of all the energies reviewed here, biofuels are the only one where no infrastructure has to be built and supply is the binding constraint.

The two fuels are not equivalent in handling, however. FAME is an ester: it carries oxygen and, depending on the feedstock, unsaturated bonds that make it prone to oxidation over time, forming acids, gums and sediment. It is also more hygroscopic than fossil diesel, so water accumulates at the bottom of storage tanks — and water together with an organic substrate is what allows microbial growth, the “diesel bug”, whose biomass

blocks filters. FAME’s solvent properties add a third route to the same outcome, loosening deposits already present in older tanks and pipework. The practical consequence is a limited storage life and a tank housekeeping requirement that operators did not have with straight diesel, and it bears hardest on depots with slow turnover, on reserve tanks and on seasonally used vehicles.

HVO has none of these characteristics. It is a paraffinic hydrocarbon with no oxygen and no double bonds, it does not absorb water, and it can be stored far longer without degrading. For an operator that difference is not a detail: it decides whether a drop-in fuel is genuinely drop-in, or whether it arrives with a maintenance regime attached.

6.1.3 Biomethane

80,000 trucks and buses running on CNG or LNG are registered to date in the EU. For that share of the fleet, biomethane offers immediate decarbonisation with no technical modification to the vehicle. The base is shrinking, however: gas-powered vehicles are losing momentum in the EU, and BEVs surpassed CNG and LNG new registrations in the region in 2024.

That is a European story rather than a global one. China registered 198,700 natural gas heavy trucks in 2025 alone, two and a half times the entire EU gas fleet in a single year — after 178,200 in 2024 and 152,000 in 2023, on a stock estimated between 600,000 and one million LNG trucks. The same shift is nonetheless under

way there, one cycle behind: natural gas held 29.6% of Chinese heavy truck sales in 2024 and 24.8% in 2025, losing share to battery electric vehicles even as its absolute volume set a third consecutive record. Elsewhere the base is thin — about 18,000 natural gas transit buses in the US, and fewer than a thousand LNG trucks registered in India.

Where the fleet does exist, the decarbonisation is already real rather than theoretical: 86% of the natural gas dispensed as motor fuel in the US in 2024 was renewable, according to the sector’s own association. The binding constraint on biomethane is therefore neither the vehicle nor the willingness to use it, it is the volume of gas available.

The main constraint on biomethane is neither the vehicle nor willingness to use it, but the volume of gas available

Figure 18: Alternative fuel truck registrations
Battery-electric and natural-gas truck registrations in the EU, 2015-2025

Source: EAFO

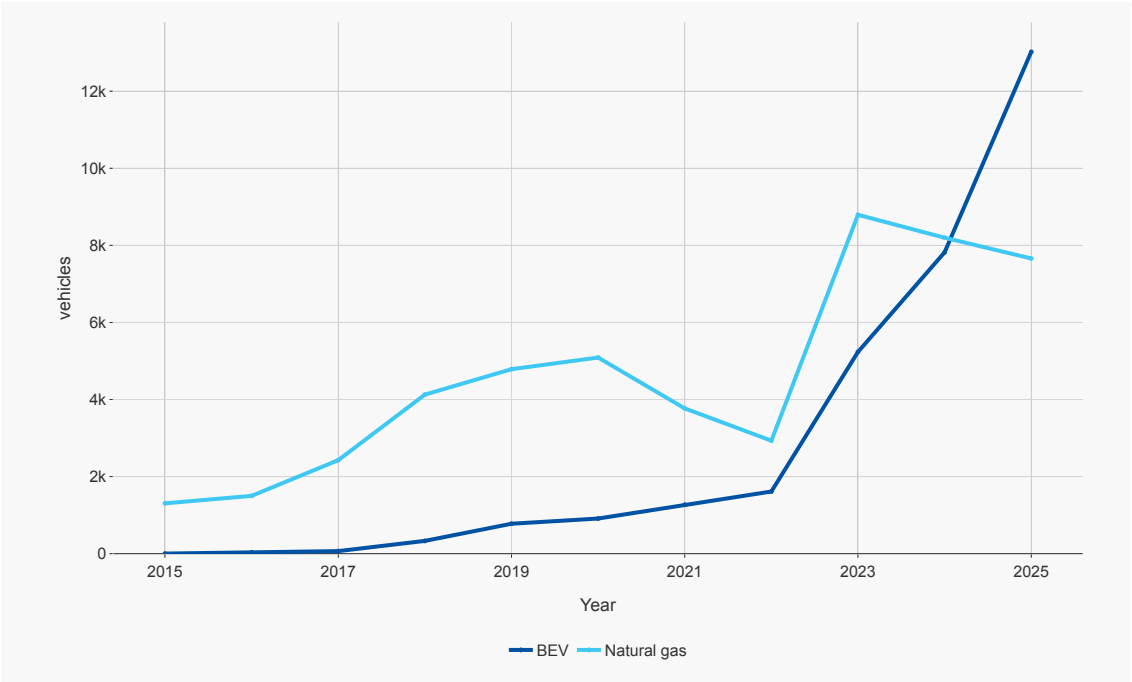
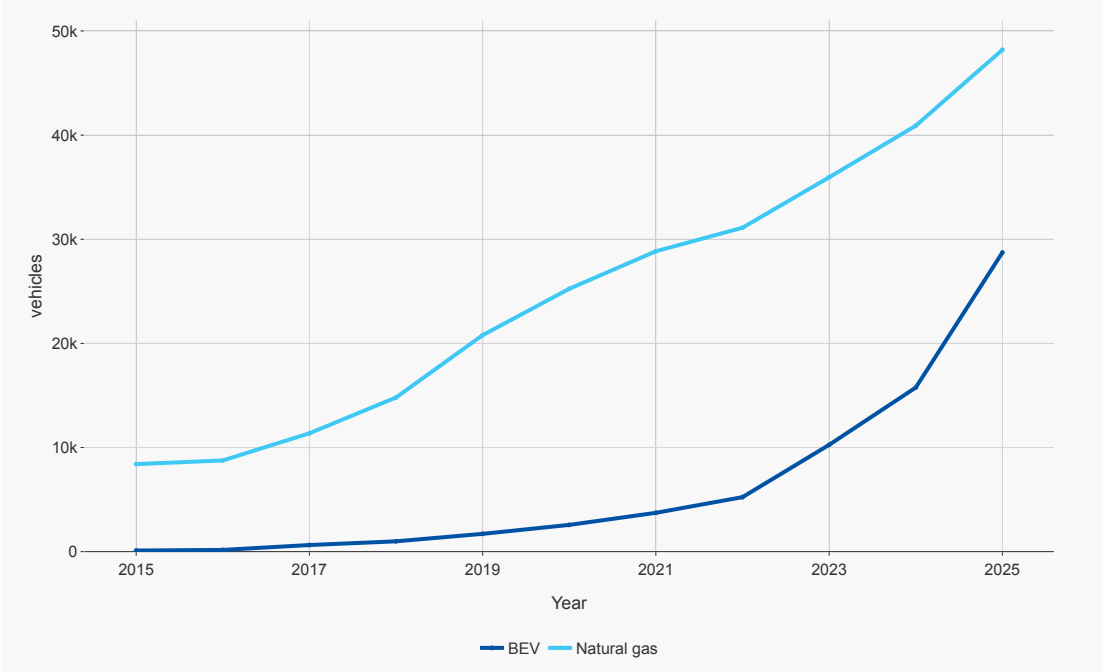


Figure 19: Alternative fuel truck fleet stock
Battery-electric and natural-gas truck fleet stock in the EU, 2015-2025

Source: EAFO





Public bus displaying a 100% biomethane vehicle label in Paris, France, 30 July 2024

Biomethane, or RNG, uses different feedstock from liquid biofuels (with a small overlap) and runs into the same ceiling, only tighter. EU production reached 4.3 billion cubic metres in 2024, around 43 TWh,²¹ and adding all US output brings the combined total to roughly 80 TWh.²²

Set against some 790 TWh of diesel energy that EU trucks and buses consume in a year²³, EU biomethane covers about 5% of that need, and the EU and US together about a tenth, before any of it is claimed by industry, heating or power generation. The REPowerEU target would lift EU output to 35 billion cubic metres by 2030, roughly

350 TWh, but EU countries' national energy and climate plans currently add up to only 12 to 15 billion cubic metres, well under half.²⁴

Biomethane distribution works with infrastructure that already exists: it is chemically interchangeable with natural gas, so it travels through the same pipelines, storage and supply chain, and no new network has to be built upstream. The constraint sits at the vehicle-facing end. Gas refuelling points remain a small fraction of the diesel network they would have to substitute for, and the share of them equipped and sited for trucks and buses is smaller still.

EU biomethane production could cover only around 5% of the energy used by EU trucks and buses, before demand from other sectors

- 21 European Biogas Association, EBA Statistical Report 2025, December 2025. Converted at 10 kWh/m³ (lower heating value, 36 MJ/m³); the EBA itself applies 10.61 kWh/m³ without stating whether this is a lower or higher heating value, which shifts the European figures by about 6%. Eurostat publishes no separate biomethane series: its "biogases" aggregate (SIEC code R5300) combines raw biogas with upgraded biomethane and stood at 190.9 TWh for the EU-27 in 2024, of which roughly three quarters is raw biogas that cannot fuel a vehicle without upgrading.
- 22 IEA, Renewables 2025, "Biogases", October 2025: 136 PJ of US biomethane production in 2024, equivalent to 37.8 TWh. Cross-checked against United States Environmental Protection Agency RIN generation data under the Renewable Fuel Standard, which records 1.02 billion D3 RINs for 2024, equivalent to 23.0 TWh of renewable natural gas sold as transport fuel — 61% of the IEA total, consistent with the IEA's statement that transport accounts for almost 60% of US renewable natural gas consumption.
- 23 Derived from the 80 billion litres of diesel consumed annually by EU trucks and buses given earlier in this chapter, at a lower heating value of 35.7 MJ per litre (9.92 kWh/l) for B7 market-blend diesel: JEC Tank-to-Wheels report v5 — Heavy duty vehicles, Joint Research Centre, 2020, EUR 30271 EN, Table 10. 80 bn l × 9.92 kWh = 793 TWh.
- 24 European Commission, Implementing the REPowerEU Action Plan: investment needs, hydrogen accelerator and achieving the bio-methane targets, SWD(2022) 230 final, 18 May 2022. The 35 bcm target refers to upgraded biomethane, not raw biogas; the Commission publishes no TWh equivalent, so the conversion is ours. On national plans: Oxford Institute for Energy Studies, Biomethane in Europe: why scaling up is harder than it looks, NG 203, January 2026, which finds EU countries' national energy and climate plans aggregate to 12–15 bcm, a shortfall of 20–23 bcm against the target.

6.1.4 Hydrogen

By 2030, European trucks and buses could require more than a quarter of the world’s committed low-emissions hydrogen production

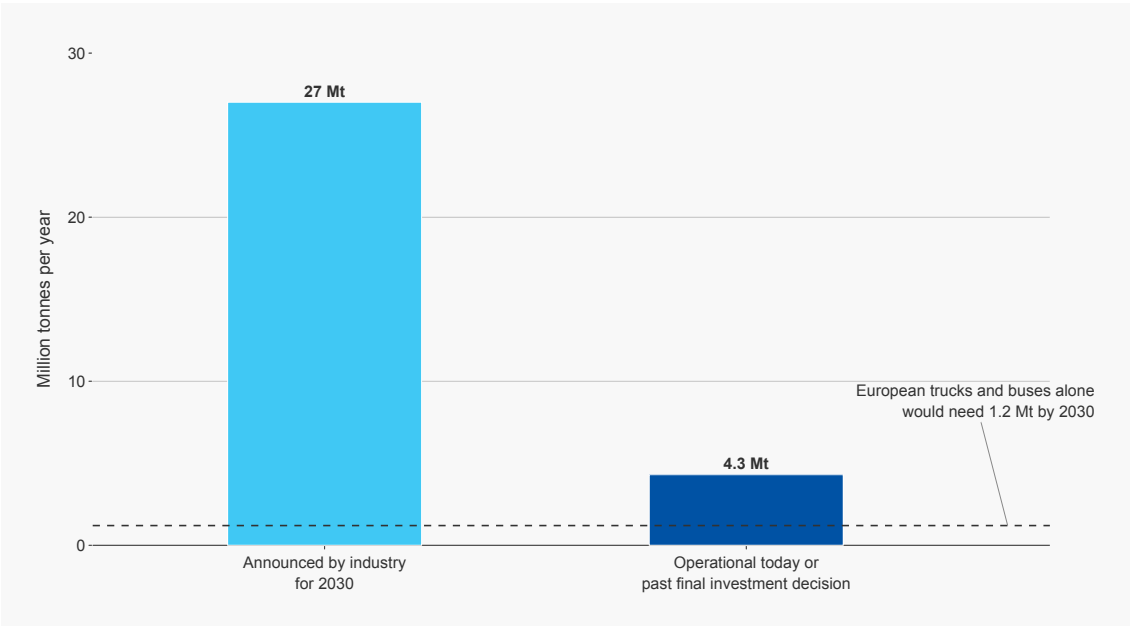
Green hydrogen is produced by water electrolysis powered by renewable electricity, and production is far from sufficient. Global hydrogen demand reached almost 100 Mt in 2024, of which low-emissions hydrogen accounted for under 1 Mt (less than 1%), while IRU Green Compact 2023 results suggest European trucks and buses alone would need 1.2 Mt by 2030. Announced projects worldwide would deliver 27 Mt a

year of low-emissions hydrogen by 2030, 10 Mt less than a year earlier; counting solely what is operational today or committed, output will reach 4.3 Mt a year by 2030, 16% of that pipeline.²⁵ On that basis, European trucks and buses alone would absorb more than a quarter of the world’s committed low-emissions hydrogen. Production is concentrated too: China holds 65% of global installed electrolyser capacity.²⁶

Figure 20: Announced hydrogen capacity is more than six times what has been committed

Low-emissions hydrogen production for 2030, million tonnes per year

Source: IEA, Global Hydrogen Review 2026 (June 2026); Geoscience Australia’s Energy Commodity Resources 2025 (as of December 2024); IRU Green Compact 2023 for the 1.2 Mt requirement; Committed: operational or past final investments. 16% from IEA figures.



25 IEA, Global Hydrogen Review 2026, June 2026. The IEA reports global hydrogen on a demand basis; production and demand are close, since most hydrogen is produced and consumed on the same site. The 27 Mtpa figure is what industry announcements would deliver by 2030, and includes projects at every stage of maturity; the 4.3 Mtpa figure covers only projects operational today or past final investment decision.

26 Europe is no exception. It produced 7.86 Mt of hydrogen in 2024; installed electrolysis capacity was 376 MW at the end of that year, about 0.06 Mt a year, with 2.84 GW under construction, about 0.46 Mt a year once complete (European Hydrogen Observatory, The European hydrogen market landscape, November 2025). Fossil routes, including by-product hydrogen from refineries and petrochemicals, still made up 94.7% of production capacity at the end of 2025, and Hydrogen Europe counts 677 MW of electrolysis installed by July 2026, 3.7 GW under construction and 0.5 GW that reached final investment decision in the first half of 2026 (Clean Hydrogen Monitor 2026). The IEA places about 2 GW of the capacity due to start in 2026 in Europe, concentrated in a few large projects (Global Hydrogen Review 2026).

Distribution is still emerging, and in one major market it is going backwards. In May 2026 the EU had 156 publicly accessible hydrogen refuelling stations in operation, of which 111 could serve trucks and buses through a 350 bar heavy-duty dispenser. The network is heavily concentrated: Germany, France and the Netherlands account for three

quarters of those heavy-duty points, while seven EU countries have exactly one.²⁷ The US is moving the other way. There were 89 stations at the end of 2024, 74 of them in California, but twelve were taken out of service during the year and only 54 remain open as retail sites, all of them serving passenger cars.²⁸

6.1.5 E-fuels

E-fuels are the hardest to produce. They require capturing carbon dioxide, producing green hydrogen, and synthesising renewable diesel. As set out in the previous chapter, the life-cycle efficiency of that chain is less than 25%: of 100 units of renewable energy, only 25 reach the wheel. E-fuels have the potential to be the most sustainable drop-in fuel, since they can be produced without land use or bio-based feedstock, but their decarbonisation potential depends entirely on the carbon intensity of the electricity used, and feeding that electricity directly into a battery will always be technically better.

Distribution is no more of an issue for e-fuels than for biofuels as they are drop-in. The constraint sits upstream, and it is of a different order of magnitude, because every unit of energy reaching the wheel has to be manufactured several times over. Replacing the 80 billion litres of diesel that EU trucks and buses burn each year with e-fuel would call for somewhere between 1,600 and 2,000 TWh of electricity, against roughly 370 TWh to move the same freight with battery electric vehicles. That is about five times the power for the same transport work, equivalent to roughly three quarters of the EU's total annual electricity consumption.

Powering EU trucks and buses with e-fuels would require around five times more electricity than using battery electric vehicles for the same transport work

- ²⁷ Public schemes are adding to the network. In the Netherlands, the SWiM scheme awarded support in its 2024 and 2025 rounds to six new hydrogen stations, seven extensions of existing stations and more than 550 vehicles, mostly heavy trucks, to be completed within three years of award; a third round with a EUR 45 million budget closed in May 2026 (RVO; Nationaal Waterstof Programma, 19 December 2024 and 14 October 2025). In Germany, the Federal Ministry of Transport's EUR 220 million call for an initial heavy-duty refuelling network, coordinated by NOW GmbH, closed on 30 June 2026 with 526 applications requesting EUR 455 million, 71 of them for stations and 455 for vehicles and fleets (NOW GmbH, 2 July 2026). No award had been announced at the time of writing (October 2026).
- ²⁸ European Hydrogen Observatory, Hydrogen refuelling stations, dataset of publicly accessible and operational stations, reference period May 2026. Heavy-duty capability is counted as a station having at least one 350 bar heavy-duty dispenser; the EU-27 total of 111 such stations comprises 122 dispensers. US figures: Ludwig-Bölkow-Systemtechnik / H2stations.org, 17th annual assessment, February 2025 (end-2024 data), and US Department of Energy Alternative Fuels Data Center for the retail station count.

Hydrogen is heavy-duty ready: Scaling the ecosystem is the new frontier

Erwin Penfornis

Vice-President of
Hydrogen Energy,
Air Liquide

Heavy-duty hydrogen transport has reached a pivotal stage. As Erwin Penfornis, Air Liquide's Vice-President of Hydrogen Energy World Business Line, emphasises, the solutions already exist and are fully industrialised. The challenge now is creating the right economic conditions and deploying vehicles, fuel and infrastructure in unison to trigger full market activation.

IRU member Air Liquide approaches this transition backed by over 60 years of expertise across the hydrogen value chain and 15 years dedicated to hydrogen mobility. Today, the company operates across the full ecosystem, from renewable and low-carbon hydrogen production through large-scale electrolysis to liquefaction, supply and end-use applications.

To overcome historical bottlenecks, Air Liquide **has joined forces with major industrial partners** – including Daimler Truck, Volvo Group, and IRU member TotalEnergies – to accelerate the European rollout of heavy-duty hydrogen mobility by 2030. Rather than attempting a scattered, continent-wide deployment, the industry is concentrating vehicles and infrastructure along designated anchor industrial hubs and connecting corridors where favourable conditions already exist.

Germany currently serves as a prime example of this synchronised strategy.

The country combines targeted incentives for clean vehicles with policy frameworks designed to help operators achieve total cost of ownership parity with diesel. Reaching a retail hydrogen price below EUR 8 per kilogram remains a vital target for commercial viability, a threshold that is becoming increasingly achievable as supply chains mature and support mechanisms such as RED III credits and GHG quotas take effect.

Scaling infrastructure and advanced logistics

Bringing costs down further requires a massive scale-up across the entire value chain, driven by higher truck volumes and greater hydrogen refuelling network utilisation. To optimise distribution over longer distances, the industry is increasingly pointing to liquid hydrogen as a strategic long-term solution. By significantly increasing energy density per load, liquid hydrogen can fundamentally improve supply economics.

Infrastructure deployment is accelerating in tandem to meet this demand. **TEAL Mobility**, an Air Liquide and TotalEnergies joint venture, is notably building high-capacity station networks engineered specifically for heavy trucks. The aim is to deliver multi-tonne daily volumes and rapid, consecutive refuelling, offering long-haul fleets the quick turnarounds required for intensive logistics.

Two technologies, one decarbonisation goal

Hydrogen is not a competitor to battery-electric technology; rather, these decarbonised drive systems are complementary, serving distinct operating profiles. Battery-electric vehicles are already proving effective for many regional routes. However, hydrogen becomes essential for the use cases responsible for the highest CO₂ emissions – specifically heavy-duty transport where heavy payloads, intensive usage, long ranges, or electricity grid congestion, such as in the Netherlands, present operational challenges.

Global precedents highlight how both technologies can thrive together. In China, around 40,000 hydrogen trucks are already operating alongside rapid battery adoption.

In Europe, initiatives like the Paris hydrogen taxi ecosystem (HysetCo) demonstrate what happens when vehicle fleets and refuelling stations expand in tandem.

Air Liquide also approaches this transition as a major shipper in its own right. Operating thousands of transport movements to deliver industrial gases, the company has begun **deploying hydrogen trucks** into its own logistics fleet in the Netherlands. This firsthand operational experience confirms that vehicle manufacturers, energy suppliers, and transport operators must build the ecosystem together. With key technologies and strategic partnerships now established, the priority through 2030 is transforming readiness into deployment at scale. ■



About Air Liquide

A world leader in gases, technologies and services for industry and healthcare, Air Liquide acts as the backbone of numerous economic sectors, serving 4.3 million customers and patients across 59 countries with approximately 65,000 employees.

With over 60 years of expertise, Air Liquide views hydrogen as a key solution in the energy transition to decarbonise industry and mobility, fully in line with its ambition to achieve carbon neutrality by 2050.



6.2 Operational feasibility: can the fleet still run?

The previous section asked whether the green energy is there. This one asks what each energy does to the way the fleet runs.

Transport flexibility is the ability of operators to adapt and respond quickly to changing shipping demands: handling varying cargo volumes within tight timeframes, servicing different routes and destinations as needed, and adapting to a range of delivery schedules despite traffic and road conditions. Flexibility is the combination of transport capacity and fleet uptime.

Capacity is the number of vehicles available on the market and, above all, the number of drivers available

to drive them. This is addressed by the [IRU Global Driver Shortage project](#) and is not covered here. What this section examines is what decarbonisation does to uptime and to the operating envelope of the vehicle itself.

The question matters because even energy that is available and affordable becomes impractical if its use forces operators to redesign how their fleets operate. Transport buyers do not purchase a truck; they purchase a delivery at a given place and time. Any solution that erodes the ability to meet that commitment is, from the customer's point of view, not a solution.

Any solution that erodes the ability to meet that commitment is, from the customer's point of view, not a solution



6.2.1 Drop-in fuels: flexibility preserved

HVO and FAME share one decisive operational property: they require no change to the vehicle, the depot, the driver's routine or the transport plan. A fleet switching to HVO keeps the same refuelling time, the same payload and the same route structure, and thanks to an energy content close to diesel's, effectively the same range. FAME is somewhat more limited on that front: its lower energy density trims the range

on a full tank, and running pure biodiesel requires the manufacturer's approval rather than being a straight swap. This is the strongest argument for these fuels, and it holds independently of their supply limits: wherever the volumes exist, the operational cost of transition is close to zero. It is also why renewable diesel leads operators' stated intentions in the survey results presented in the next chapter.

Where supply is available, HVO and FAME can be adopted with little operational disruption, requiring no changes to vehicles, depots or transport plans

6.2.2 Range, payload and refuelling

Hydrogen and biomethane both reduce the operational range a vehicle can cover on a single fill compared to diesel, although there is no range difference between methane and biomethane. But battery electric vehicles go further, changing the operating envelope on three fronts at once.

Range determines which duty cycles are addressable. Urban distribution, regional round trips and return-to-base operations sit comfortably within current battery ranges (currently around 500km for a 4-tonne battery pack). Long-haul international operations do not. They depend entirely on the public network discussed below. This is why electrification progresses fastest in the segments where the operational change is smallest, a pattern confirmed by the results of the survey.

Payload and axle-load distribution are the second constraint, and they operate at two levels. The first is how much the vehicle can carry. Battery weight reduces the available payload, the exact reverse of the lightweighting lever described earlier in this report. Where an operator is volume-limited, the penalty is invisible. Where the operator is weight-limited, it translates directly into more trips for the same tonnage, and therefore a higher cost per tonne-kilometre.

Regulation is defining the maximal vehicle weight, and can help compensate the kerb weight increase. As such, EU weight and dimension rules allow up to two additional tonnes for zero-emission vehicles, but capped at the actual weight of the zero-emission technology within the limit of 2 tonnes. The allowance offsets part of the battery's weight and, by design, restores none of the revenue-earning payload. A revision raising the allowance – the European

Parliament's position foresees four tonnes, potentially decoupled from the technology's weight – was still under negotiation between the co-legislators at the time of writing.

The second level is less visible but felt at every loading dock: where the load may be placed. Axle-load limits do not move with the gross-weight allowance, and on an electric tractor more than two additional tonnes of battery and driveline mass sit over the drive axle before any cargo is loaded, making 4 tonnes of the 11.5-tonne limit already consumed at kerb. For the same payload, the window of admissible positions for the cargo's centre of gravity therefore narrows: load plans that are legal behind a diesel tractor must be shifted rearward or split behind an electric one. Battery weight and placement then erode how much goods a vehicle can carry and how freely that load can be arranged.

Timing is the third. A diesel refuelling stop takes minutes; recharging takes hours. The practical test is whether charging can be absorbed within the driver's mandatory rest periods rather than added on top of them, the 45-minute break being the natural window for on-the-road charging. But that stop is shaped by economics as much as by charging power. Public charging is considerably more expensive than depot electricity, so a cost-optimising operator draws en route only the energy needed to reach the depot and shifts the bulk of the charge to where electricity is cheapest: the mid-day stop could be a top-up, not a fill-up. The Megawatt Charging System can deliver such a top-up comfortably within the break, provided the grid delivers the power to the charger, but how intensively it will be used will depend on its price per kilowatt-hour as much as on its power rating.

Electrification is progressing fastest in urban, regional and return-to-base operations, where current battery ranges require the least operational change

Biomethane and hydrogen sit between the drop-in fuels and the battery on this front. Refuelling remains a matter of minutes, comparable to diesel for gas vehicles, and around 8 to 20 minutes for a heavy fuel cell truck. Ranges differ more: gas vehicles approach diesel in the best configurations, with up

to some 1,600km on LNG and over 1,000km demonstrated on CNG, while today's fuel cell trucks cover around 400km per refuelling (up to 800 with liquid hydrogen). For these energies, the operational constraint is less the stop itself than the sparseness of the station network, which dictates where the stop can happen.

6.2.3 Depot and public charging: two different problems

Electric long-haul could increasingly be organised around goods rather than vehicles, with trailers relayed between depots while trucks and drivers remain regional

Most electric truck charging today happens overnight at the depot, and this is where the transition is easiest for an operator to control: it owns the site, gets lower charging prices and knows the average charging power for easier scheduling. The binding constraint there is not the charger but the connection. Securing the additional grid capacity for a depot typically takes one to two years in Western European countries, a lead time that sits with the distribution

system operator rather than with the fleet, and that operators therefore cannot compress on their own.

Between the depot and the public network, a third tier is taking shape: semi-public charging, where operators open their depot chargers to other fleets. The economics push hard in that direction. Prices roughly double at each step, semi-public charging costs about twice depot electricity, and public charging about

Long-haul vehicle charging station in Andalusia, Spain, 8 August 2025



twice semi-public, and depot charging points are currently being deployed faster than public ones. Predictability points the same way: an operator knows what power a depot or semi-public site can deliver, while the energy actually available on arrival at a public site is far less certain. If the depot base can be opened up as it grows, the bulk of the network builds itself: a system in which 80-90% of charging points (and an even larger share of the energy delivered) sit at depot and semi-public locations, leaving public charging to the one place nothing else can serve: the highway network, where drivers are legally required to stop.

That remaining slice is nonetheless decisive, as it determines whether long-haul is addressable at all. Beyond the number of points covered in the previous section, the highway network has to be usable

by a 40-tonne combination: bays sized for the vehicle's length and turning circle, accessible without uncoupling the trailer, and located where drivers must take their breaks. Signals suggest the grid and the land are the bottlenecks for faster deployment of these sites, rather than the chargers themselves.

How much public charging the system ultimately needs also depends on how long-haul itself evolves. Limited range and drivers' preference for returning home daily create an incentive to reorganise long-haul around the goods rather than the vehicle (trailers relayed between depots while trucks and drivers stay regional) and to buy vehicles with smaller battery packs, lower purchase prices and a better total cost of ownership. If operations move that way, the case for a dense public network shrinks further.

6.2.4 Cross-border operations

Commercial road transport in Europe is international by design, and this is where uneven national conditions turn from a statistic into an operational problem. Charging and refuelling networks are planned and financed country by country, so a vehicle whose range and energy supply are secure in one EU country may find no equivalent conditions across the border. The rational response for an operator is to keep that vehicle on domestic work – and that is where the damage spreads

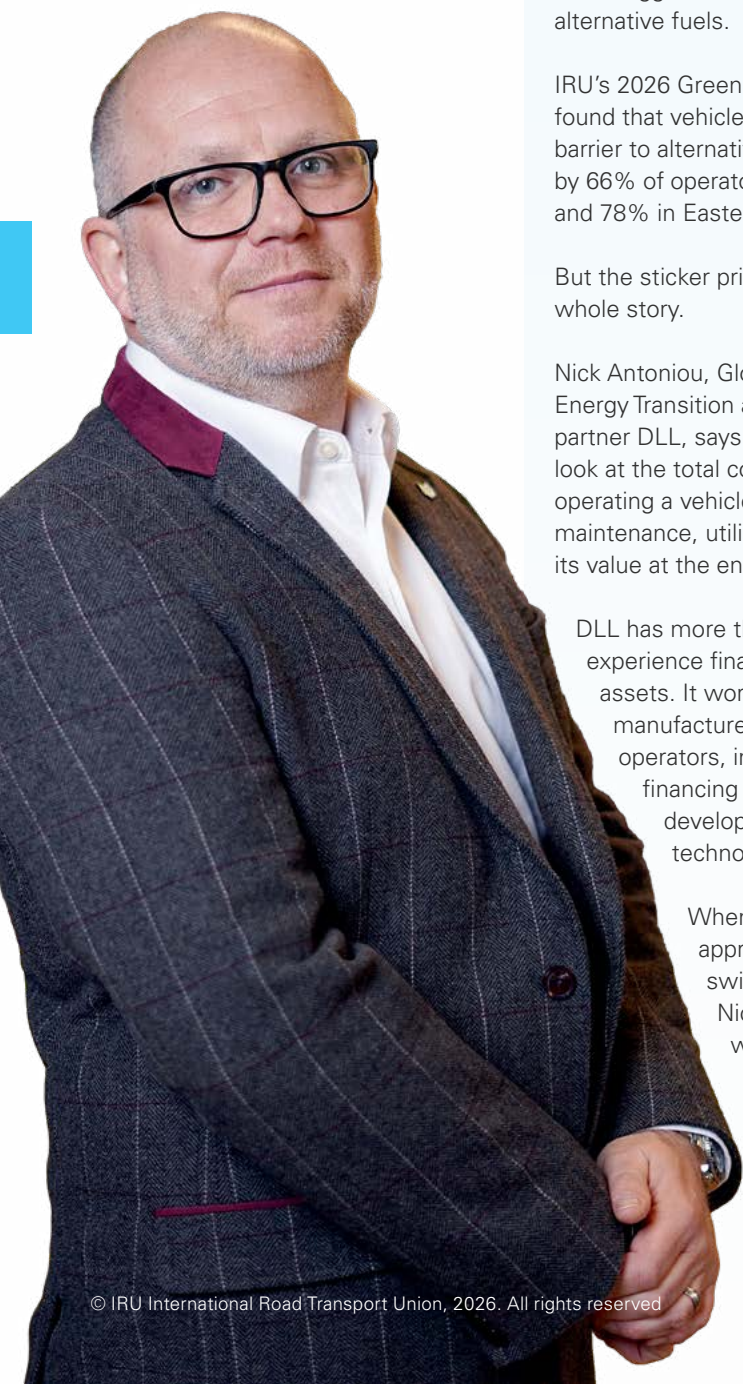
in two directions at once. Fleets confined to their home market lose access to international routes and become less competitive; countries whose inbound capacity thins out come to rely more heavily on their national fleet, and their transport costs rise accordingly. An energy transition planned nationally but operated internationally will therefore not deliver flexibility. The test is not how dense each national network is, but whether it is continuous along the corridors traffic actually uses.

A road transport energy transition planned nationally but operated internationally cannot deliver the flexibility operators need

How financing can jump-start road transport's energy transition

Nick Antoniou

Global Manager for Energy Transition, DLL



High upfront costs remain one of the biggest barriers to decarbonising road transport. But financing can change the equation by spreading costs, reducing risk and giving operators more flexibility as technology evolves, explains DLL.

For many road transport operators, cost is the biggest obstacle to switching to alternative fuels.

IRU's 2026 Green Compact survey found that vehicle price is now a leading barrier to alternative fuel adoption, cited by 66% of operators in Western Europe and 78% in Eastern Europe.

But the sticker price does not tell the whole story.

Nick Antoniou, Global Manager for Energy Transition at IRU strategic partner DLL, says operators need to look at the total cost of owning and operating a vehicle, such as energy, maintenance, utilisation, financing and its value at the end of its first life.

DLL has more than 25 years of experience financing transport assets. It works directly with manufacturers, dealers, and fleet operators, including through financing programmes developed with OEMs and technology providers.

When an operator approaches DLL about switching powertrains, Nick Antoniou starts with a basic question: "What's driving your decision to transition away from traditional internal combustion engine vehicles?"

The answer matters. An operator may be responding to regulation, sustainability targets, customer expectations, or total cost of ownership. Each requires a different assessment of routes, utilisation, charging infrastructure, and fleet replacement cycles.

Beyond the sticker price

Leasing can make the upfront cost of an electric vehicle more manageable, allowing operators to spread costs over its operating life. Future residual value can also be incorporated into the financing structure, helping to lower periodic payments.

But Nick Antoniou stresses that it's about more than moving expenditure from one place to another.

"An operating lease can fundamentally change the conversation from 'how much does the vehicle cost today?' to 'what will the vehicle cost my business over time, and who is best placed to manage the associated risks?'"

Those risks are particularly important for newer technologies.

Battery degradation, technological changes, and uncertainty over the future used-vehicle market all make the residual value of an electric commercial vehicle harder to predict than that of an established diesel equivalent.

Under many operating leases, financiers can take on that residual value risk.

The operator therefore gains greater certainty over the cost of using the vehicle, while the financier assesses what the asset is likely to be worth when the lease ends.

That assessment considers the vehicle's intended use, battery capability, technological development, market adoption, and manufacturer warranties.

The market is still young. Very few electric trucks and buses have already completed their first full financing cycles and entered the second-hand market.

That should gradually change. More used vehicles, stronger battery-health data and longer manufacturer warranties could all help financiers assess future values with greater confidence.

Smaller operators face a steeper climb

Financing could be particularly helpful for smaller operators.

The Green Compact survey has revealed a clear gap between larger and smaller operators when it comes to planned investment in battery-electric vehicles.

Large fleets can often dedicate teams and budgets to testing new technologies. Smaller operators have less room for error. A vehicle that cannot complete its route or a charging solution that does not perform as expected can have a much greater impact on their business.

Stephen Lidgley, Global Equipment Portfolio Manager- Energy Transition at DLL, nevertheless sees the market broadening beyond its early adopters. Mid-sized operators are showing more interest as vehicles improve, financing options mature and more operational data becomes available.

Through leasing solutions, DLL can help customers align costs more closely

with the benefits and operational life of the vehicle.

"Our asset management specialists assess factors such as vehicle utilisation, contract duration, and expected residual values to structure affordable monthly payments," said Stephen Lidgley.

By incorporating future asset value into the financing solution, operators can reduce their upfront investment and avoid taking on the risks associated with depreciation, residual value uncertainty, and future technology developments.

But infrastructure remains a major constraint.

"If I had to pick one factor, it would be charging infrastructure," Nick Antoniou told us. "Operators ultimately need confidence that vehicles can do the job they were purchased for."

That means financing cannot solve the transition alone.

Operators also need confidence that charging networks can support their routes and that grids can accommodate larger electric fleets.

Policy certainty matters, too. Financiers make decisions based on asset values and customer economics over several years. Frequent changes to regulation, incentives or taxation can increase uncertainty around future demand, residual values and credit risk, ultimately affecting how financing is structured and priced.

A clear and stable long-term regulatory framework, by contrast, can give financiers greater confidence to take a longer-term view on residual values and deploy more capital into the sector.

As these conditions improve, DLL expects alternative fuel vehicle financing to become increasingly mainstream – and the gap between large and smaller operators to narrow. ■



About DLL and its eMobility solutions

DLL is a global asset finance company for equipment and technology with a managed portfolio of more than EUR 47 billion.

With more than 25 years of experience financing transport assets, DLL recognised early that the industry was beginning a significant transition towards alternative fuels and reduced-emission technologies.

In response, it established a dedicated eMobility team to work closely with vehicle manufacturers, dealers and fleet operators to develop financing solutions that would help accelerate the adoption of electric vehicles and supporting charging infrastructure.

Today, eMobility remains a key pillar of DLL's broader Energy Transition strategy.

Stephen Lidgley

Global Equipment Portfolio Manager - Energy Transition, DLL



6.3 The economic equation: does the business case add up?

Even where the energy is available and the operation is feasible, nothing happens unless the numbers work for the operator. This section brings

together the cost side of every energy reviewed above, and the policy measures designed to shift the balance between them.

6.3.1 Where transport costs stand today

Transport costs, or freight rates, derive from operators' TCO and from their capacity to fulfil transport demand. Measured against 2019, road transport is around 40% more expensive in Europe today and close to 50% more expensive in the US. Almost all of that is general inflation, at least until 2026: deflated by consumer prices, freight rates at the end of 2025 stood 1.7% above their 2019 level in Europe and 2.9% above it in the US, and at the end of 2024 European rates were marginally below it.

For six years, operators have passed rising costs through rates and little more. This should be kept in mind when wondering about decarbonisation's economic equation. Rates follow the cost base rather than the value of the service, so there is no accumulated margin from which to fund a vehicle costing two to three times as much as its diesel equivalent.

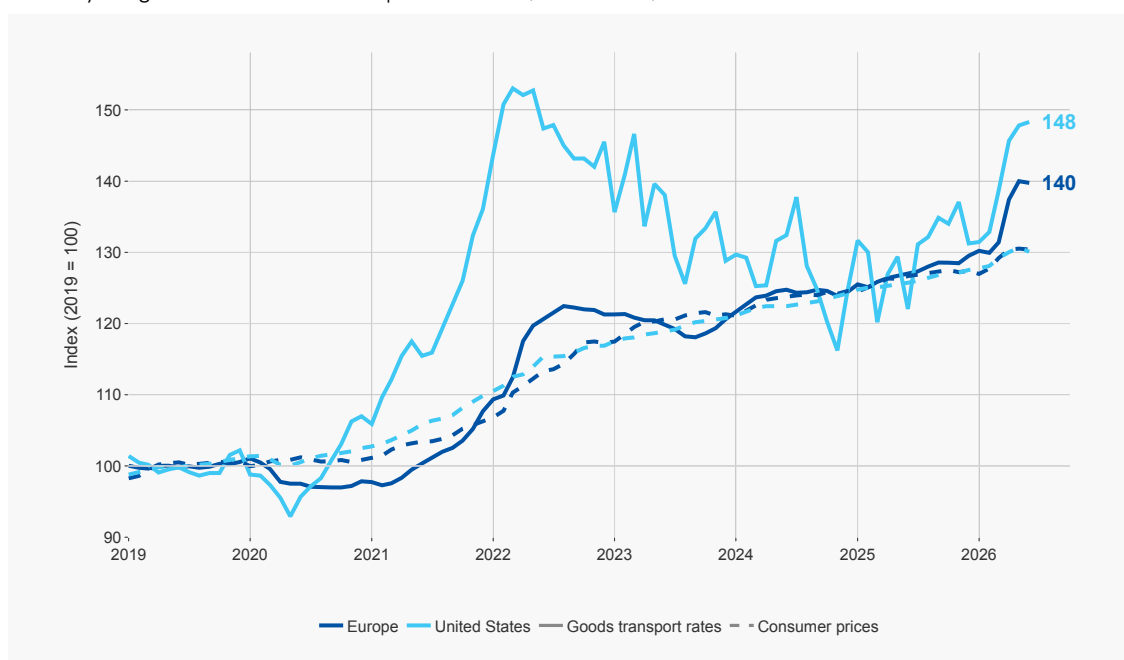
The 2026 increase in transport costs reflects the impact of high diesel prices linked to the global energy

Transport rates leave little margin to fund vehicles costing two to three times as much as their diesel equivalents

Figure 21: By the end of 2025, real rates were close to their 2019 levels, despite substantial fluctuations in the intervening years

Monthly freight rate and consumer price indices (2019 = 100)

Source: Transporeon Market Insights (Trimble), FRED (PPI general freight trucking long-distance truckload, CPI-U), Eurostat (prc_hicp_midx)



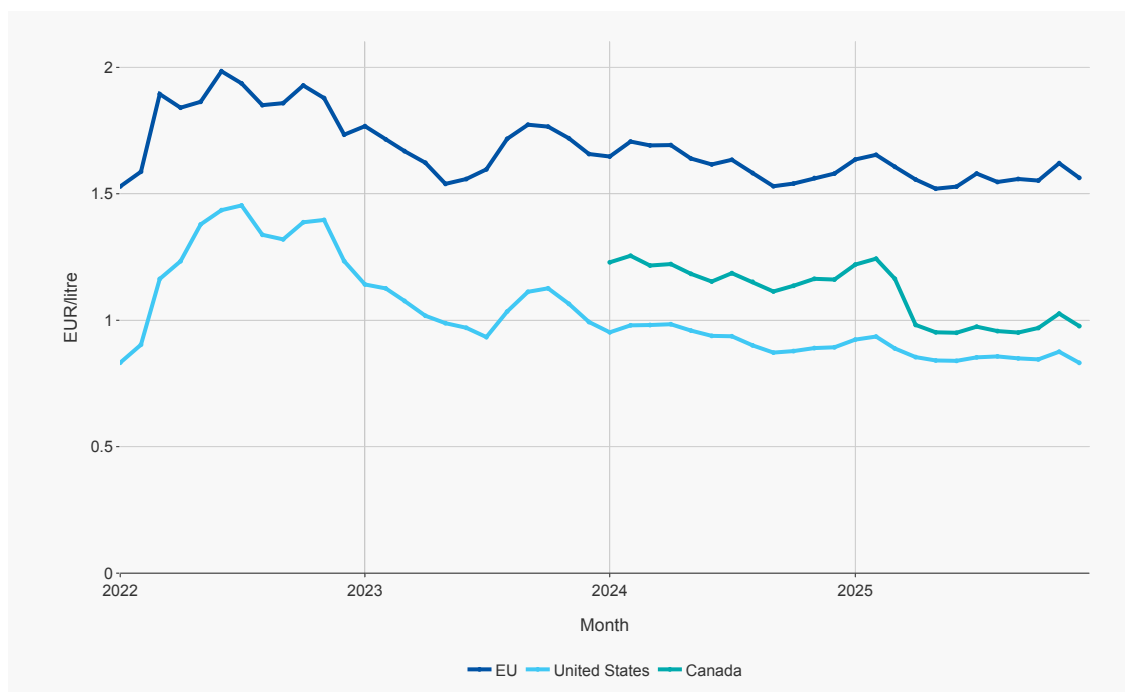
crisis. Shippers face higher freight rates, but operators are neither widening their margin nor rebuilding reserves: contract rates put strong pressure on cashflow, because the fuel floater rarely moves as fast, or as far, as the fuel price itself. And while higher diesel prices create an incentive to transition to cleaner solutions, HVO prices tracked diesel

upward, and the cash drained by the crisis challenges the capacity to invest in new chargers and electric vehicles.

That is the starting point for everything that follows: the cost of decarbonisation is being added to a cost base that has already absorbed a 40% increase.

Figure 22: Diesel prices in the EU, US and Canada

Monthly diesel prices, EUR per litre



Source: Xavvy

6.3.2 The green premium on decarbonised vehicles

Decarbonising road transport carries a green premium: the extra cost of choosing a zero-emission version over the conventional one. For operators, that extra cost lands on TCO, which combines CAPEX and OPEX. And even if parity is reached (the point at which the green premium disappears), the TCO at that point will still be higher than the one operators know today, because parity is reached partly by pushing the cost of diesel up.

On CAPEX, zero-emission vehicles carry almost all of the premium, because their purchase price is far above the diesel version: battery-electric trucks now in serial production cost two to three times as much, and fuel-cell vehicles as much as five times. To convert their fleets, operators must expand their capital base and negotiate loan access and interest rates, while explaining to lenders that a substantially more expensive production tool generates the same added value.

Residual value for ZEVs is the less visible half of the same problem. Fleet renewal plans are built on the resale price of the vehicle at the end of the first ownership cycle, and the second-hand market for electric and hydrogen trucks is not yet formed.

Uncertainty on the residual pushes leasing and financing costs up, and it falls hardest on small operators, who renew their fleets by buying used, which is also the mechanism by which any new technology eventually reaches the majority of the market.

Figure 23: Difference from EU average: electricity and diesel prices
Percentage deviation from the EU average

Source: Eurostat (nrg_pc_205_c) & xavvy

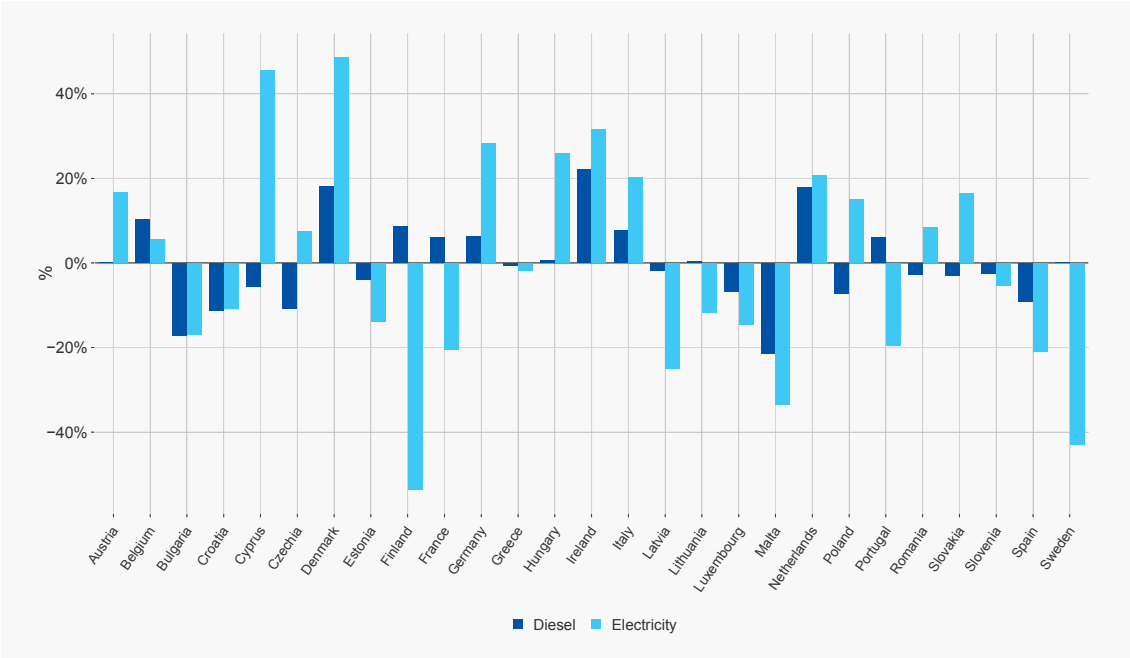
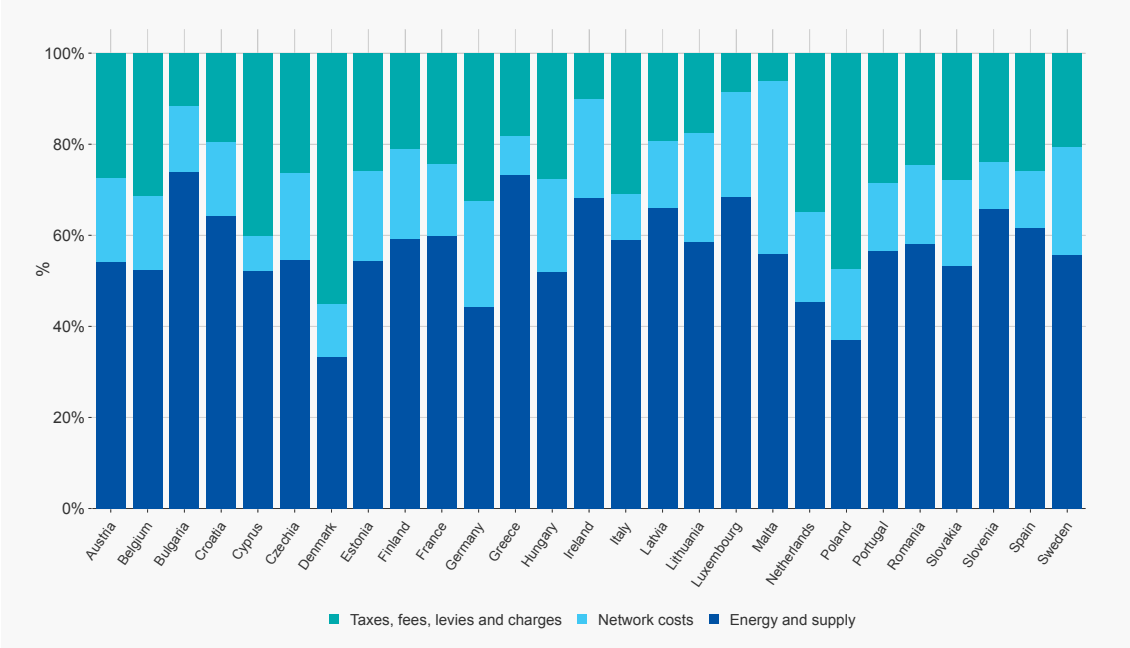


Figure 24: Share of national electricity prices
Taxes, fees, levies and charges; network costs; energy and supply (%)

Source: Eurostat (nrg_pc_205_c and nrg_pc_205)



The vehicle premium can in principle be recovered over the life of the vehicle, since ZEVs trade higher CAPEX for lower OPEX.

A more efficient powertrain and cheaper energy should bring the energy component of TCO below diesel. But that only works if energy prices cooperate.

Taken together, four of the five greener energies are nevertheless more expensive than diesel. Electricity is the exception in the EU. It is the only energy whose per-kilometre cost sits structurally below diesel, and that is before ETS2 widens the gap. There, lower OPEX can offset higher CAPEX – but only where the saving is actually realised, which requires the vehicle's range to allow the annual mileage the offset depends on. The price spread between EU countries, however, is far wider than for diesel, largely because of taxation differences, which creates a risk of fleets becoming economically

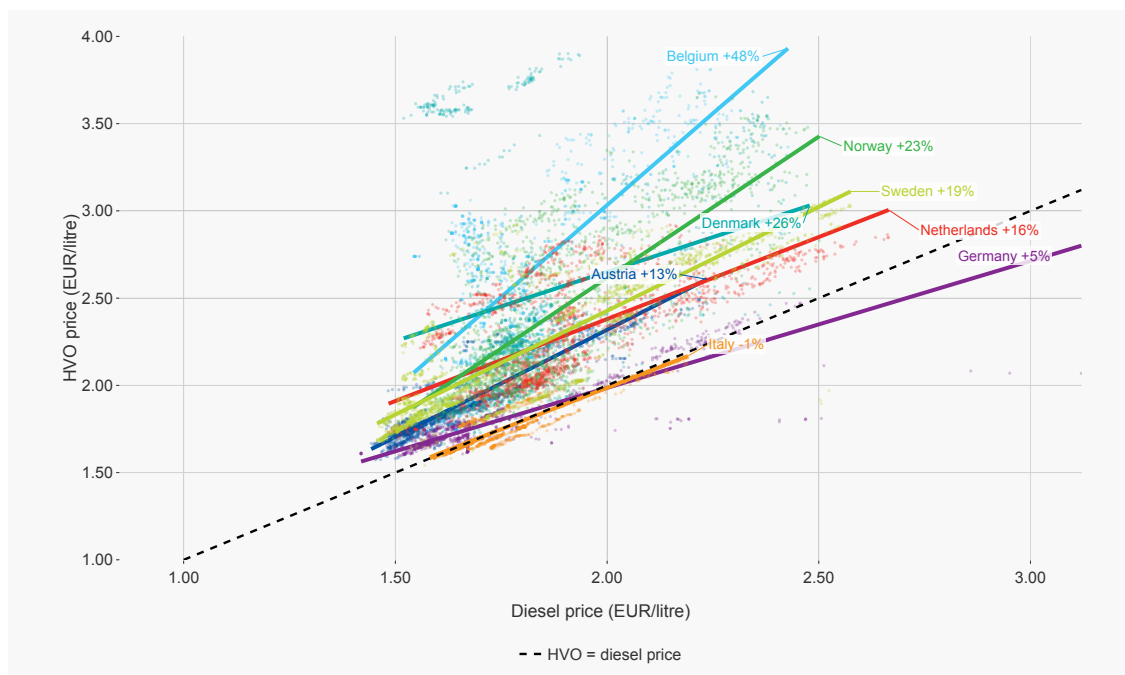
uncompetitive depending on where they are established, and of countries seeing transport costs rise.

HVO costs more than diesel in every market IRU tracks but one. The EU median premium is about 14%, and the spread is what an operator actually faces: parity in Italy (thanks to favourable HVO taxation), 5% in Germany, 26% in Denmark, 48% in Belgium, and 57% in the US, the world's largest HVO producer. The same vehicle running on the same fuel therefore carries a different business case depending on where it refuels. The premium also widens as diesel gets more expensive. In most markets, the relationship between the two prices is steeper than parity, so each increase in the diesel price lifts HVO by more than one for one. The incentive that expensive diesel is supposed to create for switching is weakest at the moment diesel is most expensive.

The incentive to switch away from diesel is weakest precisely when high diesel prices should make it strongest

Figure 25: HVO and diesel price relationship

Renewable diesel (HVO) and fossil diesel prices, EUR per litre



Source: IRU
fuel services

The cost gap between green and fossil fuels depends as much on fossil fuel prices as on the cost of the green alternative

Biomethane production costs run from about 50 to 90 EUR/MWh in Europe, with the average now near 75 to 80. What that means for an operator depends entirely on what fossil gas costs at the same moment, and that has moved violently: the European benchmark averaged 36 EUR/MWh across 2025 and passed 70 at the end of August 2026. Measured against last year, biomethane was twice the price of fossil gas; measured against today, it is close to parity. The US shows the same arithmetic running the other way. American production costs sit inside the European range, and landfill gas there is cheaper than anything in Europe, but abundant domestic gas at under USD 3 per million BTU makes the most expensive route, manure digestion, look ten times more expensive.²⁹

Nothing about the fuel changed between those two readings. What an operator faces is therefore not a stable premium but the volatility of the fossil price it is measured against.

The pattern is the same for every energy in this section: the gap that decides whether a switch makes sense is set less by the cost of the green fuel than by the price of the fossil fuel it is measured against, HVO indexed to diesel, biomethane to the gas benchmark, and the e-fuel premium widening in 2025 not because e-fuel became more expensive but because fossil fuel became cheaper.

Green hydrogen costs more than the fossil route everywhere, and the size of the gap is set by the gas price rather than by electrolysis. Steam methane reforming, the conventional route, is three-quarters natural gas by cost. Its price was EUR 1.2 to 1.5 per kilogram before 2022, rose to 5.70 during the gas crisis, fell back to 3.20 in 2023, and at the gas prices of late 2026 is back toward 4.5 to 5. Electrolytic hydrogen production in Europe cost EUR 6.7 per kilogram from dedicated renewables in 2024, and 7.4 from the grid. To date, the few hydrogen stations distributing to fuel cell trucks sell the energy in

Green hydrogen fuel cell bus in New Delhi, India, 13 February 2025



²⁹ OIES paper NG203 (Jan 2026) and IFRI (Jun 2026) for European production costs; European Commission DG ENER quarterly gas market report for the 2025 TTF average; ICE via press for the August 2026 level; US EIA Henry Hub monthly series and the AGF/ICF RNG Supply Assessment (Jul 2025) for the American figures.

the EUR 8 to 15 per kilogram band, making OPEX higher for H2 trucks than for diesel trucks, as a fuel cell truck runs on 7kg/100km and a diesel truck on 25L/100km in a classic 40-tonne combination.³⁰

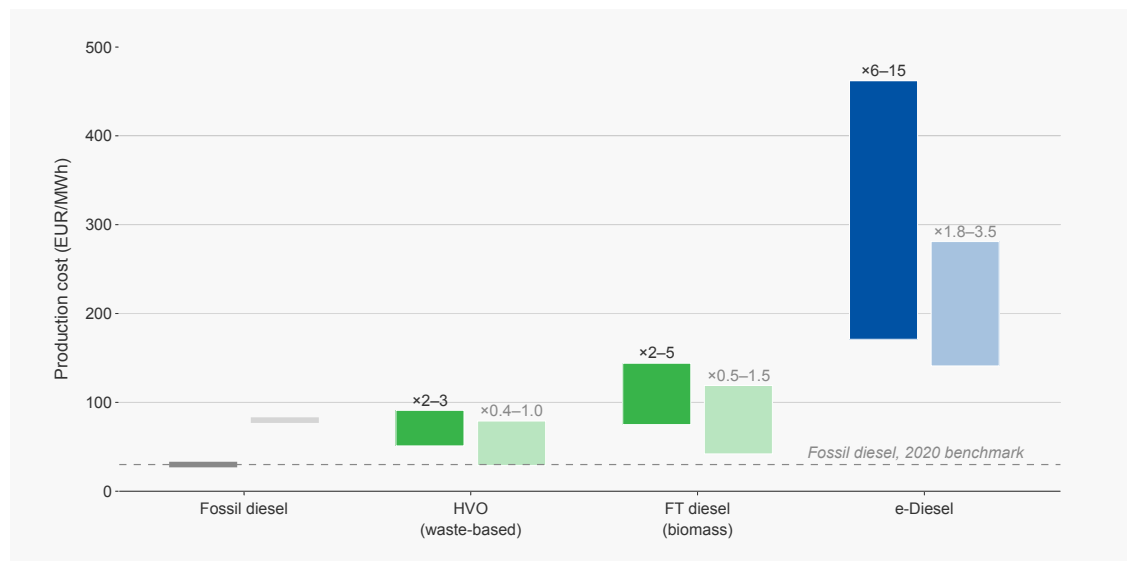
E-fuels are the most expensive by a wide margin, and the margin is widening. The European Union Aviation Safety Agency's (EASA) 2025 reference prices put synthetic aviation fuel at EUR 7,520 per tonne against EUR 640 for conventional jet fuel. That is a multiple of almost twelve, against ten and a half a year earlier. It widened because fossil fuel became cheaper, not because e-fuel improved: conventional jet fuel fell 13% over the year, synthetic fuel 2%.

Two details from the same exercise matter more than the price. EASA found no market price for synthetic fuels to use, because no price reporting agency publishes an index for them, and had to model the cost of hypothetical first-of-a-kind plants instead. And aviation, which has a binding mandate carrying penalties, and no electric alternative, is not buying them either: the synthetic share of the ReFuelEU blend was zero in 2025, and sustainable aviation fuel of all kinds covered 0.53% of global jet fuel use in 2024. Road transport would be bidding for the same molecules from a weaker position, as the greater number of operators compared to aviation gives them less leverage to secure the supply and to bargain prices.

Synthetic fuel costs are almost twelve times those of conventional fuel, with the gap widening as fossil fuel prices fall

Figure 26: Biofuels can close the gap with fossil diesel. Synthetic diesel cannot

Production cost, EUR/MWh. Dark bars current, light bars long-term potential; multiples use current or long-term fossil benchmarks



Source: Concawe report 4/24, E-Fuels: A techno-economic assessment of European domestic production and imports towards 2050 – Update (2024), for fossil diesel and e-diesel; IEA Bioenergy Task 41: 2020:01, Advanced Biofuels – Potential for Cost Reduction (2020), Table 12, for HVO and FT diesel. Concawe values converted from EUR per litre of diesel-equivalent at 9.96 kWh/l. Biofuel long-term figures are that report's aggregate technology-category ranges at a 2030–2035 horizon.

³⁰ Posted prices and contract prices differ. H2 MOBILITY's posted price for 350 bar refuelling in Germany, the pressure used by trucks and buses, has been EUR 9.50 per kilogram for green and EUR 12.85 to 13.75 for grey hydrogen since October 2023, cut by about 10% at five high-volume stations in June 2026; most Dutch public stations still charged above EUR 20 per kilogram in December 2025. Fleets buy on volume contracts settled through fuel cards, and two such offers are public: about EUR 8 per kilogram net for hylane card customers at selected H2 MOBILITY stations in the Düsseldorf and Rhine-Neckar regions from 1 January 2026, green hydrogen only; and a uniform pump price of EUR 9.95 per kilogram including VAT, about EUR 8.2 net, at TEAL Mobility's nine Benelux stations from 1 October 2026, with card customers possibly below EUR 6.5 excluding VAT depending on annual volume.

standard Euro VI articulated vehicles by 83%. IRU estimates suggest this translates into a 10% TCO increase. Such an increase has, according to the same estimate, brought diesel to parity with battery-electric trucks, as the electric version is toll-free until 2031. The step for diesel trucks is steeper still where

the CO₂ component arrives together with a switch from time-based to distance-based charging: for a vehicle running 75,000km a year nationally, the toll bill rose by 500% in Denmark in 2025 and by 1,000% in the Netherlands from July 2026. More information is available on the IRU Intelligence Platform.

Germany's higher tolls have brought diesel trucks to TCO parity with battery-electric trucks, which remain toll-free until 2031

Figure 28: ETS2 will increase the TCO of diesel vehicles

TCO index and ETS2 for a long-haul articulated diesel class 1 vehicle operating in France

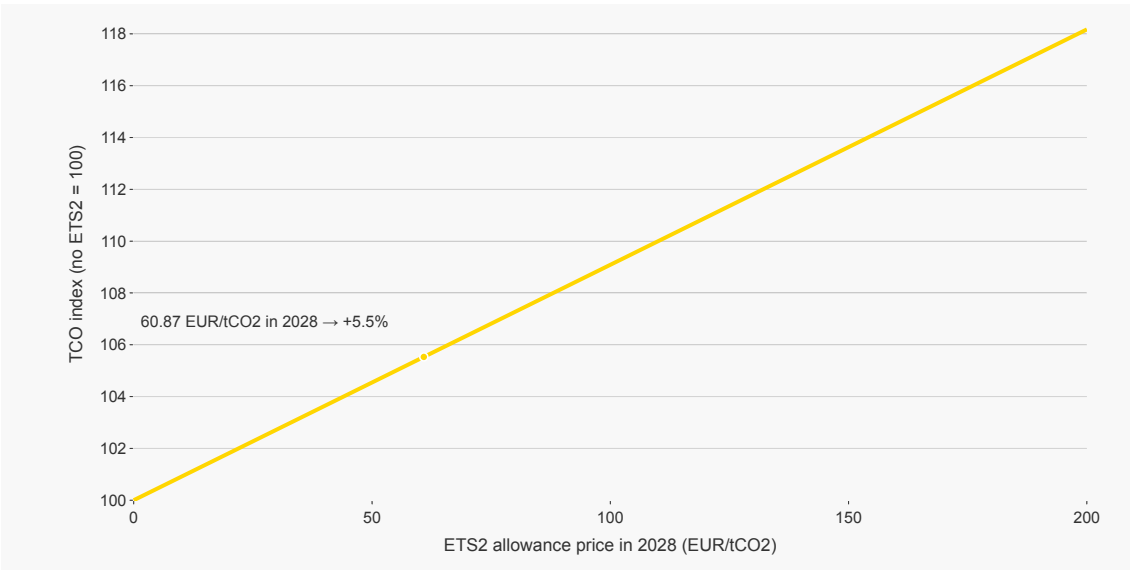
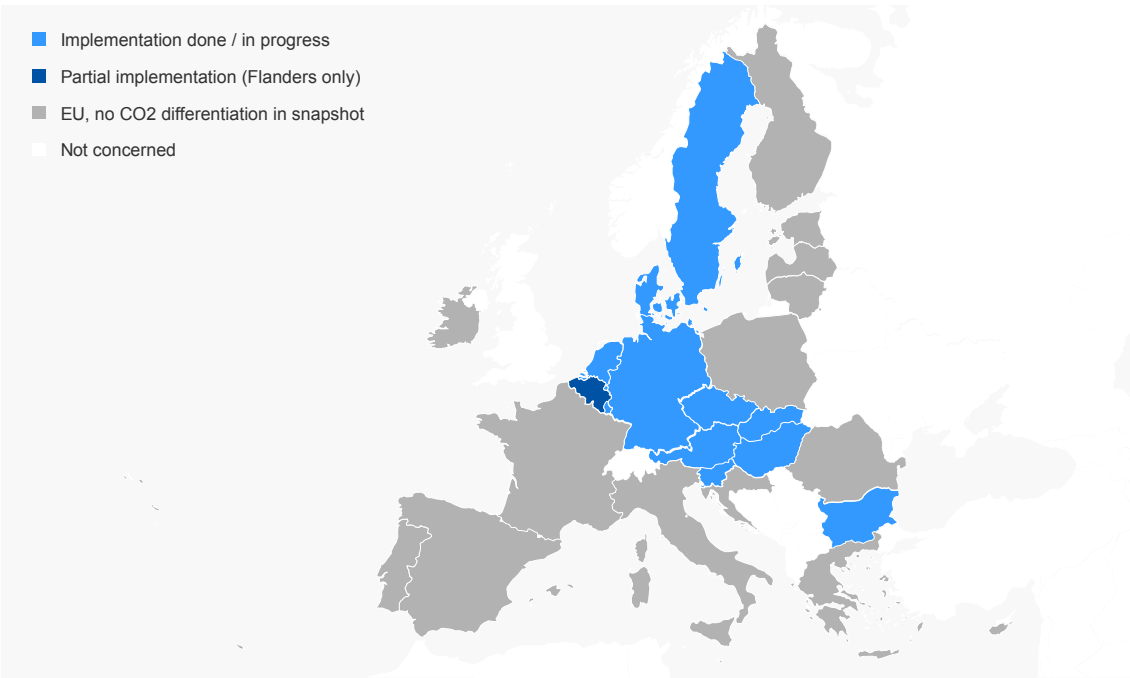


Figure 29: Latest Eurovignette deployments

CO₂-differentiated tolling; status at 21 September 2026



6.3.4 Closing the green premium gap with pull measures

Purchase incentives absorb part of the green premium directly, influencing the CAPEX side of the TCO

Push measures make zero-emission vehicles more competitive by raising the TCO of diesel. The mechanism works, but it works by making transport more expensive overall, which is likely to reduce transport volumes and can feed through to consumer prices. It is also less effective than improving the efficiency of ZEVs to lower their own TCO. Governments can offset these rising costs with pull measures; the most powerful ones reduce green energy prices, offer purchase incentives to operators, and waive toll fees for zero-emission vehicles.

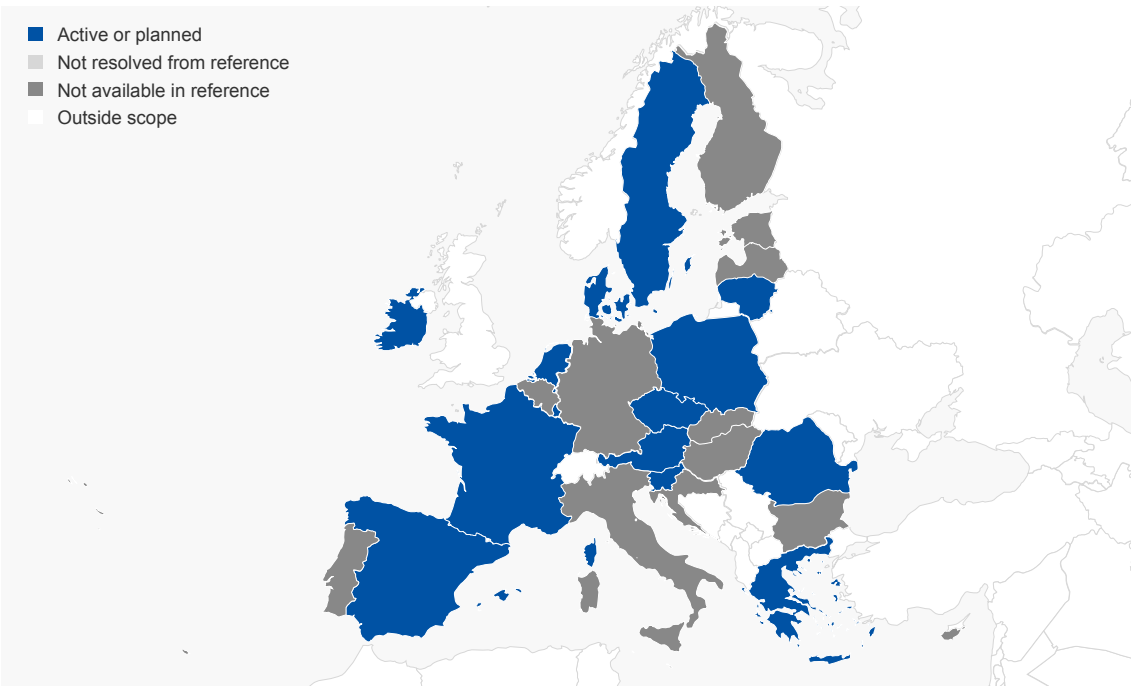
Purchase incentives absorb part of the green premium directly, influencing the CAPEX side of the TCO. Many are available to operators, and the figure below shows the EU countries offering them. In practice they are often capped in total funding, difficult to apply for, and open only for short windows, which limits their usefulness for fleet renewal, a process that runs on multi-year cycles.

France however recently modified its incentive scheme, indexing the value of the incentives to savings certificates (certificats d'économie d'énergie), aiming to offer operators a more future-proof solutions. Readers can access the IRU Intelligence Monitoring for the full worldwide view of purchase incentives, as well as the latest TCO France report to better understand the French mechanism.

On the OPEX side, tolling can be used to lower the green premium, notably in countries where tolling cost intensity is close to fuel cost intensity. Toll exemption is one significant lever, alongside tax reductions such as registration and ownership taxes, which have less impact on TCO. Following implementation of the latest Eurovignette directive, several EU countries now vary tolling rates by CO₂ emission class, with significant reductions for class 5 trucks (electric and hydrogen).

Figure 30: Purchase incentives for zero-emission trucks and coaches
EU-27; active or planned national schemes; status at 1 September 2026

Source: IRU Intelligence Monitoring — Zero-emission vehicle incentives, worldwide

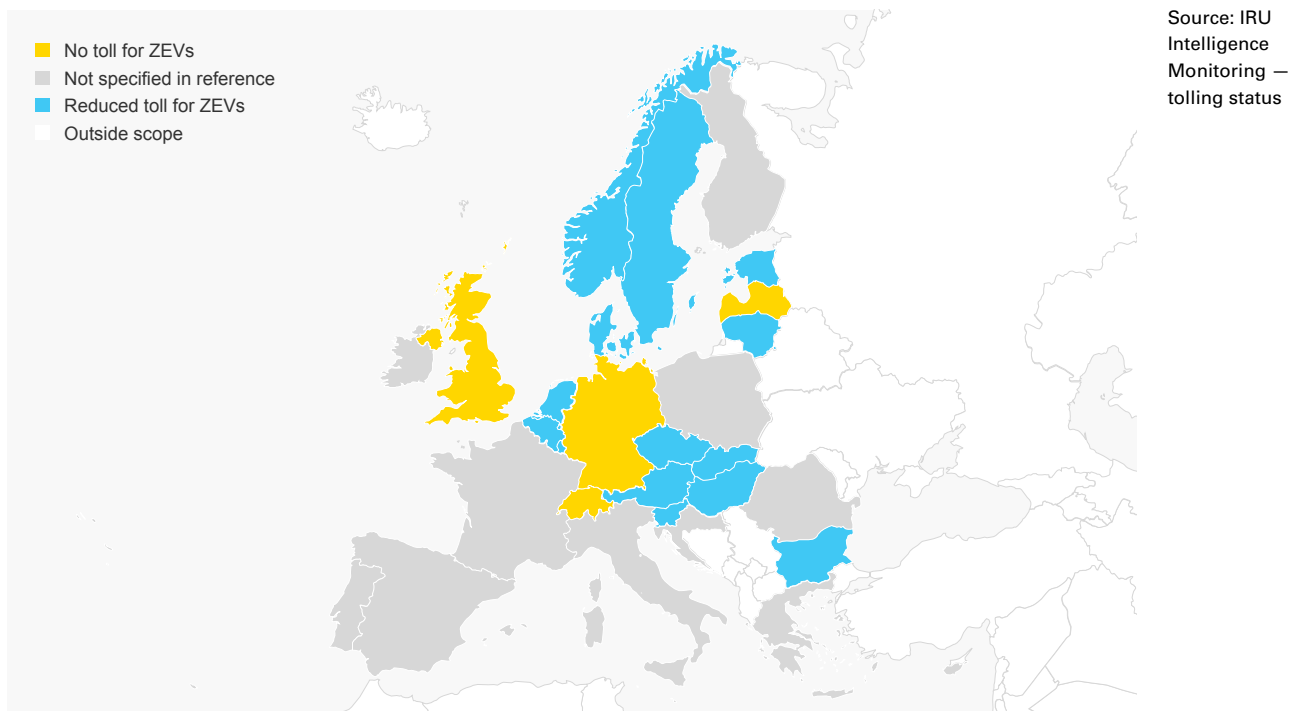


Germany grants a complete truck-toll exemption. Latvia also applies zero rates to eligible zero-emission goods vehicles under its road-user-charge scheme. Vehicle coverage and charging arrangements differ. In the rest of Europe, the UK exempts battery-electric and hydrogen fuel cell

trucks from its HGV levy, a time-based road user charge, with no end date currently set. Switzerland also exempts zero-emission trucks from its distance-based heavy vehicle charge, although it plans to start charging electric trucks from 2031.

Figure 31: ZEV toll reductions and exemptions

Europe; scheme-specific concessions checked at 1 October 2026; grey countries remain unverified



6.3.5 Who absorbs the green premium?

Push and pull measures shift cost between the operator and the local authorities. They leave open the question of the third party to the transaction: the customer. Commercial road transport is a contracted service operating on thin margins, and no operator can absorb a two- to three-fold increase in vehicle cost out of its own margin. Whether the premium can be passed on to shippers, and on what contractual basis, determines whether the business case closes at all.

Several mechanisms are emerging: green transport contracts at a premium rate, longer contract

durations matched to the amortisation period of the vehicle, and book-and-claim schemes that decouple the purchase of green energy from the physical movement of the goods, allowing a shipper to fund decarbonisation on a lane where it is feasible rather than on the one it actually uses. None of them is yet standard practice.

Until the demand side of the market puts a value on a decarbonised tonne-kilometre, every measure described in this section moves cost between operators and taxpayers without creating a buyer for the product. ■

Without demand for decarbonised transport, policy measures shift costs without creating a market for it

Strategic investments, wider benefits: decarbonising road transport

Andreas Marschner

Vice-President of Worldwide
Sustainable Operations,
Amazon



Battery-electric vehicle adoption remains concentrated among larger operators and shorter routes. But large-scale deployment can also help create the conditions for others to follow, Amazon's Andreas Marschner told us

The road transport industry's shift to alternative fuel vehicles is gaining momentum. But the transition remains uneven.

IRU's 2026 Green Compact survey found that planned investment in battery-electric vehicles is heavily concentrated among larger companies. In Western Europe, 87% of operators with annual turnover above EUR 100 million plan to invest in battery-electric trucks within five years, compared with 26% of operators with annual turnover up to EUR 100 million.

IRU member Amazon offers an example of what deployment at scale can look like.

In 2022, the company committed EUR 1 billion over five years to further electrify and decarbonise its European transport network. At the end of 2025, Amazon and its delivery partners had more than 10,000 electric delivery vans in Europe.

Amazon is also electrifying heavier transport and has more than 200 electric heavy trucks operating across its European network.

"Our investments in Europe are helping drive the region's

transition to a low-carbon economy, while also supporting economic growth, competitiveness and long-term resilience," said Andreas Marschner, Amazon's Vice-President of Worldwide Sustainable Operations.

Using scale to bring others along

For Andreas Marschner, the value of scale extends far beyond reducing emissions within Amazon's own network.

"Scale gives manufacturers and infrastructure providers confidence that demand will be there," he said. "Large and sustained orders can help reduce investment risk and accelerate the deployment of both vehicles and charging infrastructure."

The Green Compact survey shows why this matters.

Vehicle price has become a leading barrier to alternative fuel vehicle adoption, cited by 66% of operators in Western Europe and 78% in Eastern Europe. Smaller operators have less capital to invest, more difficulty accessing financing and less room for unsuccessful trials or operational disruption.

Amazon has sought to reduce that barrier for some of the third-party companies operating within its network.

In certain cases, Amazon works with fleet management companies to specify electric vehicle requirements.

Those companies then purchase and lease the vehicles to operators serving Amazon routes. This reduces the upfront capital required from the operator and allows the broader network to benefit from operational experience gained through Amazon's wider transportation network.

The underlying principle extends beyond vehicles.

Through long-term power purchase agreements, Amazon provides revenue certainty that can help large-scale renewable energy projects reach deployment. This reduces financial risk for developers and encourages investment in new renewable capacity.

The resulting energy supports Amazon's own operations, but also contributes to wider grid decarbonisation serving households, public services and industry.

In transport, large vehicle orders and predictable freight demand can play a similar role by giving manufacturers and infrastructure providers clearer signals about where the market is heading.

Beyond the vehicle

The vehicle, however, is only one part of the transition. Charging infrastructure remains a major challenge, particularly for heavy-duty transport.

Amazon has installed thousands of electric vehicle charge points in Germany and the UK, as well as hundreds more in France, Italy and Spain. It is also working on the wider infrastructure challenge beyond its own sites.

One example is CHALET, an open-source planning tool that aggregates and anonymises operator data to help identify where public commercial vehicle charging infrastructure is most needed on European highways.

Amazon is also supporting the development of an electric freight corridor in Poland. The pilot, scheduled for 2027, aims to aggregate demand for zero-exhaust emission freight along major logistics routes so electric trucks and high-capacity charging infrastructure can be deployed together.

The approach reframes one of electrification's core challenges: instead of waiting for infrastructure before deploying vehicles, aggregated demand can help show infrastructure providers where investment is needed.

"Electrifying transport means recognising how investments in vehicles, charging infrastructure and power grids need to enable each other. We need to confidently invest across the whole electric logistics ecosystem to accelerate the sector's transformation," said Andreas Marschner. "That requires coordination across operators, infrastructure providers, energy companies and policymakers."

Amazon has applied the same principle of collective demand more broadly. It co-founded the Sustainable Freight Buyers Alliance, which brings freight buyers together to coordinate demand for battery-electric vehicles and charging infrastructure.

That reflects a wider lesson from the transition.

Amazon may have the scale to move early, but even the largest companies cannot decarbonise road logistics alone. Grid capacity, charging networks, vehicle availability and supportive policy frameworks all need to develop alongside demand.

For Amazon, transport decarbonisation forms part of its Climate Pledge goal to reach net-zero carbon emissions across its operations by 2040.

"Our investments are not only reducing our own environmental footprint.

They are also helping to de-risk investment in the technologies and infrastructure that will underpin Europe's green transition and long-term industrial competitiveness," said Andreas Marschner.

Amazon's experience shows what can happen when large-scale demand is put behind decarbonisation. The wider challenge is creating the conditions that allow more transport operators – particularly smaller companies which make up most of the road logistics sector – to follow. ■



About Amazon

Since its inception as an online retailer in 1995, Amazon has been relentlessly focused on being Earth's most customer-centric company, where people can find and discover anything they want to buy online. Amazon also enables other retailers to sell through the Amazon. Since 2021, Amazon has invested €17 billion in European companies pioneering low-carbon technologies across the energy, transportation and packaging sectors. According to a report by Frontier Economics commissioned by Amazon, these investments have supported up to 144,000 jobs and generated as much as EUR 11 billion in gross value added (GVA) across the EU and the UK.

Chapter 7

Voices from the road: what operators told us

Central to the Green Compact is putting operators' voices first: asking them directly where they stand, so the pathway to decarbonisation is a pragmatic one. The annual survey tracks what they have already changed, what they plan to invest in, and what is holding them back. This 2026 edition is the second one,

gathering the views of road freight operators in Western Europe, Eastern Europe and Australia. Where earlier chapters rely on modelling and estimates, this one reports what operators themselves say. Several questions were redesigned this year, so comparisons with 2025 are drawn only where the wording allows.

7.1 Where operators stand: commitment and confidence

Central to the Green Compact is putting operators' voices first, ensuring the pathway to decarbonisation is pragmatic

Before looking at what operators do, it is worth asking whether decarbonisation has entered their strategy at all. A reduction target is the simplest sign that it has: it turns a general intention into something the company can be measured against, and, as the results below show, it changes how confident operators feel about delivering emissions reductions. This section therefore looks at four linked questions: whether operators have

a target, how confident they are in cutting emissions, how much weight decarbonisation carries in their plans, and whether they measure their emissions at all. The answers follow the same regional gradient throughout, from Western Europe to Eastern Europe to Australia.

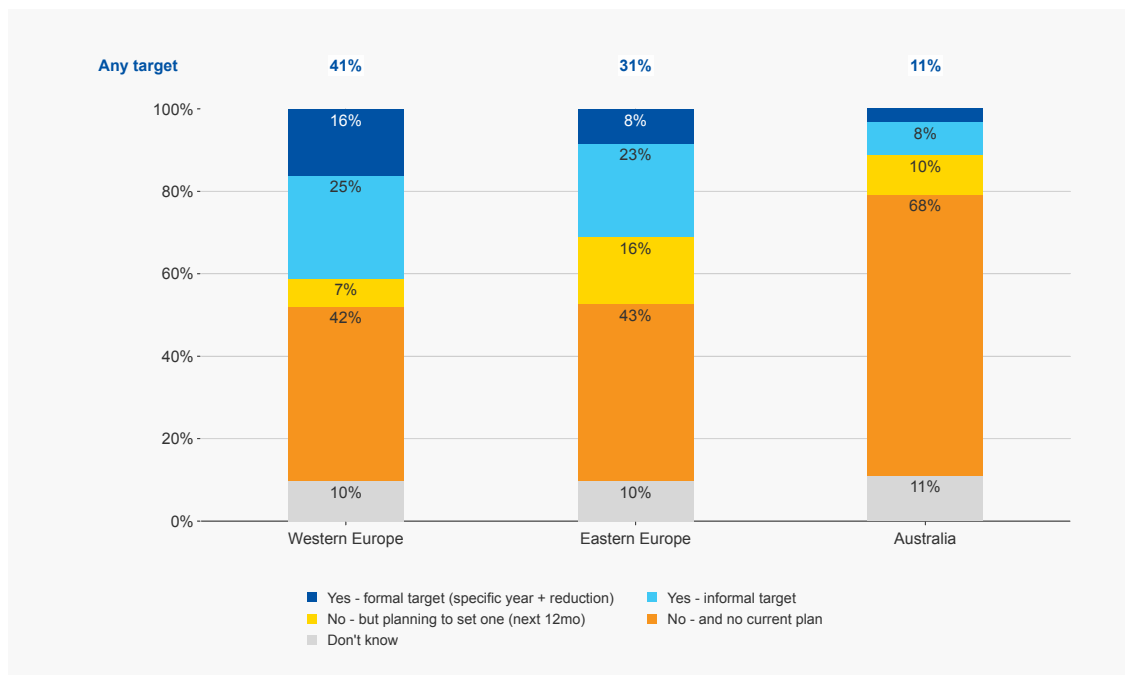
Emission reduction targets are more prevalent in Western Europe, with two in five (41%) of truck operators surveyed indicating they have some form of target, whether formal or informal. In Eastern Europe, this proportion decreases to 31%, while in Australia it drops to 11%. Most of these targets remain informal, however: only 16% of Western European operators have set a formal target with a target year and a reduction figure, against 25% working towards an informal one, and the pattern is the same in Eastern Europe (8% formal, 23% informal).

Australia contrasts strongly with the surveyed European countries, with a majority of companies (68%) reporting no target and no plan to set one. These results suggest that emissions reduction is less of a strategic priority for Australian truck operators than it is in Europe.



Figure 32: Emission reduction targets are more prevalent in Western Europe

Emission reduction targets, 2026; Western Europe, Eastern Europe and Australia

**Base:** 2026 Freight respondents – Western Europe, Eastern Europe, Australia**Note:** New question added in 2026. Results based on weighted sample.**Q7.** Does your company have a formal emissions reduction target?

Confidence follows a different pattern from targets. Globally, at least a third of truck operators feel confident in their company's ability to cut emissions. Confidence is highest in Eastern Europe, where nearly one in two operators (48%) say they are very or somewhat confident. Western Europe and Australia follow, at 38% and 34%, respectively, but show far more hesitation: 41% and 42% of operators sit in the middle, neither confident nor concerned.

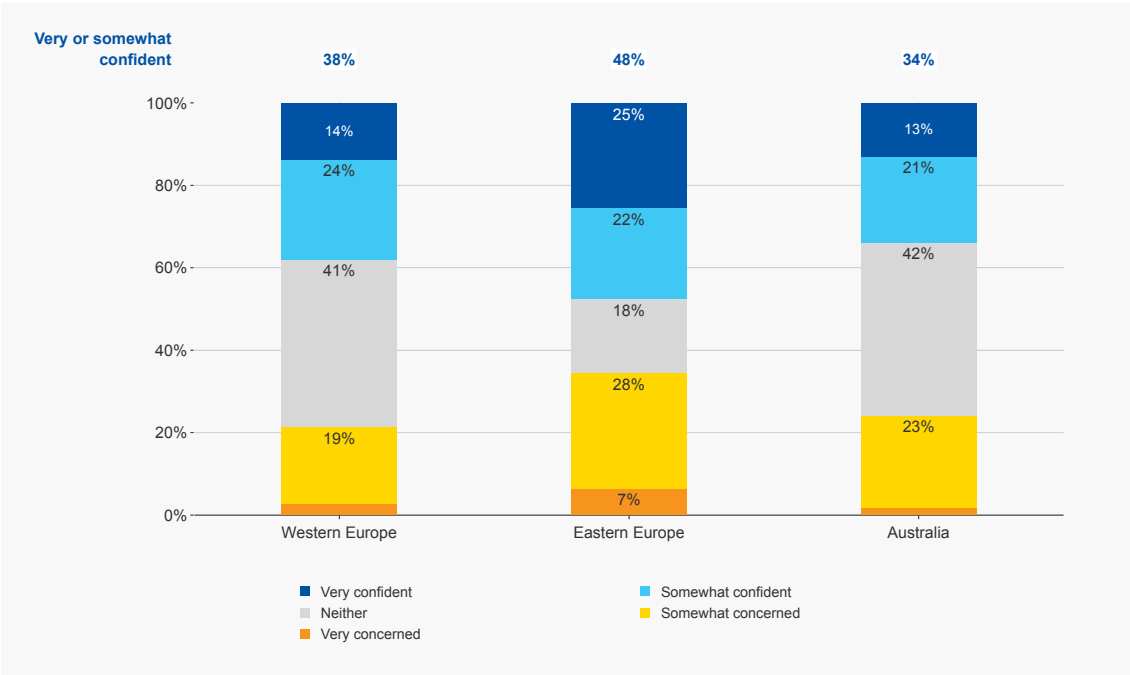
Eastern Europe is also where concern runs highest, with 28% of operators somewhat concerned and 7% very concerned. Feelings there are therefore polarised rather than simply optimistic, while Western Europe and

Australia tend to sit on the fence. What separates confident operators from hesitant ones, however, is less the region than whether the company has set a target.

Within a single region, the clearest dividing line is whether the company has set a target. In Western Europe, 54% of operators working with a target feel very or somewhat confident in their ability to cut emissions, against 20% of those without one. The gap is not so much a shift from confidence to concern as from confidence to uncertainty: half of the operators without a target (51%) say they are neither confident nor concerned, against 31% of those with one. An emission reduction objective

At least a third of truck operators globally feel confident about cutting emissions, while over two in five European operators prioritise decarbonisation

Figure 33: Confidence in cutting emissions is highest in Eastern Europe
Confidence in reducing emissions, 2026; Western Europe, Eastern Europe and Australia



Base: 2026 Freight respondents – Western Europe, Eastern Europe, Australia
Note: Question re-designed in 2026. Results based on weighted sample. No comparison possible with 2025 due to different design (i.e. 2025 multi response vs. 2026 single)
Q7a/b. How confident or concerned are you in your company’s ability to achieve its emissions reduction or operational decarbonisation target? / to significantly reduce its emissions?

Larger operators are more likely to prioritise decarbonisation, a pattern seen across both Western and Eastern Europe

Larger operators are more likely to prioritise decarbonisation, a pattern seen across both Western and Eastern Europe

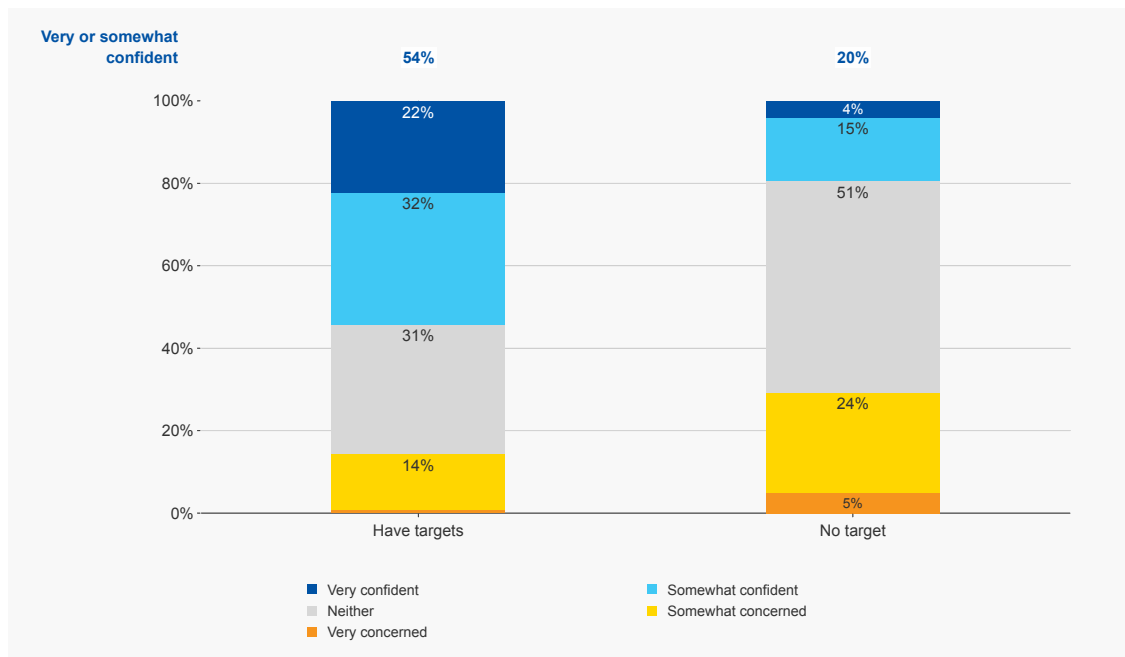
helps anchor decarbonisation in strategic planning. It helps a company to put a horizon and a figure on paper, and with them a view of what it can realistically achieve.

The same divide appears when operators are asked how much decarbonisation weighs in their plans. Over two in five European operators (46% in Western Europe and 42% in Eastern Europe) consider it important or very important, against less than 1 in 5 in Australia (18%), where a plurality of 42% say it is not important at all. This mirrors the regional pattern on targets, and it deserves the same caution: even in Western Europe, most operators still place decarbonisation at neutral or below.

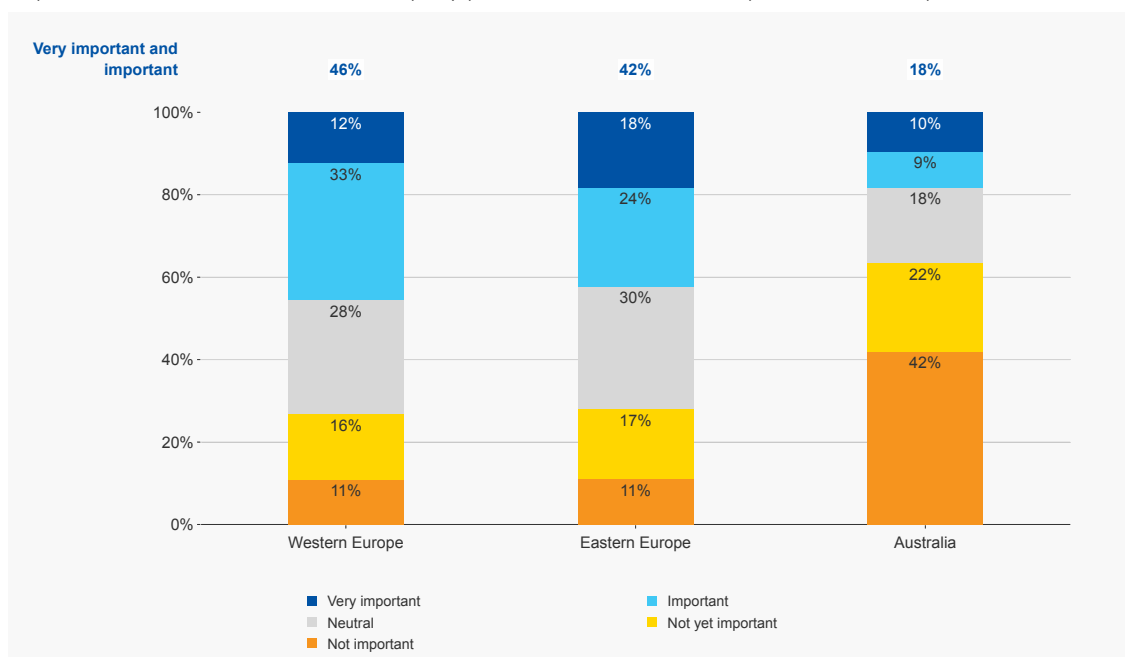
Company size shapes the answer as much as geography does. Larger operators are more likely to treat decarbonisation as a priority, whether size is measured by turnover (78% of Western European operators above EUR 100 million, against 51% below it) or by fleet (70% of those running more than 20 vehicles, against 45% of smaller fleets), with the same pattern in Eastern Europe. This looks like pressure rather than principle: larger operators tend to serve larger customers with their own emissions targets and face reporting and regulatory requirements sooner, while smaller operators, running on thinner margins, are more likely to keep decarbonisation behind more immediate cost reduction priorities.

Figure 34: Operators with a target are more confident about reducing emissions

Confidence in reducing emissions, Western Europe, 2026

**Base:** 2026 Freight respondents – Western Europe only**Note:** Question re-designed in 2026. Results based on weighted sample. Respondents who indicated 'Not planning to reduce emissions' excluded from the results. Significance testing conducted between the two subgroups 'have targets' 'No target' at a 95% confidence interval. Arrows show statistically significant difference between the two subgroups**Q7a/b.** How confident or concerned are you in your company's ability to achieve its emissions reduction or operational decarbonisation target? / to significantly reduce its emissions?**Figure 35: Decarbonisation carries more weight in European operators' plans**

Importance of decarbonisation in company plans, 2026; Western Europe, Eastern Europe and Australia

**Base:** 2026 Freight respondents – Western Europe, Eastern Europe, Australia**Note:** Question re-designed in 2026. Results based on weighted sample. No comparison possible with 2025 due to different design (i.e. 2025 importance in 'investment plans' vs. 2026 'company plans')**Q8.** How important is decarbonisation to your company plans?

7.2 Measuring emissions: effort without a common framework

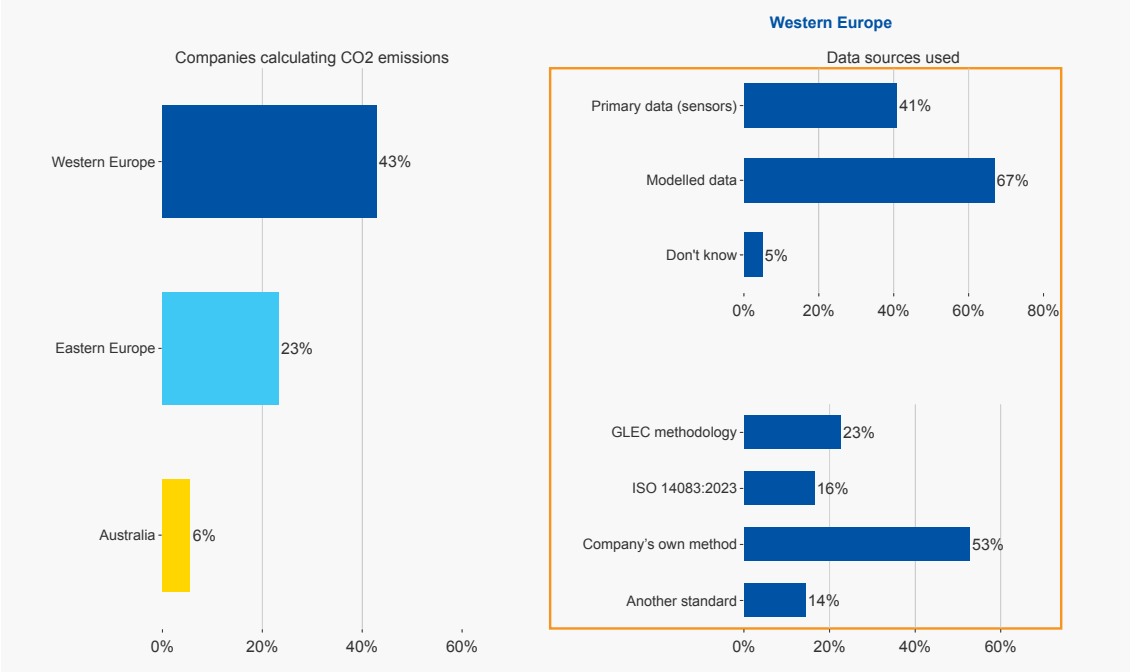
Even in the leading region, fewer than half of operators quantify their emissions

Decarbonisation involves counting emissions. Calculating emissions is still far from standard practice, and it follows the same regional divide as target-setting: over two in five operators (43%) in Western Europe calculate their CO₂ emissions, against 23% in Eastern Europe and just 6% in Australia. Only in Western Europe does measurement keep pace with commitment, elsewhere it lags behind target-setting, at 23% against 31% in Eastern Europe and 6% against 11% in Australia. Even in the leading region, fewer than half of operators are able to put a figure on their emissions, and in Australia the overwhelming majority do not quantify them at all.

Among the Western European operators who do measure, most rely on modelled data: nearly two in three (67%) use emissions estimated through calculation, while 41% use primary data captured directly from sensors. The two are not exclusive, and a number of operators combine them. This likely reflects the complexity of road transport operations, where emissions vary with vehicle load, cargo type, distance, route and even weather, and a model can account for these variables in a way that sensor readings alone cannot easily capture. Methodologies are more fragmented still: over half (53%)

Figure 36: Calculating emissions is still far from standard practice

Companies calculating emissions, data sources and methodologies; Western Europe, Eastern Europe and Australia



Base: 2026 Freight respondents – Western Europe, Eastern Europe, Australia
Note: Question re-designed in 2026. Results based on weighted sample. No comparison possible with 2025 due to different design (i.e. 2025 ‘do you monitor’ vs. 2026 ‘calculate’)
Q14a. Does your company calculate its CO₂ emissions?
Base: 2026 Freight respondents – Western Europe only; Companies calculating their CO₂ emissions
Note: New question added in 2026. Results based on weighted sample.
Q14b. Which of the following data sources does your company use to calculate its CO₂ emissions?
Q14. Which of the following, if any, methodologies do you use to calculate your CO₂ emissions?

use their company's own method, well ahead of recognised standards such as the GLEC methodology (23%) or ISO 14083:2023 (16%). Operators are therefore putting real effort into quantifying their emissions, but modelled data and in-house methods produce figures that are hard to compare from one company to the next, a direct hurdle to benchmark progress industry-wide.

In addition, emissions data reveals commercially sensitive information about routes, costs and efficiency, and in a fragmented, multi-layer subcontracting market, operators have little incentive, and often little technical means, to pass it up the chain. Hence 47% of the respondents from Trimble's "Green Freight Report 2024" stated they would not share any GHG emissions-related data with anybody, not even in consolidated form or with a neutral body.

Within the EU, this fragmentation is precisely the gap that the new CountEmissionsEU regulation sets out to close. Adopted in April 2026 and in force since 1 June 2026, it establishes a single, EU-wide methodology for calculating and reporting transport emissions, built on the EN ISO 14083:2023 standard, with full application expected by the end of 2030. Its reach is deliberately proportionate: it binds companies that already report their transport emissions, or are legally required to do so, rather than every operator.

The survey suggests that those concerned are still some way from that benchmark, with only 16% of Western European operators currently using ISO 14083:2023 to measure emissions. That figure alone understates the picture, however. The GLEC Framework and ISO 14083 are materially almost identical, the main difference being that GLEC is a framework while ISO is the formal standard built upon it, so the two are best read together. Taken that way, around four in ten operators

(39%, 16 percentage points up compared to Trimble's "Green Freight Report 2024") already rely on a state-of-the-art methodology, even if a majority still use their own in-house methods. A common methodology should, over time, make emissions figures genuinely comparable across operators and transport modes.

The prevalence of modelled over primary data is relevant here too. The regulation asks all transport and hub entities to prioritise primary data when calculating the emissions of a transport service. It also lets an EU country go further and make primary data compulsory for entities above a national employee threshold – but only for services that start and end on its territory, with cross-border and transit operations, as well as SMEs, explicitly excluded. For part of the sector, that implies a further shift. For now, the incentive to make that shift is limited as capturing primary data is costly and hard to share across a fragmented supply chain, and it does not reliably lower an operator's reported emissions, so there is little immediate commercial reward for the effort. The wider benefit lies elsewhere, in more accurate and comparable figures across the sector, rather than in any single operator's number.

Around four in ten Western European operators measuring emissions use ISO 14083 or GLEC, up 16 percentage points since 2024



7.3 What operators do and what’s holding them back

Routing optimisation is operators’ most common efficiency action, followed by eco-driving training

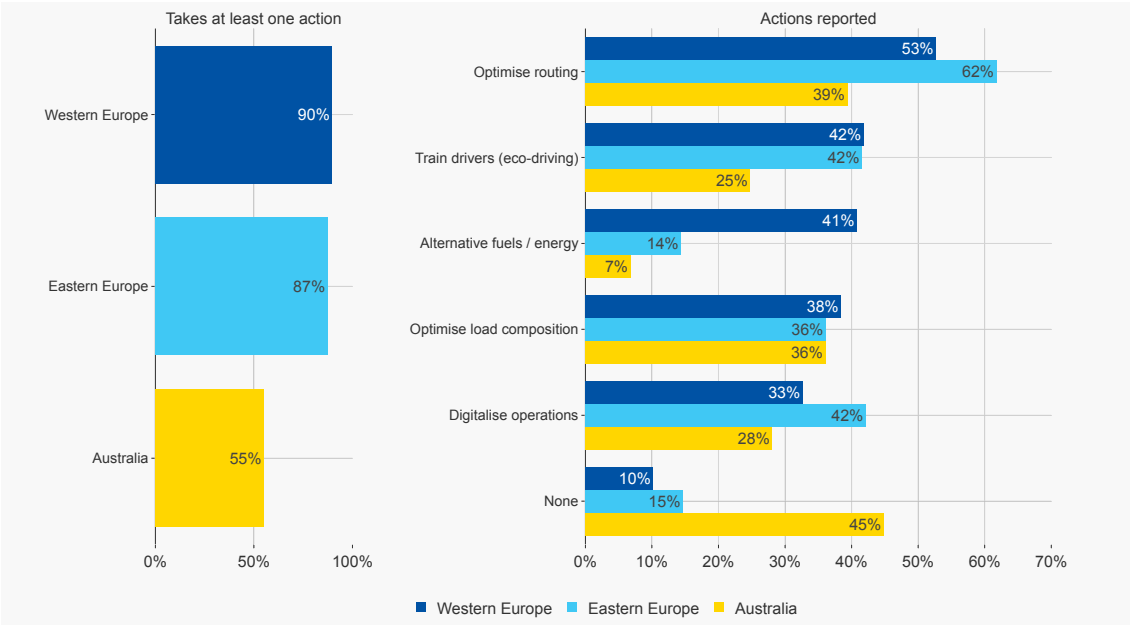
Taking action to reduce emissions is now common across Europe, far less so in Australia. Nine in ten Western European operators (90%), and almost as many in Eastern Europe (87%), report taking at least one action to cut their emissions. In Australia the figure drops to just over half (55%), with 45% reporting no action at all. Action therefore runs well ahead of formal commitment: in every region, far more operators are doing something about emissions than have set a target or measure them.

The most widely used levers are operational and economic, and they all save fuel. Optimising routing is the most common action in both European regions (53% in Western Europe and 62% in Eastern Europe), followed by eco-driving training (42% in both) and optimising

load composition (around a third everywhere). These measures require little or no capital investment and pay for themselves through lower consumption, which likely explains their uptake. Eastern European operators use them somewhat more than their Western counterparts, both for routing and digitalisation (42% against 33%), consistent with the thinner margins they work on, where every litre saved counts.

The clearest regional divide is on alternative fuels, the one lever that carries a direct and recurring cost. Around two in five (41%) Western European operators use alternative fuels or energy, far more than the one in seven (14%) in Eastern Europe and fewer than one in ten (7%) in Australia. Operators everywhere are willing to adopt efficiency measures that cost little,

Figure 37: Action runs well ahead of formal commitment
Actions taken to reduce emissions, 2026; Western Europe, Eastern Europe and Australia



Base: 2026 Freight respondents – Western Europe, Eastern Europe, Australia
Note: New question added in 2026. Results based on weighted sample. ‘Modal shift’, ‘Load matching’ and ‘Green procurement’ excluded from the results due to low base sizes (i.e. below 30 respondents). These responses were only prompted to shippers without fleets, cargo brokers and forwarders
Q11a/11/11B. Which of the following actions, if any, does your company take to reduce the emissions of its operations?

but the shift to alternative fuels depends on more than willingness. It requires real investment, and it hinges on how far alternative fuels and the supporting refuelling and recharging infrastructure are actually available in each region, which varies considerably.

What would actually move operators is money, not mandates. The levers rated most likely to drive emissions cuts are financial in every region, whether the money comes from customers or from governments.

In Western Europe, the single strongest motivator is a price premium from customers, which more than one in three operators (37%) say would drive them to a very large extent, narrowly ahead of government tax incentives (32%) and subsidies (31%). Western European operators are, in short, moved most by commercial reward.

The balance shifts elsewhere. In Australia the order reverses, with

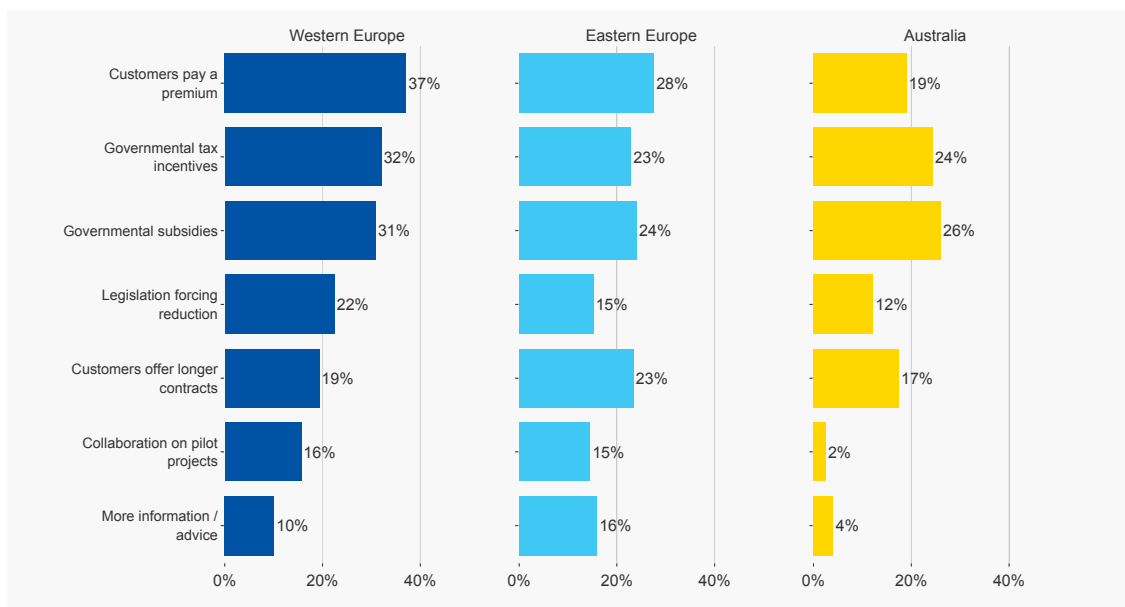
government subsidies (26%) and tax incentives (24%) the leading levers and a customer premium (19%) noticeably weaker, which suggests Australian operators look to the state rather than the customer for the decisive push. Eastern Europe sits lower and flatter, with no single lever standing out strongly, though a price premium leads modestly (28%) and longer customer contracts matter more here (23%) than in Western Europe (19%), pointing to the value operators place on commercial certainty as well as price.

Regulation and softer forms of support are slightly weaker motivators. Legislation forcing emissions reduction sits mid-table in Western Europe (22%), but falls to 15% in Eastern Europe (below even information and advice at 16%) and to 12% in Australia. Pilot collaboration and information/advice are the least motivating levers in both regions, but they remain relevant to 16% and 10% of Western European operators respectively.

In Western Europe, the single strongest motivator is a price premium from customers

Figure 38: Financial support would move operators more than mandates

Levers to decarbonise, 2026; Western Europe, Eastern Europe and Australia



Base: 2026 Freight respondents – Western Europe, Eastern Europe, Australia

Note: Question re-designed in 2026. Results based on weighted sample. 'Very large extent' results reported only to de-clutter the charts

Q12a. To what extent would the following get your company to reduce its CO₂ emissions?

Cost is the dominant barrier across all three regions: solutions are expensive, while customers are unwilling to pay the premium

Australian shares are 2% and 4%. Operators, in other words, treat decarbonisation as an economic decision: financial support, whether from customers or governments, is what they say would move them most, while mandates and advice carry far less weight in their own account of what drives them.

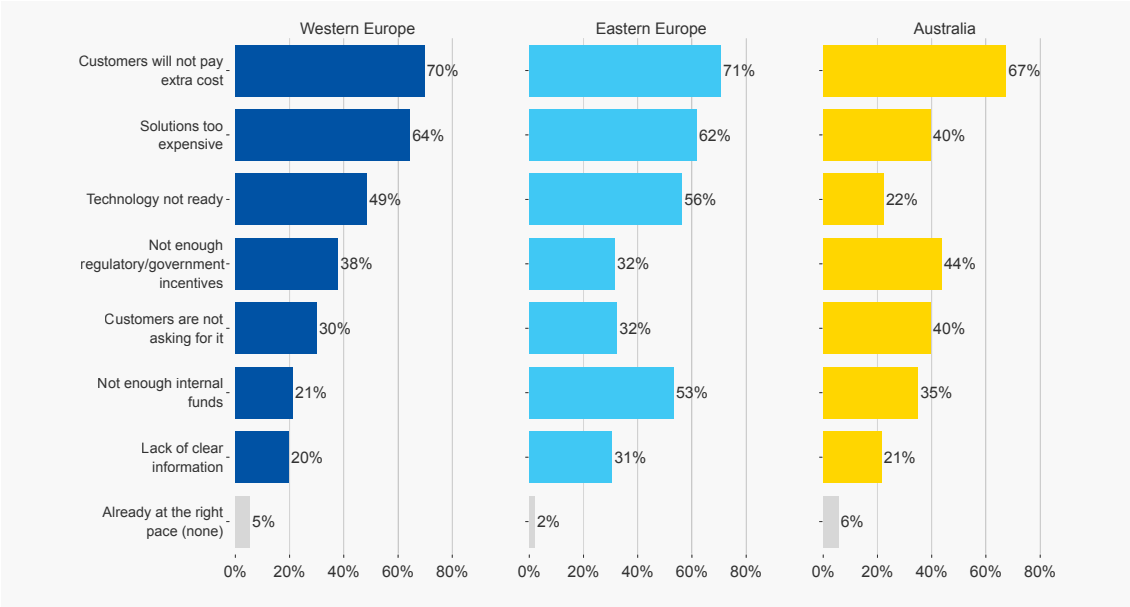
Cost is the dominant barrier to decarbonising in all three regions, and it takes two forms. The most widely cited barrier everywhere is that customers will not pay the extra cost: 70% of operators in Western Europe, 71% in Eastern Europe and 67% in Australia. Close behind, in Europe at least, is that the solutions themselves are too expensive (64% in Western Europe and 62% in Eastern Europe). Together they form a cost wall: the price of decarbonising is high, and there is no reliable way to pass it on. Neither half of that wall can be removed by the operator alone.

Beyond cost, the barriers diverge by region. Technology readiness

is a major concern in Europe (49% in Western Europe and 56% in Eastern Europe) but much less so in Australia (22%). Eastern European operators stand out for citing a lack of internal funds far more often (53%, against 21% in Western Europe), pointing to tighter financial capacity. Australia, for its part, points more to a lack of government incentives (44%) and to customers not asking for decarbonisation (40%) than European operators do.

The barriers are also shifting. In Eastern Europe, the share citing a lack of government incentives has fallen since 2025 while the share saying customers are not asking for it has risen, a move away from a policy-gap framing towards a demand-gap one. In Western Europe, fewer operators now point to a lack of clear information (20%, down since 2025), suggesting that awareness of the options has improved. Awareness aside, then, the central obstacle is financial: operators see the solutions as too costly

Figure 39: Cost is the dominant barrier to decarbonising in all three regions
Barriers to decarbonisation, 2026; Western Europe, Eastern Europe and Australia



Base: 2026 Freight respondents – Western Europe, Eastern Europe, Australia
Note: Question re-designed in 2026. Results based on weighted sample. Significance testing conducted between 2025 and 2026 results at a 95% confidence interval. Arrows show statistically significant difference between the two subgroups
Q13. What is stopping you, or slowing you down, from decarbonising?

and their customers as unwilling to fund them, which is precisely why financial support, from customers or governments, is what they say would move them most.

Behind these survey results lies a shift on the ground. Several Eastern European governments are now deploying financial support for both the acquisition and the operation of lower-emission trucks, consistent with the fall in operators reporting a lack of government incentives as a barrier.

Poland took the purchase-support route. In 2025, the National Fund for Environmental Protection and Water Management (NFOŚiGW) opened a dedicated programme, “Support for the purchase or lease of zero-emission N2 and N3 category vehicles”, with applications accepted from 30 May 2025 and a budget of PLN 2 billion drawn from the EU Modernisation Fund. The scheme runs until 30 June 2029, or until the budget is exhausted.

Elsewhere, support has come less through purchase subsidies than through tolls, which account for a substantial share of a truck's total cost of ownership. This reflects the 2022 revision of the EU's Eurovignette Directive, which requires distance-based road tolls to be varied by a truck's CO₂ emissions and allows EU countries to exempt zero-emission vehicles or apply significantly reduced rates, a relief initially due to expire on 31 December 2025, and extended to 30 June 2031 by Directive (EU) 2025/2459 of 26 November 2025. The toll thereby becomes a lever that rewards cleaner trucks rather than a flat charge, and Eastern European countries are transposing it into national systems at different speeds. Czechia has applied

a CO₂-differentiated truck toll (Myto CZ) since 1 March 2024, under which zero-emission trucks fall into the lowest of five emission bands and pay the lowest rates. Slovakia's distance-based truck toll, operated by the national motorway company (NDS), likewise assigns zero-emission trucks to the lowest band. Romania has moved furthest most recently, replacing its flat vignette with a distance-based, CO₂-differentiated system (TollRo), whose launch was postponed from 1 July to 1 October 2026, while in the meantime supporting zero-emission trucks fiscally through exemptions from acquisition and ownership taxes.

IRU's TCO analysis reinforces the point: tolls weigh heavily enough for this relief to improve the competitiveness of battery electric trucks, and to ease the cost barrier that operators identify in the Green Compact survey as their main obstacle to decarbonisation.

CO₂-differentiated tolls can improve the competitiveness of zero-emission trucks and help address operators' main barrier to decarbonisation: cost



The biggest barrier to decarbonising road transport?

The whole system

There are already proven ways to cut emissions. The harder challenge is adopting them at scale, says Trimble, pointing to data, collaboration and policy as the keys to accelerating progress in a highly fragmented sector.

Serge Schamschula

Head of Partner Management,
Trimble Transportation
& Logistics

"Road transport does not lack ideas for cutting emissions," Serge Schamschula, Head of Partner Management at Trimble Transportation & Logistics, told us.

He referred to Professor Alan McKinnon who identified over 30 pathways to decarbonise freight back in 2018. "Yet years later, many of the simplest and most immediate measures are still far from widespread."

The challenge is moving from available solutions to large scale adoption.

"Eco-driving is a good example," said Serge Schamschula.

"It improves efficiency, reduces emissions and needs no major upfront investment. Yet more than half of logistics operators still do not use such programmes."

"The difficulty is not always finding new solutions," he added. "It is escaping from established ways of working."

Data, efficiency and collaboration

Trimble's approach focuses on three areas: data, tools that improve individual efficiency and networks that enable companies to work together.

That matters in a highly fragmented sector:

There are more than 550,000 companies organising road freight in the EU alone. The average transport company has only around six employees.

"In such a fragmented market, efficiency gains increase significantly when supply chain actors can make better decisions together, based on data," said Serge Schamschula.

Trimble therefore sees its role as going beyond individual software modules.

Its platform connects thousands of shippers, retailers, operators and other logistics service providers, allowing them to collaborate and improve utilisation across the supply chain.



"The aim is to create savings in both dimensions- cost and emissions," said Serge Schamschula. "That comes from connecting trusted partners, not just from optimising one company in isolation."

Policy remains key

Public policy remains essential to accelerating decarbonisation. Tax incentives, subsidies, regulation and carbon-related charges all influence and determine operator behaviour.

"Government measures remain one of the main drivers of freight decarbonisation," said Serge.

His argument is that governments need to look beyond individual measures and reconsider the wider system of taxes, incentives, prices and benefits.

Austria offers one example. It provides around EUR 900 million annually in support for greener freight, while fossil energy still receives around EUR 1.5 billion in subsidies.

"That balance needs to change," said Serge Schamschula. "But it needs to change through a clear transition plan that gives operators time and certainty to adapt."

Charging infrastructure, the energy transition and clarity on future technologies and fuels all remain important. The industry benefits from a clear outlook and an undisputed political framework.

"But these are details compared with the bigger question of whether the system of taxation and subsidies actually facilitates decarbonisation," he added. "On the long run, no-one will race against his profits."

Measuring progress

Trimble has applied to the Science Based Targets initiative and reports sustainability performance in line with ESRS and CSRD requirements.

Compared with its 2019 baseline, Trimble says it has reduced its direct Scope 1 and Scope 2 emissions by 65%.

"Our direct emissions are moving in the right direction," said Serge Schamschula. "But Scope 3 emissions from purchased goods and services are still growing."

For the wider freight sector, the lesson is similar.

Many of the tools already exist. The challenge now is making them commercially attractive, easier to adopt and scalable across a fragmented industry. ■



About Trimble

Trimble is a global technology company that connects the physical and digital worlds, transforming the ways work gets done. With relentless innovation in precise positioning, modelling and data analytics, Trimble enables essential industries including construction, geospatial and transport. Whether it's helping customers build and maintain infrastructure, design and construct buildings, optimise global supply chains or map the world, Trimble is at the forefront, driving productivity and progress. For more information about Trimble (Nasdaq:TRMB), visit: www.trimble.com

7.4 The fleet today and where it’s heading

Operators broadly regard more efficient vehicles as a legitimate way to cut emissions. The view is most widespread in Eastern Europe, where more than three in four operators (77%) consider that minimising fuel consumption through more efficient vehicles is a decarbonisation solution, the same region leaning hardest on operational, fuel-saving levers. Around two in three agree in Western Europe (65%), and just under three in five in Australia (58%). Fuel efficiency is therefore widely accepted across the industry as part of the route to decarbonisation rather than as something separate from it, which matters for a fleet that remains overwhelmingly diesel, and where efficiency gains can be realised without waiting for full fleet renewal.

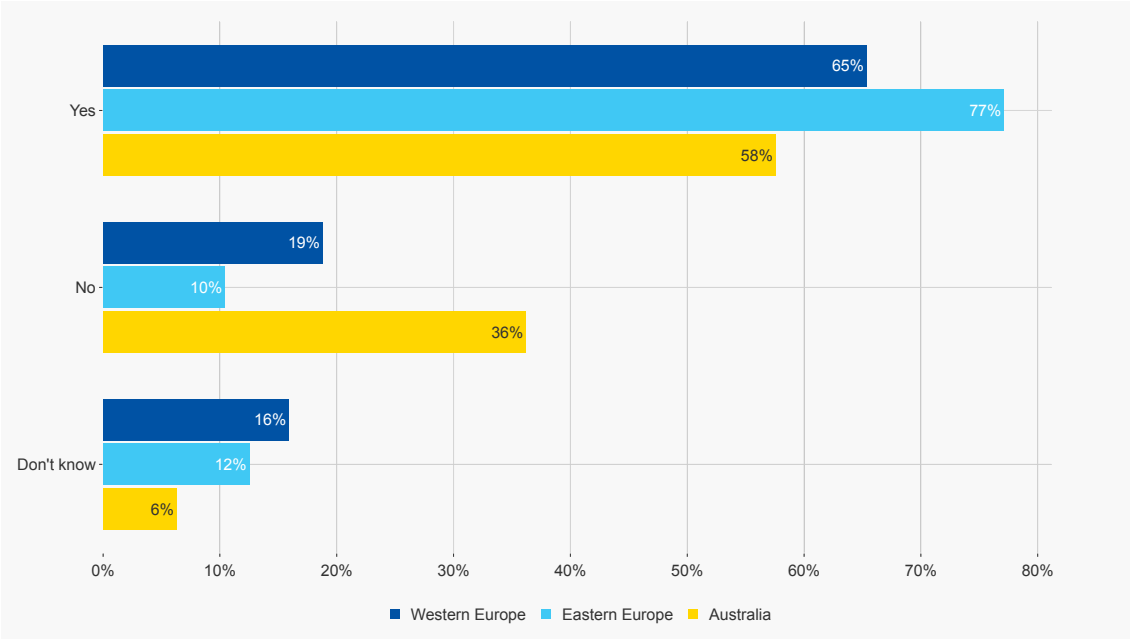
Doubt is limited, but more evident in Australia. Around one in three Australian operators (36%) do not

see more efficient vehicles as a decarbonisation solution, against one in ten in Eastern Europe (10%) and around one in five in Western Europe (19%). Uncertainty is low everywhere, with “don’t know” answers ranging from 6% in Australia to 13% in Eastern Europe and 16% in Western Europe. What sets the Australian market apart is therefore scepticism rather than a lack of awareness, consistent with its lower engagement on decarbonisation throughout the survey. Even in Western Europe, however, roughly a third of operators either reject the link or are unsure of it, a communication gap on the cheapest and most immediately available lever the industry has.

According to the survey data, fleets in Europe are relatively young, while Australia’s is noticeably older. In Eastern Europe, more than three in five operators (62%) reported running

Across all three regions, most operators see more efficient vehicles and lower fuel consumption as part of the route to decarbonisation

Figure 40: Perception of efficient vehicles as a decarbonisation solution



Base: 2026 Freight respondents – Western Europe, Eastern Europe, Australia; 2025 – Western Europe, Eastern Europe, Australia
Note: Results based on weighted sample. No statistically significant results identified year on year, tested at 95% confidence interval
Q19. Do you think that minimising your fuel consumption with more efficient vehicles is a decarbonisation solution?

fleets with an average age of five years or less, as do around half in Western Europe (53%). In Australia, fewer than two in five operators have fleets in the newest band (37%), almost level with the five-to-ten-year band (36%). Older vehicles are also far more common: around one in four Australian fleets (26%) average ten years or more, including 12% at fifteen years or older, against roughly one in ten fleets in each European region and only 1% in Western Europe and 2% in Eastern Europe in that oldest band.

Fleet age sets the pace of everything that follows. A young fleet renews sooner, bringing both the fuel savings of the latest diesel models and the first real opportunity to switch powertrains. An older one locks in today's consumption for longer, leaving retrofit measures such as tyres, aerodynamics and

maintenance as the main levers available in the meantime.

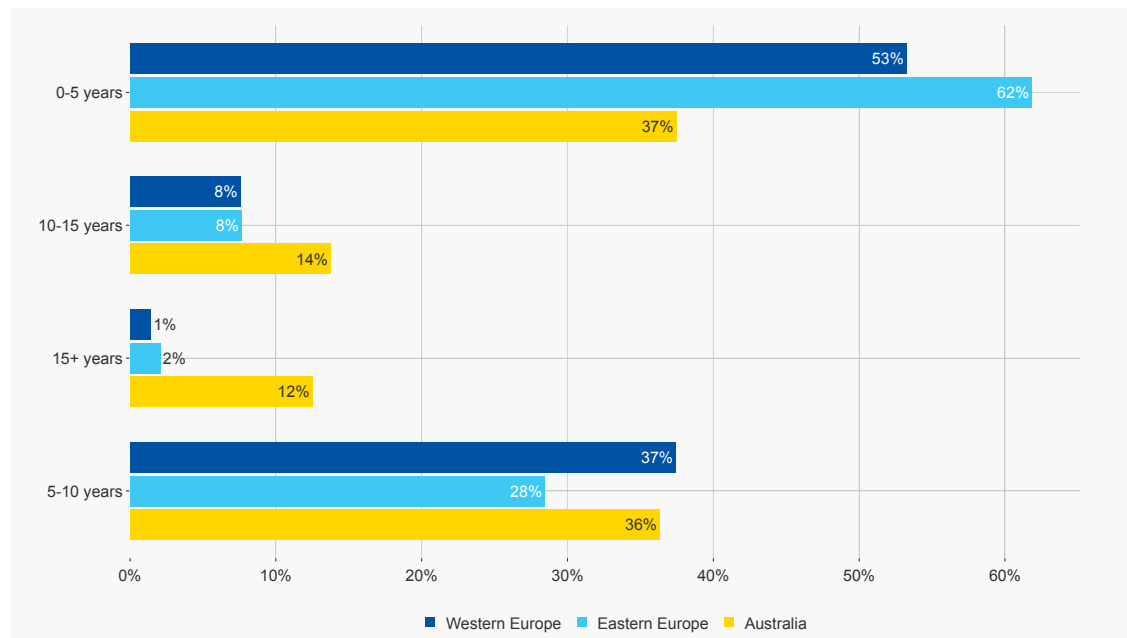
The bulk of the remaining European fleets sits in the five-to-ten-year band (37% in Western Europe and 28% in Eastern Europe), and vehicles beyond ten years are the exception in both regions (around 10%). This likely reflects not only faster renewal but also Europe's well-established second-hand market, where trucks can be sold after around five years, often to markets outside the region, keeping the operating fleet young. Australia, more geographically isolated and with a smaller pool of right-hand-drive buyers, lacks that easy outlet, which helps explain why its vehicles stay in service longer.

These figures should be read within the Green Compact survey sample, rather than of the fleets as a whole.

Australian operators see government support as a stronger decarbonisation lever than customer premiums

Figure 41: Surveyed fleets in Europe are younger than those in Australia

Average age of the fleet, 2026; Western Europe, Eastern Europe and Australia



Base: 2026 Freight respondents – Western Europe, Eastern Europe, Australia; 2025 – Western Europe, Eastern Europe, Australia

Note: Results based on weighted sample. No statistically significant results identified year on year, tested at 95% confidence interval

Q20. What is the average age of your fleet (tractors and rigid trucks / buses and coaches)?

Virtually all operators still run diesel vehicles, while alternative powertrains remain marginal

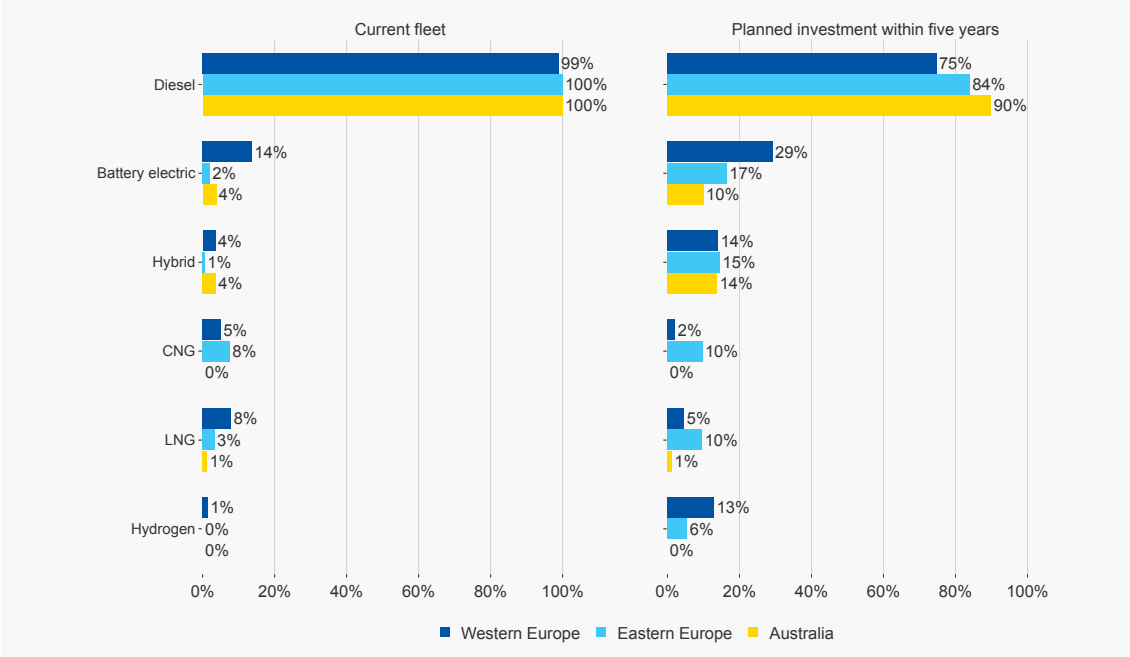
According to the latest ACEA report, the average truck on EU roads is 14 years old, ranging from the youngest fleet in Austria (7.4 years) and Luxembourg (7.7 years) to the oldest in Greece (22.9 years).³¹ The same source shows that battery-electric trucks make up just 0.3% of the EU fleet, against 96.3% still running on diesel. The survey therefore captures the age and technology profile of a particular, more renewawl-active part of the sector, not the ageing, and overwhelmingly diesel stock that characterises the European fleet as a whole.

Today’s fleets are almost entirely diesel. Effectively all operators run diesel vehicles (99% in Western Europe, 100% in both Eastern Europe and Australia),

and alternative powertrains remain marginal. Battery electric is the most established of them, and clearly furthest along in Western Europe, where around one in seven operators (14%) already run electric vehicles, well ahead of Australia (4%) and Eastern Europe (2%). Other options are rarer still, with gas (CNG and LNG), hybrid and hydrogen each in single figures across all three regions among respondents.

Planned investment shifts the picture, but only at the margin. Diesel remains the most common intended purchase everywhere, and by a wide margin (75% in Western Europe, 84% in Eastern Europe and 90% in Australia): the fleet will be renewed largely with diesel in the near term. Battery electric intent nonetheless runs well above current ownership,

Figure 42: Diesel remains the most common intended purchase everywhere
Current fleet vehicle profile and planned investment within five years, 2026; Western Europe, Eastern Europe and Australia



Base: 2026 Freight respondents – Western Europe, Eastern Europe, Australia
Note: New question added in 2026. Results based on weighted sample.
Q21. Which of the following types of vehicles do you currently have in your fleet?
Q21a. In which of the following types of vehicles are you planning to invest in within the next five years?

31 <https://www.acea.auto/publication/report-vehicles-on-european-roads-2026/#:~:text=On%20average%2C%20trucks%20remain%20the,with%203.5%25%20being%20electrically%20chargeable>

with around three in ten Western European operators (29%) planning to invest (roughly double the share already running electric), ahead of Eastern Europe (17%) and Australia (10%). Operators could report more than one intended powertrain, so these figures show where investment is heading rather than how a renewed fleet would divide.

Feedback from operators points to what that intent typically looks like in practice: a cautious first step, replacing one or two diesel vehicles with battery-electric units as a pilot. The exercise is used to work out what makes them viable (reconfiguring routes, building recharging patterns, rebuilding the cost model around a different vehicle) before committing further. That groundwork takes time,

which helps explain why intent runs high while adoption stays low.

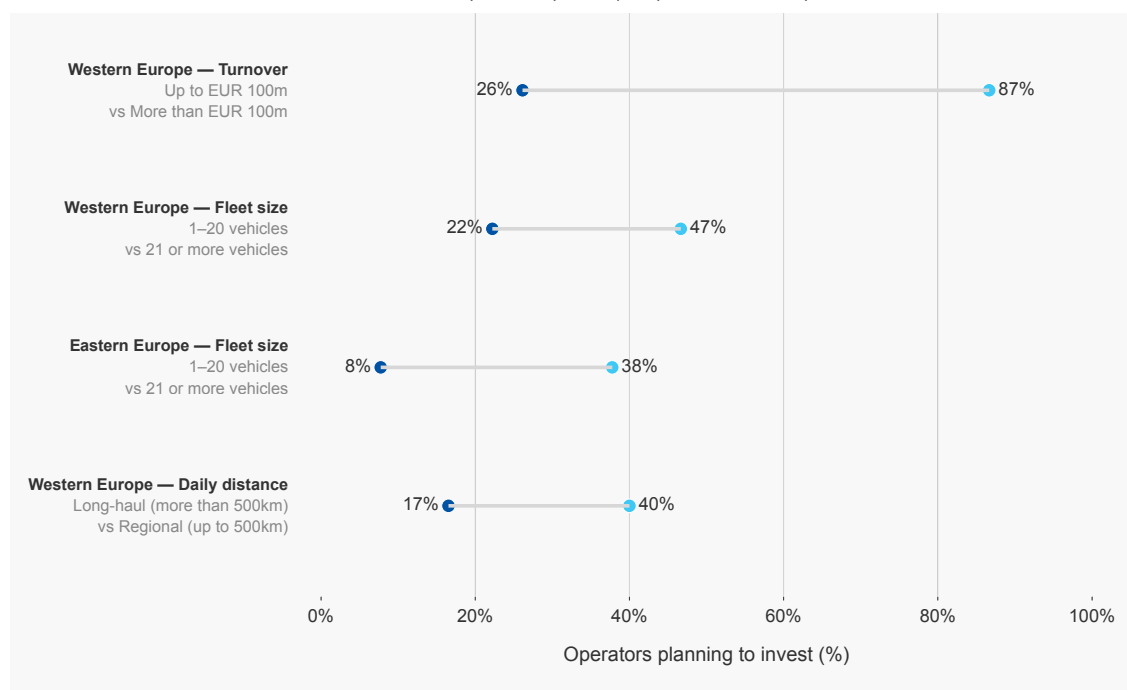
Hydrogen also emerges as a Western European consideration (13% plan to invest, against next to none today), though interest at this stage says more about operators keeping their options open than about a market they can buy from: hydrogen remains the most expensive powertrain and refuelling points are scarce. Australia, for its part, plans no hydrogen or gas investment at all. Overall, operators see electric as the main direction of travel for the fleet, with Western Europe consistently the front-runner and Australia the most committed to staying with diesel.

Plans to invest in battery-electric trucks are not spread evenly across the market.

Plans to invest in battery-electric trucks are not spread evenly across the market

Figure 43: Larger companies are more likely to plan electric truck investment

Plans to invest in electric trucks within five years, by company size and daily distance, 2026



Base: 2026 Freight respondents – Western Europe Company turnover: up to EUR 100m vs more than EUR 100m Fleet size: 1-20 vehicles vs 21 or more vehicles Daily distance: long-haul vs regional. Eastern Europe – Fleet size: 1-20 vehicles vs 21 or more vehicles

Note: New question added in 2026. Results based on weighted sample.

Q21a. In which of the following types of vehicles are you planning to invest in within the next five years?

Larger companies, by both turnover and fleet size, are far more likely to plan an investment over the next five years:

- 87% of Western European operators with a turnover above EUR 100 million plan to invest in electric trucks, against 26% of those below it
- 47% of Western European operators running 21 or more vehicles, against 22% of those with 20 or fewer, with Eastern Europe following the same pattern (38% against 8%)

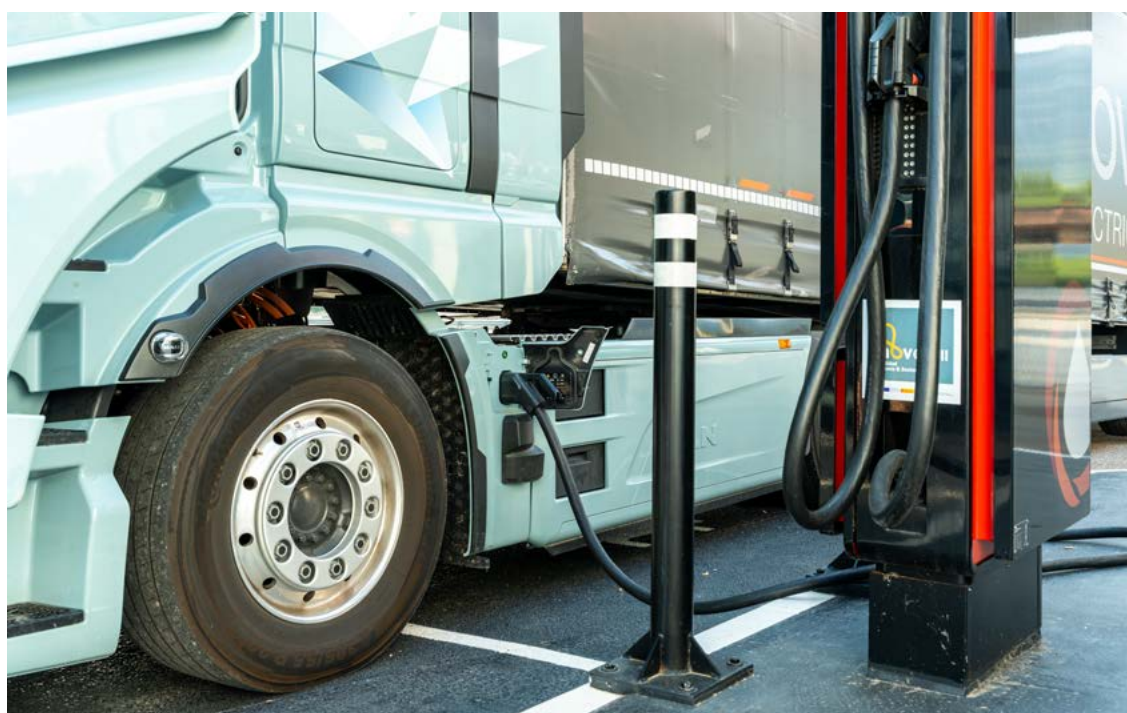
This is the same size divide seen earlier on the importance of decarbonisation, and it is sharper here: what separates the operators moving to electric from those staying with diesel is company size, and the capital, credit and depot capacity that come with it.

Route length shapes the picture too. In Western Europe, operators running regional distances of up to 500km a day are far more likely

to plan battery-electric investment (40%) than long-haul operators above 500km (17%). That fits the technology: shorter, predictable daily distances can be served from a depot charger, whereas long-haul work depends on a public charging network that does not yet exist at scale.

Taken together, these results show where the electric transition is starting, and where it has yet to begin. Larger companies on regional routes are the front-runners, while smaller operators and long-haul fleets remain furthest from investing. That points to a role for targeted support, but also to what the industry can do for itself. Charging infrastructure is a shared bottleneck, as operators reported during the IRU Green Compact roundtables. Cooperation between operators (including companies opening their charging facilities to others) could widen access to the infrastructure that cost-efficient electric operations require, letting those leading the transition bring the rest of the market with them.

Cooperation between operators could widen access to charging infrastructure and help accelerate electric vehicle adoption



7.5 Efficiencies and decarbonisation: a deeper dive

Efficiency is the Green Compact's first pillar, and for a fleet that will remain largely diesel for years to come, it is the lever that delivers today. The survey therefore asked operators which measures they plan to adopt to cut their vehicles' fuel consumption. Their answers say as much about the vehicles they run as about their appetite for decarbonisation.

Preventive maintenance tops operators' plans everywhere, with 64% in Western Europe, 54% in Eastern Europe and 51% in Australia. A well-kept engine and correctly inflated tyres simply use less fuel.

Beyond that, European operators focus on the two forces a truck fights all day:

- Rolling resistance, the energy lost as the tyres flex against the road, tackled with low-rolling-resistance tyres (47% in Western Europe, 46% in Eastern Europe)

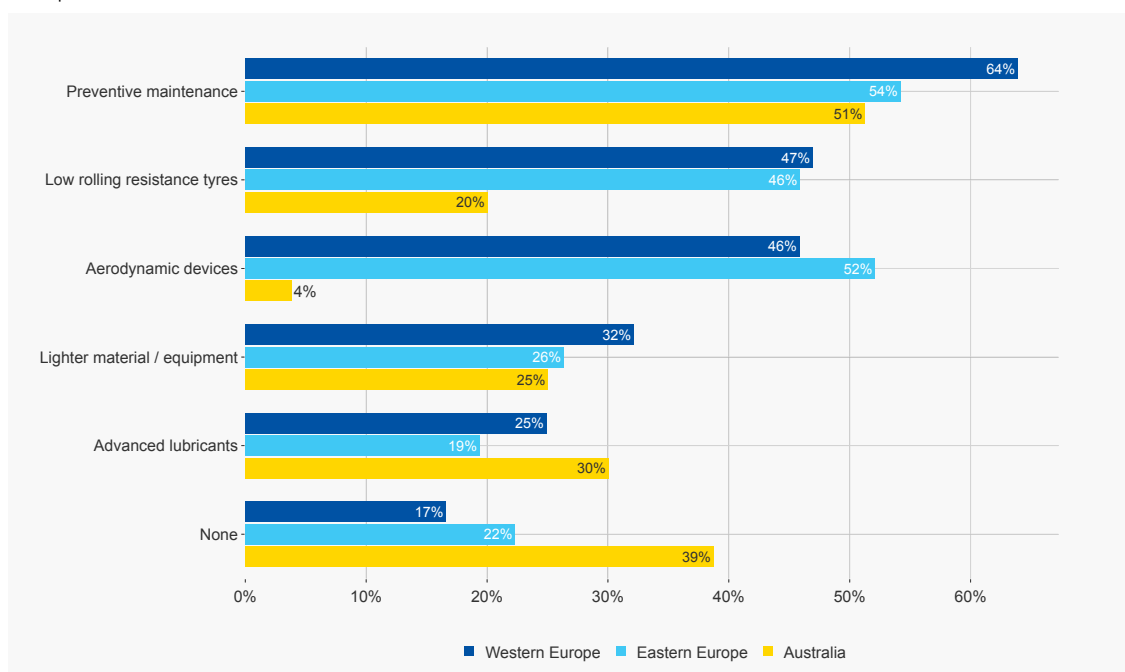
- Aerodynamic drag, the effort of pushing a large flat vehicle through the air, tackled with aerodynamic devices (46% in Western Europe and 52% in Eastern Europe)

Australia is the outlier, and the gap is widest on aerodynamics: just 4% plan aerodynamic devices, against around half in Europe, and only one in five (20%) plan low-rolling-resistance tyres. This likely comes down to the vehicles themselves. Australia's long-distance routes are often run by road trains, a prime mover pulling several trailers, whose many gaps and trailing edges are far harder to streamline than the single tractor-and-trailer combinations common in Europe. Tellingly, the one measure on which Australian operators lead on is the planned use of advanced lubricants (30%, compared with 25% in Western Europe and 19% in Eastern Europe), which works whatever the vehicle configuration.

Preventive maintenance tops operators' plans everywhere, with 64% in Western Europe, 54% in Eastern Europe and 51% in Australia

Figure 44: Preventive maintenance tops operators' efficiency plans everywhere

Efficient vehicle technologies planned to minimise fuel consumption, 2026; Western Europe, Eastern Europe and Australia



Base: 2026 Freight respondents – Western Europe, Eastern Europe and Australia

Note: New question added in 2026. Results based on weighted sample.

Q22. Which technology, if any, are you planning to leverage to minimise your fuel consumption?

European operators prioritise reducing empty running, while Australian operators focus more on increasing payload per vehicle

Alongside changing the fuel or the vehicle, operators are decarbonising by running their existing fleets more efficiently, and here the leading measure is reducing empty running. Close to six in ten operators in Western Europe (59%) and two in three in Eastern Europe (67%) cite it, making it the most common measure in both regions. In Australia it falls to around a third (35%), behind increasing payload per vehicle (37%), a difference that fits the way the country moves freight, optimising the load where Europe optimises the trip. These are levers operators control directly, without new vehicles, fuels or infrastructure, which sets them apart from the cost-bound measures seen earlier.

Eastern Europe stands out for both breadth and movement, adopting most measures more widely than Western Europe and raising three of them since 2025:

- Consolidating loads (44%, up from around a quarter)
- Exploring new routes (42%, up from 14%)

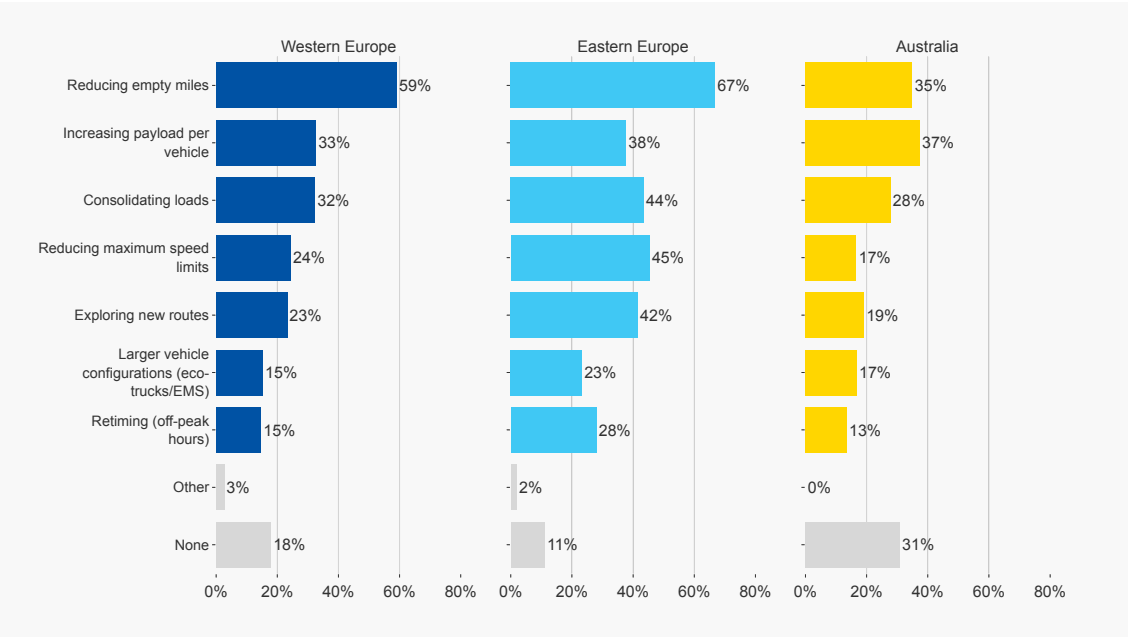
- Larger vehicle configurations such as eco-combis (23%, up from 9%)

These measures matter because they cut emissions without the capital cost that blocks the fuel and vehicle pathways, which likely explains both their wide uptake and Eastern Europe’s growing use of them. Operators are reaching for the decarbonisation they can act on now, while the costlier solutions remain constrained.

That reach has limits, however. Empty running depends on shippers and on the balance of freight flows as much as on the operator’s own choices, and, as this report has shown, efficiency alone cannot deliver carbon neutrality. It buys time and cuts fuel bills; the remaining emissions can only be addressed by changing the energy itself.

Looking five years ahead, operators intend to keep running their fleets more efficiently at broadly today’s level, rather than to expand these

Figure 45: Reducing empty running leads operational efficiency in Europe
Efficient logistics already implemented, 2026; Western Europe, Eastern Europe and Australia



Base: 2026 Freight respondents – Western Europe, Eastern Europe and Australia
Note: Results based on weighted sample. Significance testing conducted between 2025 and 2026 results at a 95% confidence interval. Arrows show statistically significant difference between the two subgroups
Q27. Which of these solutions, if any, have you already implemented in your operations?

measures sharply. Reducing empty running remains the most widely planned measure, held almost exactly at current levels in Western Europe (59%) and Eastern Europe (66%), and edging up slightly in Australia (from 35% to 37%).

The clear exception is larger vehicle configurations such as eco-combis, the one measure operators plan to expand in all three regions, most strongly in Eastern Europe (from 23% to 38%) and Western Europe (from 15% to 23%).

The next phase of operational efficiency is therefore less about new practices than about moving the same freight in fewer, larger vehicles. Larger configurations carry more goods per trip, so their growing appeal follows the same logic that makes fuller loads such an effective lever: each journey's emissions and costs are spread across more freight.

The strongest intent sits in Eastern Europe, which fits the region's operating profile. Operators there

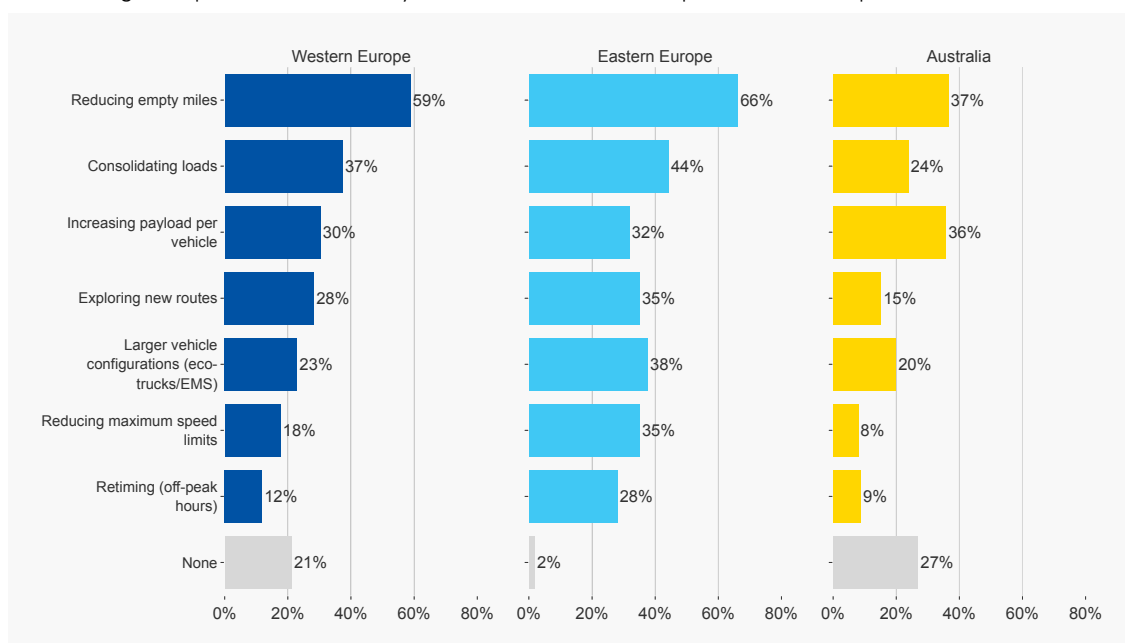
report that, on average, around three-quarters of their volume is international, far above Western Europe. This aligns with IRU's analysis of EU freight flows, which finds eastern EU fleets among the most internationally oriented and covering the longest distances, with Poland alone accounting for over a quarter of the EU's long-distance operations.

That intent, however, runs into the rules. Larger configurations are permitted only where national law allows them, and cross-border use is precisely what remains restricted. The revision of the EU's Weights and Dimensions Directive would allow European Modular Systems to be used in international operations between neighbouring EU countries that already permit them, without bilateral agreements, but it was still under negotiation between the Council and the Parliament as this report went to press. How far operators' intent translates into practice will therefore depend as much on regulation as on their own plans.

The next phase of operational efficiency is therefore less about new practices than about moving the same freight in fewer, larger vehicles

Figure 46: Operators in all three regions plan greater use of larger vehicle configurations

Efficient logistics planned within five years, 2026; Western Europe, Eastern Europe and Australia



Base: 2026 Freight respondents – Western Europe, Eastern Europe and Australia

Note: New question added in 2026. Results based on weighted sample.

Q28. Which of these solutions, if any, are you planning to implement within the next five years? Please select all that apply.

Decarbonisation for more than the few

From electric trucks and biofuels to AI-powered routing and new commercial models, CEVA Logistics is taking a multifaceted approach to cutting emissions – helping extend decarbonisation beyond short routes, individual markets and larger transport companies.

Decarbonising road transport is not about choosing one winning technology.

Routes and infrastructure differ. Energy prices move. Customers have different requirements and varying levels of willingness to pay.

For **IRU member CEVA Logistics**, the answer is to build flexibility into the transition, combining battery-electric vehicles, biofuels, infrastructure, digital tools and new commercial models.

Why a multi-energy approach

Technology is evolving quickly. What makes sense for one route, country or customer may not work somewhere else.

“We have seen this with different energy sources over time. Costs can change significantly, technologies improve and geopolitical developments can alter the economics very quickly,” said Pierre-Alain Saclier, Vice President of Global Consumer & Retail at CEVA Logistics.

“We therefore need the ability to move between different solutions depending on cost, availability and operational requirements,” he added.

There is also a global dimension. CEVA's major customers increasingly want credible solutions across their operations worldwide.

That means CEVA has to offer lower-carbon options across different regions and avoid relying on a single technology or model.

Alternative fuels: where things stand

CEVA increased its alternative fuel vehicle fleet by 38% between 2024 and 2025, reaching 1,591 vehicles.

That includes 542 electric vehicles and more than 870 trucks running on HVO and B100 biofuels. It aims to have 1,700 alternative fuel vehicles in ground operations in 2026.

“Fleet renewal is broader than alternative fuels alone,” said Pierre-Alain Saclier. “We systematically replace vehicles with newer, more efficient models and encourage our subcontractors to follow the same standards.”

Pierre-Alain Saclier
Vice President of Global
Consumer & Retail,
CEVA Logistics



"We need to work on developing our exclusive subcontractor network and provide them with efficient solutions. Decarbonisation cannot stop with the vehicles that we own ourselves," he added.

Beyond short distances?

CEVA is also testing how electric trucks can perform over longer distances.

In April 2026, CEVA completed an **eight-day pilot along the China–Kazakhstan corridor**, covering nearly 6,000km from Shenzhen, China to Almaty, Kazakhstan.

A pure electric heavy-duty truck completed the 5,000km domestic leg from Shenzhen to Alashankou in 4.5 days, supported by nine charging stops, before the cargo was transferred to a diesel fleet for the final leg to Kazakhstan. It reduced CO₂ emissions by 46% compared to standard diesel operation.

"Examples like this are important. There is still a perception that electric trucks are limited to short distances," said Pierre-Alain Saclier. "The technology is developing quickly. We need real operational experience to understand where it can already work and where further development is still needed."

Investing in infrastructure

The vehicle is only one part of the equation.

CEVA is investing directly in recharging and refuelling infrastructure at its sites.

In the UK, for example, CEVA has invested in dedicated **HVO infrastructure and storage tanks** across 18 locations.

The network gives it more consistent access to HVO100 and supports wider deployment of the fuel across the country.

CEVA's current UK infrastructure can support around 6 million litres of

HVO annually, with the fuel delivering reductions of up to 90% in CO₂e emissions on a well-to-wheel basis.

It is also developing commercial solutions that make lower-carbon transport accessible even where the physical infrastructure is not yet available.

Its **Mass Balance** offer, for example, allows customers using CEVA-operated road services across Europe to purchase verified emissions reductions generated through the use of lower-carbon energy elsewhere in CEVA's network. Customers can select reductions of 25%, 50% or 80% compared with a B7 diesel benchmark.

What about digitalisation?

CEVA is using different telematics solutions for its own fleet and subcontracted transport.

It has embedded Samsara Fleet Telematics – a cloud-based platform combining real-time GPS tracking, vehicle diagnostics, safety and compliance tools – into its own trucks and trailers.

Meanwhile, project44 enables CEVA to connect with subcontracted vehicles and access relevant data for the journeys they perform.

"We are now using this type of connectivity across more than two million shipments," said Pierre-Alain Saclier. "It gives us more accurate information on kilometres travelled and vehicle positions, which in turn improves the accuracy of our CO₂ calculations."

Digital tools are also improving planning.

CEVA has deployed an **AI-powered dispatching tool** across more than 40 locations in the US. It considers variables such as vehicle capacity, appointments, traffic, loading configurations and customer requirements to optimise routes. Among the results so far is a 40% improvement in planning productivity.

Subcontractors? It starts with procurement

CEVA looks beyond price and operational performance when selecting transport providers. It considers factors such as fleet efficiency, connectivity, safety and commitments to driver training.

Those expectations are built into its supplier-selection process and followed through its vendor management system, with key suppliers reviewed regularly against agreed performance criteria.

Tracking progress

CEVA built an internal business intelligence tool three years ago to monitor its sustainable fleet.

The tool tracks the number of vehicles in operation and CO₂ savings by energy type and region, allowing teams to see progress and identify where further improvements are needed. "Strict governance, regular monitoring and a company-wide mindset are what turn the data into operational change," he concluded. ■



About CEVA Logistics

CEVA Logistics, a world leader in third-party logistics, provides global supply chain solutions to connect people, products and providers all around the world. Headquartered in Marseille, France, CEVA Logistics offers a broad range of end-to-end, customized solutions in contract logistics and air, ocean, ground and finished vehicle transport in more than 170 countries worldwide thanks to its approximately 110,000 employees at more than 1,700 facilities.

7.6 Alternative fuels and decarbonisation: a deeper dive

If efficiency is what operators can do with the fleet they already have, alternative fuels decide whether road transport reaches carbon neutrality at all. Efficiency lowers how much energy a truck needs; only the energy itself can remove what remains. The survey asked operators which alternative fuels they use today, and which they expect to use within five years.

Most operators use no alternative fuel today, but their five-year plans point to a real shift, fastest in Western Europe. Close to three in five operators (58%) in Western Europe currently use none, rising to around two in three (65%) in Eastern Europe and nine in ten (90%) in Australia. Within five years those shares fall to around one in four (26%) in Western Europe, just under half (48%) in Eastern Europe and

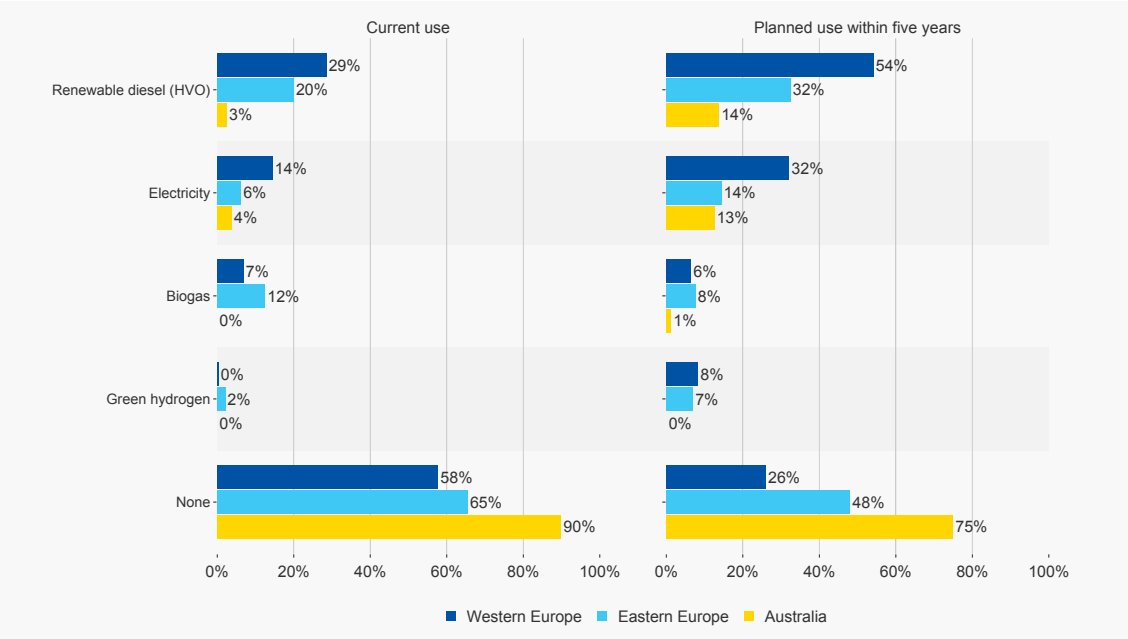
three-quarters (75%) in Australia. The distance between regions therefore widens: Western Europe pulls away, while Australia moves more slowly from a much lower base.

Renewable diesel (HVO) is the front-runner in every region, both now and in operators' plans. Just under three in ten (29%) use it in Western Europe today, and more than half (54%) plan to do so within five years. Eastern Europe follows the same path, while Australia climbs from a very low base (3% to 14%). Electricity use rises from 14% current to 32% planned in Western Europe, 6% to 14% in Eastern Europe, and 4% to 13% in Australia.

The fuels gaining ground are those that ask the least of operators. HVO runs in existing engines and uses existing refuelling infrastructure,

The fuels gaining ground are those requiring the least change to operators' vehicles, infrastructure and operations

Figure 47: Renewable diesel leads operators' alternative fuel plans in every region
Alternative fuels currently used and planned within five years, 2026;
Western Europe, Eastern Europe and Australia



Base: 2026 Freight respondents – Western Europe, Eastern Europe, Australia
Note: Question re-designed in 2026. Results based on weighted sample. No comparison possible with 2025 due to different design (i.e. 2026 'if any' added into question wording)
Q23. Which alternative fuels, if any, have you already implemented in your fleet?
Q24. In which alternative fuels, if any, are you planning to invest in within the next five years?

so switching carries almost no capital or infrastructure risk. That also means its ceiling lies elsewhere: in feedstock availability and in the price premium over fossil diesel, not in the fleet. Electricity, by contrast, asks the most, and the intent it nonetheless attracts in Western Europe says a good deal about how firmly operators there expect to be pushed in that direction. Hydrogen remains marginal everywhere, both in current use and in future plans.

Read alongside the fleet profile, these results describe two routes to a lower-emission fleet, running in parallel:

- One changes the vehicle – the intent to invest in battery-electric seen earlier, which reappears here as electricity, on almost the same share of Western European operators (around 3 in 10)
- The other changes the fuel, since renewable diesel drops straight into existing engines and existing refuelling

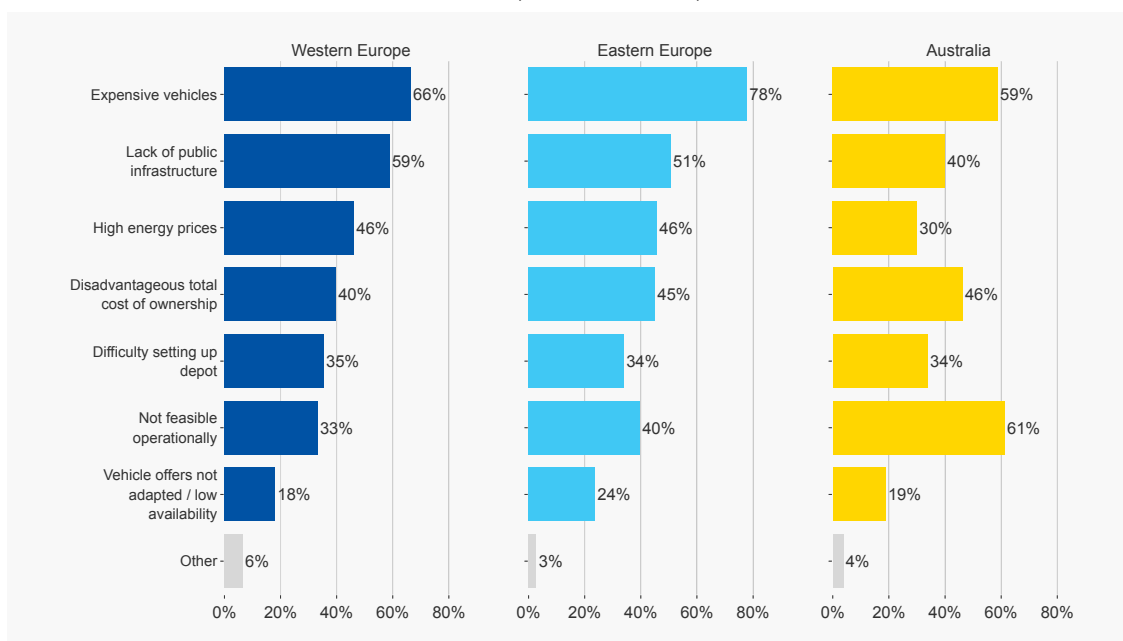
The second route asks the least of operators, which likely explains both why renewable diesel leads in every region and why it is the one option on which Australia shows any movement. It also fits the continued investment in diesel vehicles reported earlier: a diesel fleet can decarbonise through its fuel alone. The electric route advances more cautiously, with intent still running well ahead of use.

The barriers to decarbonisation in general centred on costs: the price of the solutions, and customers' unwillingness to pay it. Asked specifically about alternative fuels, operators point to a sharper version of that cost: the price of the vehicle itself, which has risen in 2026 to become the leading barrier in both European regions. Nearly four in five operators in Eastern Europe (78%) now cite expensive vehicles, up from around half (52%) in 2025, and 66% do so in Western Europe, up from 49%. Concern about a lack of public infrastructure held

The main barriers to decarbonisation centred on cost: the price of solutions and customers' unwillingness to pay for them

Figure 48: Vehicle prices have become the leading alternative fuel barrier in Europe

Barriers to alternative fuels, 2026; Western Europe, Eastern Europe and Australia



Base: 2026 Freight respondents – Western Europe, Eastern Europe and Australia

Note: Results based on weighted sample. Significance testing conducted between 2025 and 2026 results at a 95% confidence interval. Arrows show statistically significant difference between the two subgroups

Q25. What is stopping you from using alternative fuels?

broadly steady over the same period (59% in Western Europe, 51% in Eastern Europe). The infrastructure gap identified as the primary barrier in 2025 has therefore been overtaken by the upfront cost of the vehicle, arguably not because infrastructure has improved, but because more operators have now come close enough to a purchase to assess the price directly.

Australia stands apart. Its most common barrier is that alternative fuels are not operationally feasible (61%), slightly ahead of expensive vehicles (59%) and well clear of infrastructure (40%). Long distances and the least developed refuelling and charging network of the three regions make the question less about what a transition costs than whether it can be run at all, consistent with the weaker battery-electric intent seen earlier among long-haul operations.

Beyond the leading barriers, high energy prices and an unfavourable total cost of ownership form a second tier, each cited by around half of European operators.

The perception of an unfavourable total cost of ownership, reported by two in five operators in Western Europe (40%) and just under half in Eastern Europe (45%), can be read in two ways. It may signal how hard total cost of ownership has become to pin down: a number of countries have already brought battery-electric trucks close to parity with diesel through toll exemptions, purchase incentives and lower energy costs, but the picture differs from one country to the next and shifts from one year to the next, and few operators have the time or the data to rebuild it for their own operations.

It may also reflect a risk operators are simply not willing to carry. The residual value of a battery-electric truck is still an unknown, and second-hand values underpin the economics of a European fleet, as its age profile suggests. No established second-hand market exists yet for electric trucks, and with transport contracts typically running far shorter than a vehicle's first life, it is the operator who would be left exposed to whatever that value turns out to be.

Without an established second-hand market for electric trucks, operators carry the risk of an uncertain residual value

Electric truck charging at a fast-charging station in Öhringen, Germany, 4 April 2025



7.7 Awareness and understanding of regulations

Awareness of decarbonisation regulation is broad but shallow, and it is the rules acting directly on the vehicle that operators grasp best. Across the six European regulations tested, a little over half of operators are aware of a given rule in some form, but only around one in eight understand it well, in both Western Europe (13%) and Eastern Europe (13%). This sits uneasily with two earlier findings: fewer operators now cite a lack of clear information as a barrier, and information or advice ranks last among the levers that would move them. Operators do not feel they lack information, yet few can say what the main rules require of them.

Understanding concentrates on the regulations closest to the truck itself. The CO₂ standards for heavy-duty vehicles and Euro 7 are the best understood in both regions

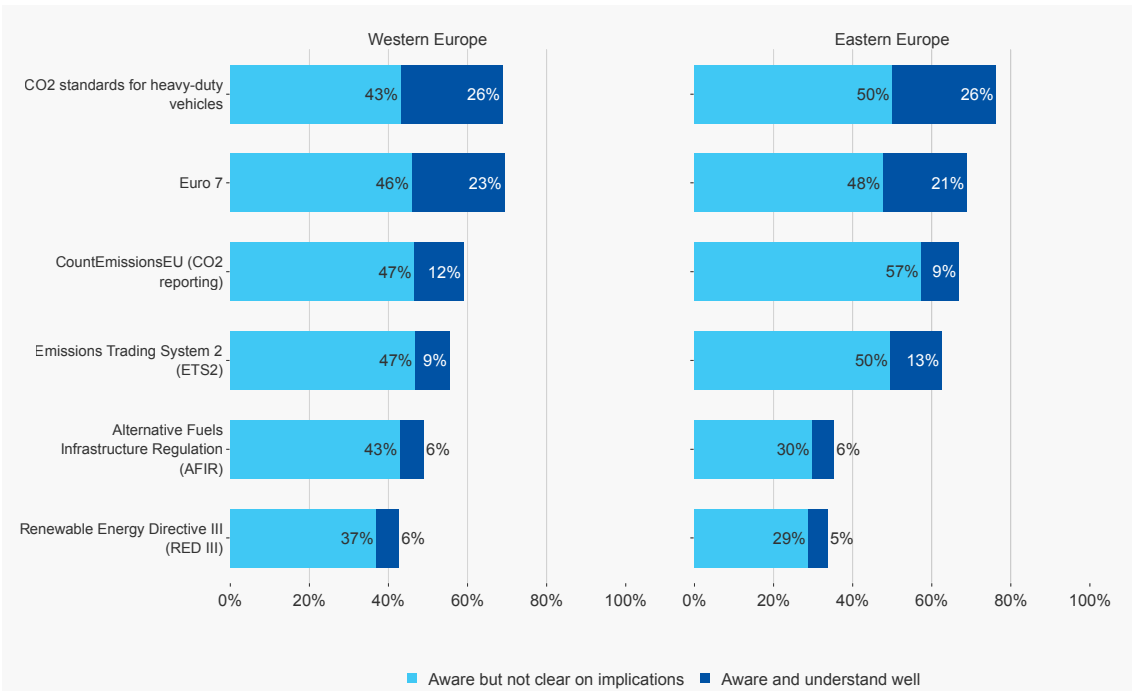
(CO₂ standards 26% in both regions; Euro 7 23% in Western Europe and 21% in Eastern Europe). At the other end sit the two system-level rules on fuels and infrastructure, the Renewable Energy Directive III and the Alternative Fuels Infrastructure Regulation, understood well by fewer than one in ten anywhere and unknown to most, with around two-thirds of Eastern European operators unaware of either.

The two regions are broadly similar, with no consistent gap, though Eastern European operators appear to understand the Emissions Trading System 2 somewhat better (13% against 9%). That last figure deserves attention on its own: ETS2 is the rule that will most directly raise the cost of diesel, from January 2028, and only 1 in 14 Western European operators claim to understand it well.

Around half of European operators are aware of key decarbonisation regulations, but only one in eight understand them well

Figure 49: Awareness of EU decarbonisation regulation is broad but shallow

Awareness of EU regulations, Western and Eastern Europe, 2026



Descending order based

Base: 2026 Freight respondents – EU-based respondents – Western Europe, Eastern Europe

Note: New question added in 2026. Results based on weighted sample.

Q9. Are you aware of the following regulations, and how well do you understand them?

Regulation registers most clearly when it changes the vehicle an operator buys, and least clearly when it acts on the fuel and charging system around it

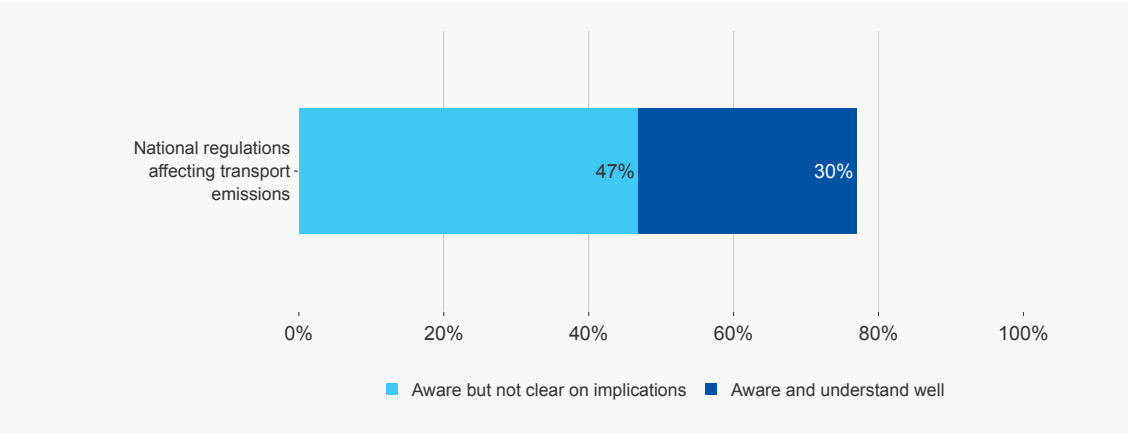
The same holds for CountEmissionsEU, in force since June 2026 and well understood by around one in eight, which echoes the earlier finding that only 16% of those measuring their emissions use the ISO standard it is built on.

Regulation therefore registers most clearly when it changes the vehicle an operator buys, and least clearly when it acts on the fuel and charging system around it.

Asked about the regulation shaping their own market, three in ten Australian operators (30%) say they understand it well, just under half (47%) are aware of it but unclear on what it means for them, and close to a quarter (23%) are not aware of it at all.

These figures cannot be set against the European ones: Australian operators answered a single, broad question about their regulatory environment, whereas European operators rated six named rules one by one, and a general self-assessment almost always scores higher than a series of specific tests. Read on its own terms, the result says two things. Regulation is not an unknown quantity for most Australian operators – but almost a quarter are unaware of the rules affecting their own market, and barely three in ten can say what those rules require, which is consistent with the lower engagement on targets, measurement and action seen throughout this chapter.

Figure 50: Three in ten Australian operators say they understand their regulations
Awareness of Australian regulations affecting transport emissions, Australia, 2026



Base: 2026 Freight respondents – Australia
Note: New question added in 2026. Results based on weighted sample.
Q9a. Thinking about the rules, laws, or policies in your country or the countries you operate in that impact transport emissions, how aware are you of these regulations, and how well do you understand them?

7.8 Key findings from the survey results

The table below maps where each region stands, and brings out both the gap in pace, four regions advancing while the US retreats, and where each applies its pressure.

Some target the manufacturers that build the vehicles, others the suppliers that provide the fuel, or the operators that run the fleets. ■

Key finding	Key figures	How regions differ	Trend
1. Action runs ahead of commitment , decarbonising through the fuel bill, not climate strategy	90% act, but only ~40% have a target (Western Europe)	Europe acts widely, Australia lags (55% act)	↑ acting ↓ committing
2. Cost is the binding barrier , now the vehicle itself. The truck's price overtakes infrastructure	Expensive vehicles: <ul style="list-style-type: none"> Western Europe, 49% (2025) -> 66% (2026) Eastern Europe, 52% -> 78% 	Rise across Europe , Australia's barrier is feasibility , not cost	↑ vehicle cost → infrastructure
3. Renewable diesel leads the fuel switch , as it asks the least of the fleet	Planned HVO: <ul style="list-style-type: none"> Western Europe 29% (current use) -> 54% (planned) 	Western Europe furthest ahead on HVO, Australia shifts from a very low base.	↑ every region
4. Electric intent runs ahead of use , concentrated where it fits	BEV intent: <ul style="list-style-type: none"> Western Europe 14% (current use) -> 29% (planned) 	Western Europe leads (29% planned), Eastern Europe (17%), Australia (10%). Regional operations higher uptake than long-haul	↑↑ intent ↑ adoption
5. Firm size decides who acts , the divide is capital, not will	Plan BEV: <ul style="list-style-type: none"> Companies with >EUR 100 million turnover 87% vs. those with lower capital 26% 	Holds in both European regions (Eastern Europe, the divide between large and smaller companies 38% vs 8%)	Large → small companies, wide gap
6. Money moves operators, not mandates . Financial levers lead	Customer premium 37%, information 10% (Western Europe)	Western Europe looks to customers, Australia looks to the state (subsidies lead)	↑ financial ↓ regulatory
7. Rules known but not grasped , thinnest where cost will bite	~1 in 8 (13%) understand a regulation well, ETS2 just 9%	Western Europe and Eastern Europe near-identical , Australia not comparable (asked differently)	↑ awareness ↓ understanding

Chapter 8

Key takeaways

Nine in ten Western European operators are already taking action, mainly through measures that pay for themselves in fuel savings and are now nearing saturation

The 2026 edition reviews the regulatory frameworks of Brazil, China, the EU, India and the US; the levers open to operators; the conditions that decide whether those levers can be deployed at scale; and what road freight operators in Western Europe, Eastern Europe and Australia reported in the second Green Compact survey.

When looking at GHG emissions, global emissions are still edging up (54.4 GtCO₂e in 2024) and transport moves against the trend in regions already decarbonising: EU road freight volumes have doubled since 1990 and its emissions rose 28%. Below are ten points that summarise what the report found.

01 Regulation is diverging, and where zero-emission trucks actually sell, pull measures are doing the work.

Four of the five regions reviewed are tightening their frameworks; the US dismantled its federal push and pull measures in little more than a year. China is showing what moves a market: purchase-tax exemptions, scrappage payments and battery swapping took new-energy vehicles to 29% of new heavy truck sales

in 2025. Brazil and India lean on biofuel mandates and electric buses. The EU has the most complete push side, from CO₂ standards on manufacturers to CO₂-based tolls and a carbon price on diesel from 2028, but leaves the pull side to EU countries, where it remains patchy and difficult to grasp for operators.

02 Efficiency is the first lever to activate, and operators have already pulled the part of it that pays for itself.

Driver training saves around 15% of fuel, while the best tyres can save up to 30% on long-haul operations, and two European Modular System combinations move the load of three articulated trucks with 15% less energy. IRU modelling suggests that more efficient logistics, fleets and drivers can save up to 50% of

CO₂ emissions. Nine in ten Western European operators already act, mostly through measures that repay themselves through the fuel bill and are now close to saturation. A more efficient diesel truck still burns diesel: the next step changes the energy, and it costs capital.

03 For passengers, the cheapest carbon saving is a fuller bus, whatever the powertrain.

Cars produce 57% of transport CO₂ in both the EU and the US. A full coach moves 295kg per passenger against 440kg for a full car, so a shift from car to coach cuts emissions before any

change of energy. It happens only when push measures on car use are matched by pull measures that make the bus more convenient for users.

04 No alternative energy yet passes all three tests: is the energy there, can the fleet run, and does the business case work?

Biofuels have a network but no volume: the six largest producing markets make 59 billion litres of diesel substitutes a year against the 800 billion litres that trucks and buses burn. Electricity has volume but no network: Europe counted 1,225 public truck-capable

charging stations against a need for closer to 50,000 high-power points. Biomethane, hydrogen and e-fuels are capped tighter still. Electricity also decarbonises only if the grid does: above roughly 730 gCO_{2e} per kWh, an electric truck emits more than the diesel it replaces.

05 Drop-in fuels preserve the operation; electricity redesigns it, so electrification starts where the redesign is smallest.

HVO changes neither refuelling time, payload, routes nor range, which is why renewable diesel leads operators' intentions in every region surveyed. A battery-electric truck changes the envelope on three fronts: range decides which duty cycles are addressable, four tonnes of battery

weight reduce payload capacity and narrow where the load can sit, and recharging has to fit into the driver's 45-minute break. Regional work by larger fleets goes first: 40% of Western European operators running up to 500km a day plan to invest, against 17% of long-haul operators.

06 Charging will be built mostly at depots, and a network planned nationally will not serve a fleet that runs internationally.

Prices roughly double from depot to semi-public to public charging, so operators will charge at base and top up en route: 80-90% of charging points can sit at depots and shared depots, leaving public charging to the highway break. The depot's own constraint is a grid

connection that takes one to two years. Across borders, a vehicle able to run in one country may find no equivalent conditions next door and is kept on domestic work, thinning international capacity. The test of a network is its continuity along the corridors traffic uses, not its density.

07 The business case still does not add up for operators: freight rates track costs, not value, leaving little margin to absorb a green premium.

Road transport costs about 40% more in Europe than in 2019 and close to 50% more in the US, but almost all of that is linked to inflation: in real terms, rates are within 3% of their 2019 level. The 2026 diesel spike showed the mechanism: shippers pay more, operators capture none of it because the fuel floater lags

the fuel price, and the cash to invest drains away. Onto that base comes an electric vehicle costing two to three times its diesel equivalent, with a residual value nobody can yet price; operators have done the sum, and expensive vehicles are now their top barrier to alternative fuels, ahead of infrastructure.

08 The decision to switch depends more on the price of fossil fuel than on the price of the green alternative.

Electricity is the only energy whose cost per kilometre sits structurally below diesel in the EU. HVO carries a premium in every market IRU tracks but one, a 14% EU median that widens as diesel gets more expensive, so the incentive to switch

is weakest when diesel is high. Biomethane was twice the price of fossil gas in 2025 and near parity in 2026 without the fuel changing. What an operator faces is not a stable premium but the volatility of the fossil price it is measured against.

09 Push measures can force parity, but by making all transport more expensive; pull measures cost the economy less but are still patchy and short-lived.

ETS2 at EUR 60 per tonne adds 5.5% to the TCO of a long-haul articulated truck in France, a rule only 9% of Western European operators say they understand. Germany's CO₂-based toll raised the bill for a Euro VI articulated truck by 83%, about 10% of TCO, enough to put diesel at parity with a toll-exempt electric truck. Push measures raised toll bills by 500% in Denmark and 1,000%

in the Netherlands, while purchase incentives are capped, hard to apply for and open for short windows, out of step with multi-year fleet renewal. Pull measures such as toll exemption for zero-emission vehicles can help mitigate the green premium. Several countries in Europe apply them, including Germany, under the Eurovignette framework allowing full exemption until mid-2031.

10 Until a shipper pays for a decarbonised tonne-kilometre, every measure moves cost between operators and taxpayers without creating a buyer.

Seven operators in ten, in all three regions surveyed, say their customers will not pay the extra cost, and in Western Europe a customer premium is what operators say would move them most, ahead of subsidies and legislation. A buyer cannot value what it cannot compare: fewer than half of Western European operators calculate their emissions, most using their own method, the gap CountEmissionsEU sets out to close by 2030.

Green contracts, longer contract durations and book-and-claim schemes are emerging, but none is yet standard practice. Operators are willing. What they cannot do alone is make the energy available, keep the operation running and close the numbers, and those three conditions, met together, are what the Green Compact asks of regulators, energy providers and shippers. ■



Glossary

Advanced driver-assistance systems

(ADAS): Electronic systems that assist the driver, such as predictive cruise control, lane-keeping and emergency braking; on trucks they also help keep fuel consumption close to the optimum.

Alternative Fuels and Efficiency

Model (AFEM): IRU's in-house model estimating a vehicle's energy consumption, emissions and efficiency potential from the operator's own operating data. Most "IRU estimates" in this report are based on it. More information at information@iru.org.

Alternative fuels: All energy sources a truck or bus powertrain can use with a lower well-to-wheel carbon emission factor than diesel: biofuels, biomethane, electricity, hydrogen and synthetic fuels, as well as fossil methane as a stepping stone to biomethane.

Alternative Fuels Infrastructure

Regulation (AFIR): EU regulation obliging EU countries to deploy minimum numbers of public charging points and hydrogen refuelling stations, including for heavy-duty vehicles, along the Trans-European Transport Network (TEN-T).

Articulated vehicle: A tractor unit coupled to a semi-trailer (a trailer without front axle resting on the tractor), the standard long-haul combination in Europe. A typical EU articulated vehicle weighs 15 tonnes empty and carries 25 tonnes of payload.

Axle load: The weight resting on one axle of the vehicle. Axle-load limits (11.5 tonnes on an EU drive axle) constrain where cargo can be placed; on an electric tractor, battery and driveline mass use part of that limit before any cargo is loaded.

Battery electric vehicle (BEV):

A vehicle driven by electric motors powered by an on-board battery recharged from the grid. No tailpipe emissions; its carbon footprint is set by the carbon intensity of the electricity that charges it.

Battery swapping: Exchanging a depleted battery pack for a charged one at a dedicated station, in minutes. Deployed at scale for heavy trucks in China.

Bharat Stage VI (BS VI): India's vehicle pollutant-emission standard, equivalent to Euro VI, applied nationwide since April 2020 and tightened in 2023.

Biodiesel blends (B5, B15, B100):

Diesel containing a stated percentage of biodiesel: B5 is 5% biodiesel, B100 pure biodiesel. Standard EN 590 diesel may contain up to 7% FAME.

Biofuel: Fuel produced from biomass: crop oils and food crops (first generation) or non-food and waste feedstocks (second generation). For diesel engines, the two products are FAME and HVO.

Biogas, biomethane, renewable

natural gas (RNG): Methane produced by anaerobic digestion of organic matter. Upgraded to natural-gas quality it is called biomethane (RNG in the US) and uses the same pipelines, stations and vehicles as fossil natural gas. Manure-based biogas has a negative carbon emission factor because it captures methane that would otherwise reach the atmosphere.

Book-and-claim: A contractual scheme separating the purchase of green energy from the physical movement of goods, so that a shipper can fund decarbonisation on a lane where it is feasible rather than on the one it actually uses.

Brake thermal efficiency: The share of a fuel's energy that an engine turns into mechanical work. The best heavy-duty diesel engines now reach around 53%, against roughly 40% a generation ago.

Capital expenditure (CAPEX):

Money spent to acquire assets such as vehicles or chargers. The purchase price carries most of a zero-emission vehicle's green premium.

Carbon dioxide equivalent (CO_{2e}):

A common unit expressing the warming effect of all greenhouse gases (CO₂, methane, nitrous oxide and others) as the quantity of CO₂ with the same effect.

Carbon emission factor (CEF):

The greenhouse gas emitted per unit of energy delivered and used, in gCO_{2e} per megajoule or kgCO_{2e} per litre. The EU reference for diesel is 95.1 gCO_{2e}/MJ, about 3.4 kgCO_{2e} per litre well-to-wheel, of which 2.6 kg leaves at the tailpipe.

Carbon intensity: Emissions per unit of transport work (CO₂ per tonne-kilometre or passenger-kilometre) or per unit of energy (gCO₂ per kWh for electricity).

CO₂ emission class: The classification of a truck by its CO₂ performance, from class 1 (conventional vehicles) to class 5 (zero-emission), used to vary tolls under the Eurovignette Directive.

CO₂ standards for heavy-duty

vehicles: EU regulation setting each manufacturer's CO₂ reduction targets over time for the trucks and buses it sells, measured with VECTO against a 2019–2020 baseline. It pushes manufacturers' offer towards zero-emission vehicles.

Collective mobility: The Green Compact pillar covering buses, coaches and taxis: everything that raises their occupancy and shifts passengers from private cars, which have a higher carbon intensity per passenger-kilometre.

Combined Charging System (CCS) and Megawatt Charging System (MCS): Charging standards for electric vehicles. CCS delivers up to 500 kW; MCS goes above that, allowing a heavy truck to recharge meaningfully within a driver's 45-minute break, provided the grid delivers the power.

Compressed natural gas (CNG): Natural gas stored on board at high pressure. CNG engines are spark-ignited or dual fuel with diesel ignition, and can run on biomethane without modification.

CountEmissionsEU: EU regulation, adopted in April 2026 and in force since 1 June 2026, establishing a single method for calculating and reporting transport greenhouse gas emissions, based on EN ISO 14083:2023, with full application expected by the end of 2030. It binds companies that already report transport emissions or are required to.

Decarbonisation Roadmap Maker (DRM): IRU's in-house energy model of road transport. It forecasts transport demand, estimates the energy trucks consume and tests combinations of efficiency and alternative fuel solutions, constrained by market capacity, to meet a CO₂ reduction curve at minimum fleet TCO.

Depot, semi-public and public charging: Three tiers of truck charging. Depot charging takes place on the operator's own site, usually overnight, at the lowest price; semi-public charging opens depot chargers to other fleets; public charging along highways serves vehicles away from base. Prices roughly double at each step.

Drop-in fuel: A fuel that replaces diesel in existing vehicles, tanks and pumps without modification: HVO and synthetic diesel fully, FAME with adapted fuel filters.

Duo-trailer (SuperEcoCombi): A tractor pulling two semi-trailers. It cuts energy per tonne-kilometre by around 25% compared with a standard articulated truck.

Duty cycle: The daily pattern of a vehicle's work: distances, loads, stops and return to base. It decides which energy is operationally feasible, for instance whether an electric truck can be recharged at its depot.

Eco-driving: Driving techniques that cut energy consumption: anticipation, smooth acceleration and braking, keeping the engine in its most efficient range, limiting idling and top speed. Training saves around 15% of fuel on average.

E-fuels (synthetic fuels, e-diesel): Drop-in fuels synthesised from renewable hydrogen and captured CO₂. Fully compatible with diesel engines, but the chain from electricity to wheel keeps less than 25% of the energy, which makes them the most expensive and least efficient use of renewable electricity.

Emissions Trading System 2 (ETS2): The EU carbon market covering fuels for road transport and buildings from 2028, with a price expected around EUR 60 per tonne of CO₂. Fuel suppliers buy allowances and pass the cost on at the pump. Part of the revenue feeds the Social Climate Fund, which helps smaller businesses access decarbonisation solutions.

Empty running: Distance driven without payload. Reducing it is the most widely used efficient-logistics measure among surveyed operators.

EN 590: The European standard for diesel fuel. It enables modern engines and their emission-control systems and caps biodiesel (FAME) content at 7%.

Energy intensity: Energy used per unit of transport work, in kWh per tonne-kilometre or passenger-kilometre; the quantity the efficiency pillar seeks to lower.

Energy Taxation Directive: EU directive setting minimum tax rates for energy products, including transport fuels; its revision aims to harmonise energy taxation across the EU.

Euro emission standards (Euro VI, Euro 7): EU limits on pollutant emissions from vehicles, such as nitrogen oxides, particulates and methane. Euro VI is the current heavy-duty standard; Euro 7 tightens it and also regulates battery durability. They do not cap CO₂.

European Modular System (EMS), Ecotrucks: Longer and heavier combinations assembled from standard modules, such as the 25.25 m EMS combination. Two EMS combinations carry the load of three standard articulated trucks with about 15% less energy.

Eurovignette Directive: EU directive on road charging for heavy-duty vehicles. Its 2022 revision requires distance-based tolls to be varied by CO₂ emission class and allows EU countries to exempt or heavily discount zero-emission vehicles until 30 June 2031.

FAME (fatty acid methyl ester): First-generation biodiesel produced by transesterification of vegetable oils or animal fats. Lower energy density than diesel (38 against 43 MJ/kg), absorbs water and ages in storage. EU carbon emission factor 23.6 gCO₂e/MJ, about 75% below diesel.

Feedstock: The raw material a fuel is made from: crop oils, waste oils and fats or agricultural residues for biofuels; manure and organic waste for biomethane. Feedstock availability caps biofuel supply and determines its climate benefit.

Freight rates: The prices operators charge to move goods. They derive from fleet TCO and available capacity.

Fuel cell electric vehicle (FCEV): A vehicle in which a fuel cell combines hydrogen and oxygen into electricity and water to drive an electric motor, buffered by a small battery.

Fuel floater: The fuel surcharge clause in a transport contract that adjusts the freight rate when the diesel price moves.

Full truck load (FTL): A shipment that fills a whole truck for one customer, as opposed to less than truckload (LTL) shipments that share the vehicle and can be consolidated.

GLEC Framework: The Global Logistics Emissions Council's method for calculating and reporting logistics emissions; the industry framework on which the ISO 14083 standard was built.

Green hydrogen: Hydrogen produced by electrolysis of water with renewable electricity, using about 48 kWh per kilogram. Carbon emission factor about 9.1 gCO_{2e}/MJ. See also steam methane reforming.

Green premium: The extra cost of the zero-emission version of a vehicle or energy over its conventional equivalent, on purchase price, on TCO or per kilometre. Parity is the point where it disappears.

Greenhouse gases (GHG): Gases that trap heat in the atmosphere, principally carbon dioxide, methane and nitrous oxide.

Grid carbon intensity: The CO₂ emitted per kilowatt-hour of electricity generated in a country, in gCO₂/kWh. Above roughly 730 gCO_{2e}/kWh, an electric truck emits more than the diesel truck it replaces.

Gross weight (gross vehicle weight, gross combination weight): The maximum authorised total weight of a vehicle, or of a tractor-trailer combination, on public roads. EU rules allow zero-emission vehicles up to two extra tonnes to offset battery weight.

Heavy-duty vehicles (HDVs): Trucks, buses and coaches above 3.5 tonnes of gross vehicle weight.

High-pressure direct injection (HPDI): A gas engine in which a small diesel pilot injection ignites natural gas or biomethane in a compression-ignition engine, keeping diesel-like efficiency at the cost of carrying both fuels.

Hydrogen combustion engine: A combustion engine burning hydrogen instead of diesel, either as a compression-ignition engine with a diesel pilot or as an adapted spark-ignition gas engine. It qualifies as zero-emission under EU law (below 1 gCO₂ per kWh) but still needs exhaust after-treatment for nitrogen oxides.

Hydrotreated vegetable oil (HVO, renewable diesel): Paraffinic biodiesel produced by hydrotreating vegetable oils, waste oils or animal fats. Same energy density as diesel, fully drop-in, stores well.

Indirect land-use change (ILUC): The emissions caused when biofuel demand pushes food or feed production onto new land. Counting it lowers the climate benefit of crop-based biofuels; the EU caps and phases out high-ILUC-risk feedstocks such as palm oil.

Intergovernmental Panel on Climate Change (IPCC): The UN body assessing climate science. Its guidelines frame how countries inventory their emissions, including those of trucks and buses.

Intermodal transport: Moving goods by several modes in one chain, typically rail or waterway for the long leg and road for the first and last mile.

Internal combustion engine (ICE): An engine burning fuel to produce mechanical work. Diesel, gas and hydrogen combustion engines are all ICEs.

IRU Green Compact: IRU's initiative, launched in 2021, to investigate decarbonisation solutions and design pragmatic roadmaps to carbon neutrality by 2050. It rests on four pillars: efficiencies, alternative fuels, collective mobility and enabling conditions.

ISO 14083:2023: The international standard for quantifying and reporting greenhouse gas emissions from transport chain operations. The basis of CountEmissionsEU, and materially aligned with the GLEC Framework.

Life-cycle assessment (LCA): Accounting that adds the emissions from manufacturing the vehicle and building its energy infrastructure to the well-to-wheel emissions of the fuel.

Liquefied natural gas (LNG): Natural gas cooled to a liquid at about -162 °C and stored in cryogenic tanks, giving gas trucks ranges close to diesel. LNG engines can run on liquefied biomethane.

Load factor: The share of a vehicle's maximum payload actually used. Usually well below 100%, because most goods fill the trailer's volume before its weight limit.

Long-haul: Operations over long distances away from the depot. In the survey, operators running more than 500km a day.

Low Carbon Fuel Standard (LCFS): California's fuel policy setting declining carbon-intensity targets for transport fuels, with tradeable credits earned by clean-fuel producers. Similar in spirit to Brazil's RenovaBio and the EU's fuel-side rules.

MOVER (Brazil): Brazil's Green Mobility and Innovation programme (2024), which makes energy-efficiency and technology requirements mandatory for new vehicles on a well-to-wheel basis, backed by tax incentives.

New energy vehicle (NEV): China's official category for battery electric, plug-in hybrid and fuel cell vehicles, which benefit from purchase-tax exemption and trade-in incentives.

Operational expenditure (OPEX): The running costs of the fleet: energy, tolls, maintenance, insurance, drivers. Zero-emission vehicles trade higher CAPEX for lower OPEX, which only works if energy prices cooperate.

Paris Agreement: The 2015 international treaty to keep global warming well below 2 °C, preferably 1.5 °C, through national commitments.

Payload: The weight of goods or passengers a vehicle can carry.

Payload-over-kerb-weight ratio (POK): Payload divided by the vehicle's empty (kerb) weight. A van sits below 1, an EU articulated vehicle around 1.7, a duo-trailer up to 2: the higher the ratio, the more of the energy moves goods rather than the vehicle.

PM E-DRIVE and PM e-Bus Sewa (India): India's 2024 electric mobility scheme, funding electric buses and, for the first time, electric trucks, and its companion scheme underwriting electric buses in smaller cities. Their predecessor, the FAME schemes, is unrelated to FAME biodiesel.

Predictive maintenance: Using sensor data and analytics to service a vehicle before a fault or efficiency loss occurs, keeping it at peak efficiency and uptime.

Primary data and modelled data: Primary data are measured, for instance fuel consumption read from the vehicle; modelled data are calculated from distances, loads and default factors.

PROCONVE (Brazil): Brazil's vehicle pollutant-emissions programme. Its heavy-vehicle phase P8, equivalent to Euro VI, applies to all new trucks and buses sold since January 2023.

Push and pull measures: Push measures penalise the polluting option: carbon pricing, CO₂-based tolls, restrictions on car use. Pull measures make the cleaner option more attractive: purchase incentives, toll exemptions, better bus services.

R diesel (co-processed renewable diesel): Diesel produced by processing biogenic feedstock together with crude oil in a conventional refinery, yielding a mixed fossil and renewable stream. Counted separately from HVO in production statistics.

Rebound effect: When efficiency lowers the cost per unit of transport, part of the saving is offset by higher demand, so absolute emissions fall less than efficiency would suggest.

Renewable Energy Directive (RED III): EU directive setting renewable energy targets, including obligations on fuel suppliers to blend renewable fuels and caps on food-crop and high-ILUC-risk feedstocks.

RenovaBio (Brazil): Brazil's fuel decarbonisation policy. It sets annual carbon-intensity reduction targets for fuel distributors, met by retiring tradeable credits issued to certified biofuel producers.

Residual value: The resale value of a vehicle at the end of its first ownership cycle.

Retrofit: Fitting efficiency technologies to vehicles already in service, such as low-rolling-resistance tyres or aerodynamic devices.

Rolling resistance: The force resisting a tyre's motion, from about 3kg per tonne for the best tyres to 10kg per tonne for a diagonal tyre.

Shippers: Companies that send goods and buy transport from operators. They set most load-factor requirements.

Steam methane reforming (SMR): The conventional way to make hydrogen from natural gas, supplying most hydrogen today. Its carbon emission factor (104 gCO_{2e}/MJ) is higher than diesel's, and its cost is three-quarters natural gas.

Tank-to-wheel (TTW): Emissions released by the vehicle itself, at the tailpipe. Zero for electric and hydrogen vehicles.

TIR and eTIR: The international customs transit system administered by IRU, and its digital version. Both cut waiting times, and therefore engine idling, at borders.

Total cost of ownership (TCO):

All costs of owning and running a vehicle over its life: purchase price less residual value, energy, tolls, maintenance, financing and insurance. Freight rates derive from it. TCO parity is the point where a zero-emission vehicle costs no more than its diesel equivalent.

Trailer swapping: Operators exchanging trailers between tractor units so that each tractor and driver stays within a region while the goods travel on. It suits the limited range of electric trucks and keeps drivers closer to home.

Trans-European Transport Network

(TEN-T): The EU's core road, rail and waterway network, along which AFIR charging and hydrogen infrastructure is mandated.

Transport flexibility: The ability of operators to respond quickly to changing demand in volumes, routes and schedules. The combination of transport capacity (vehicles and drivers) and fleet uptime, the share of time a vehicle is available for work.

VECTO: The EU's Vehicle Energy Consumption calculation Tool, which simulates each new truck's CO₂ emissions from its characteristics and mission profiles. The basis of the CO₂ standards and of CO₂ emission classes.

Vehicle categories (N2, N3): EU type-approval categories for trucks: N2 between 3.5 and 12 tonnes, N3 above 12 tonnes. Buses and coaches above 5 tonnes are category M3.

Weighted sample: Survey results adjusted so that the mix of respondents reflects the target population; all survey figures in this report are weighted. The base (n) is the number of respondents answering a question.

Weights and Dimensions Directive:

EU rules on maximum vehicle weights and lengths. They allow zero-emission vehicles up to two extra tonnes; a revision raising that allowance and allowing EMS combinations across borders was under negotiation at the time of writing.

Well-to-wheel (WTW): Emissions counted from energy extraction and production (well-to-tank) through to use in the vehicle (tank-to-wheel). The basis on which alternative fuels are compared in this report.

Zero-emission vehicle (ZEV): A vehicle emitting neither CO₂ nor pollutants from its exhaust: battery electric, fuel cell electric or, under EU law, any vehicle whose combustion engine emits less than 1 gCO₂ per kWh, which includes hydrogen combustion.



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IRU is the world road transport organisation, representing the full spectrum of the industry across more than 100 countries.

IRU Intelligence is built on direct engagement with transport operators, shippers, policymakers and industry partners. Combining field insight, regulatory expertise, operational understanding and proprietary data tools, it translates complex market developments into practical, decision-ready intelligence.



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