MAKING ZERO-EMISSIONS TRUCKING POSSIBLE

An industry-backed, 1.5°C-aligned transition strategy

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Adding to the Picture: vehicle efficiency and the impact of subsidies on zero-emissions trucking

Addendum to

MAKING ZERO-EMISSIONS TRUCKING POSSIBLE

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November 2022

Preface

The *Making Zero-Emissions Trucking Possible* report, published in July 2022, set out an industry-backed roadmap for the transition of the heavy-duty trucking sector to zero greenhouse gas (GHG) emissions vehicles by 2050.[i] The report found that the transition was cheaper than remaining with diesel trucks and set out necessary steps for enabling the transition. Since publication, trucking efficiency gains have accelerated and government incentive programs have expanded, making zero-emissions trucking more economic for the industry. This addendum incorporates these developments and presents new insights on the pace of the zero-emissions trucking transition.

Industry support for MPP's Trucking Transition Strategy

This effort benefited from the input of the MPP Road Freight Zero community, comprising over 50 members and 20 organisations representing the entire trucking value chain. Members of the initiative have validated the model inputs and architecture and endorse the general thrust of the arguments made in this report, but they should not be assumed to agree with every finding, input, or recommendation. These companies agree on the importance of reaching zero emissions from the heavy-duty trucking (HDT) sector by mid-century and share a broad vision of how to achieve the transition. Since the release of the primary report in July 2022, MPP has added several more signatories and welcomed insights that contributed to this continued analysis.

This agreement among industry leaders should give decision makers across the world confidence that it is possible to meet global HDT demand and simultaneously reduce emissions from the sector to net zero by 2050. It should also inspire belief that the critical actions required in the 2020s to set the sector on the right path not only are clear but can be pursued without delay — and that the industry is ready to collaborate with its value chain to achieve those goals.

This effort was prepared in collaboration with Mission Possible Partnership, World Economic Forum, Energy Transitions Commission, RMI, and McKinsey & Company. The primary report includes more information on MPP's goals, signatories, report authors, and affiliated organisations.

[i] The report is available at https://missionpossiblepartnership.org.

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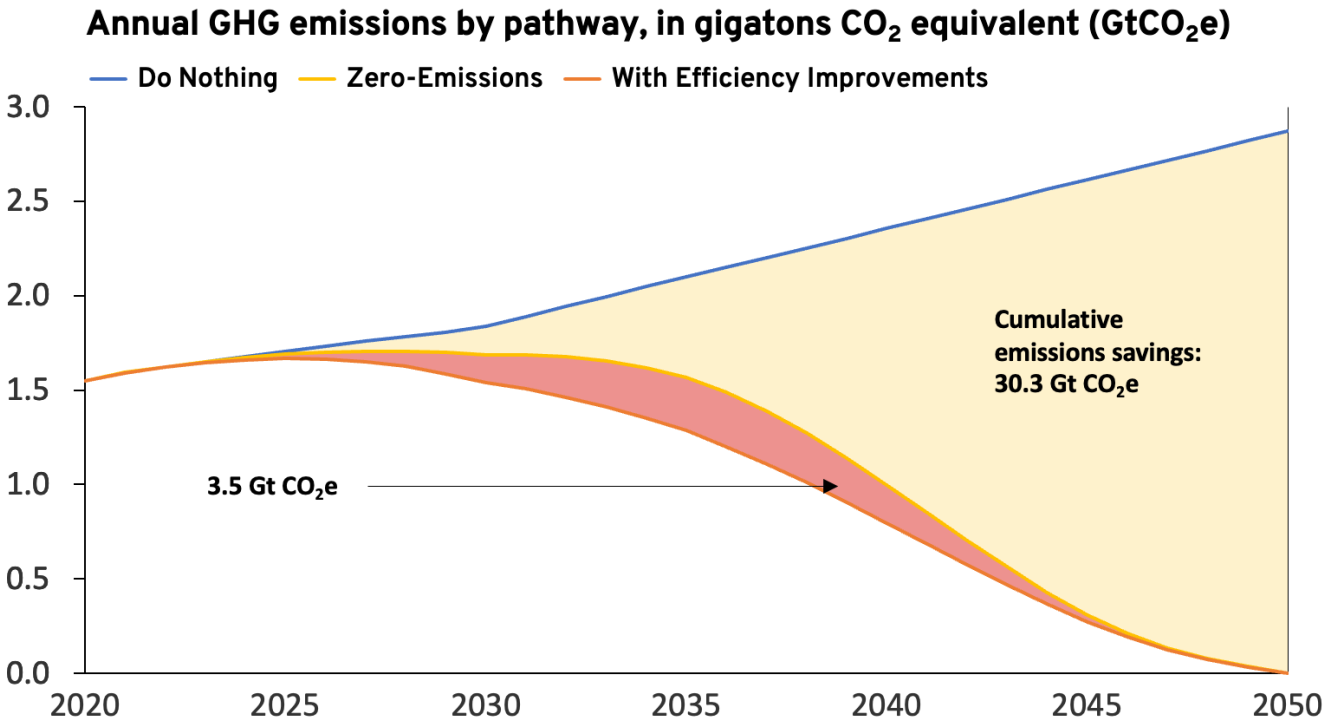
Introduction

Zero-emissions trucking is at a pivotal moment, and recent developments have made the path forward clearer. In response to new vehicle performance data and national policies, the Mission Possible Partnership (MPP) recently updated its Heavy-Duty Trucking (HDT) model. The initial MPP analysis found that the trucking industry can decarbonise by 2050 at a lower cost than continuing on our carbon-intensive, mostly diesel-based path, and that most electric trucks (e-trucks) will reach total cost of ownership parity with diesel within the next decade. Recently enacted incentive programs and new vehicle efficiency data significantly improve the business case for zero-emissions trucks and suggest that a faster transition to zero-emissions trucking is possible.

The MPP HDT model includes technical assumptions,[ii] capital costs, and operating costs across three duty cycles and four global regions over time.[iii] These costs and technical assumptions, such as vehicle efficiencies, captured the savings that come from technology scaling and maturation. The model uses these inputs to calculate the total cost of ownership (TCO) for each vehicle type, and then uses these to inform the purchasing decisions of fleets through 2050, while considering policies such as zero-emissions truck (ZET) mandates or carbon pricing schemes that have their largest impacts in the 2030s or later.

EXHIBIT 1: Efficiency improvements drive significant additional cumulative emissions



[ii] See the Technical Appendix of the main report for detail on these assumptions.

[iii] The three duty cycles are urban vehicles (assumed to travel 50–100 km per day), regional (165–230 km per day), and long-haul (500–600 km per day). The four regions considered are Europe, China, the United States, and India.

This addendum adds to the initial report by:

- Updating electric vehicle efficiency projections, which have improved since the model was first created[iv]
- Showing the impacts of today's policies on accelerating zero-emissions truck adoption and the lower long-term costs that are achieved by achieving market scale and learnings sooner
- Considering the impact on economics of other operational models that allow for smaller batteries and more frequent or higher power charging

Zero-emissions trucking technologies and strategies are changing rapidly, and for the better. Our analysis shows that the current landscape of efficiency improvements, incentives, and different operational practises could lead to e-trucks across nearly all HDT segments achieving cost parity within the next five years. This addendum, the product of the HDT model's flexibility, aims to provide continued guidance on the journey to zero-emissions trucking.

[iv] Efficiencies have not been updated for India because there have been no demonstrations of vehicles on sale in the country surpassing our original assumptions.

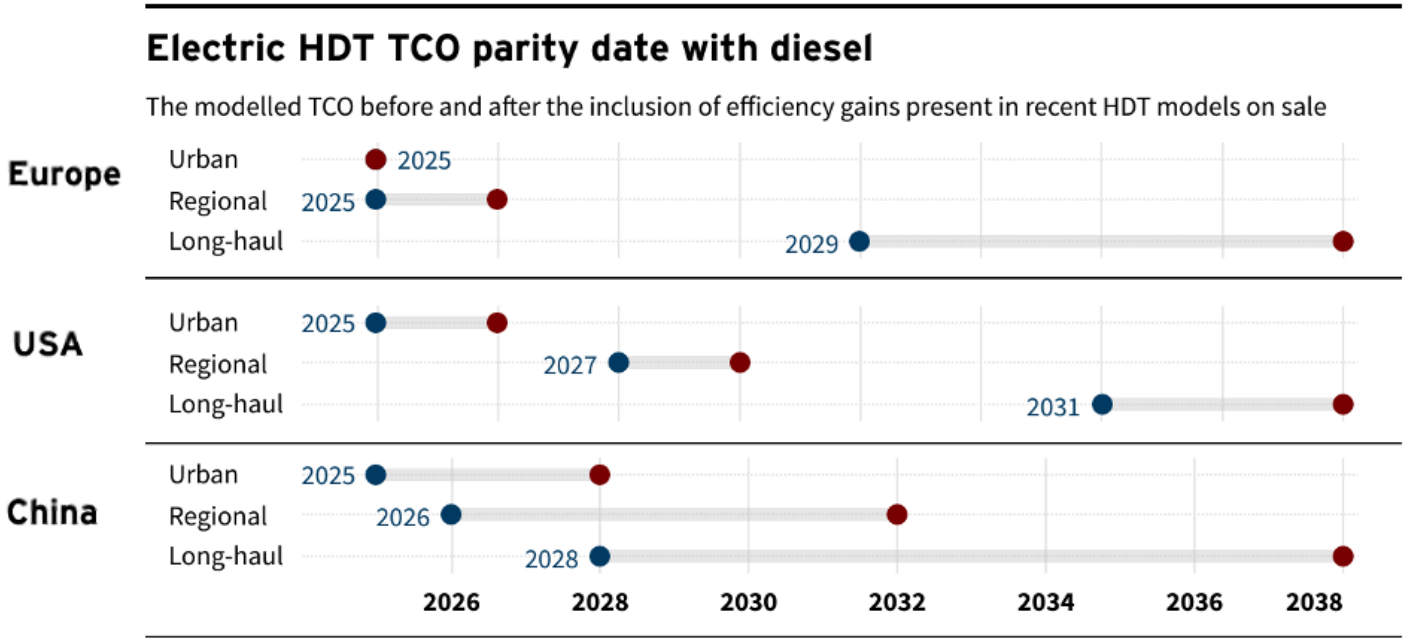
Section 1: Updates on Vehicle Efficiencies

Numerous models of e-trucks are now available in the United States and Europe, and many companies have begun adding initial vehicles to their fleets. Real-world truck data also shows that some vehicles are using less energy than previously anticipated, and some upcoming models claim even greater efficiencies.[v] Efficiency has a major impact on both vehicle operations and economics. Greater efficiency has a cascading effect, reducing vehicle price, charging costs, charging time, and vehicle weight. Efficiency will likely continue to improve with structural batteries, increased aerodynamics, and new power systems.

In the revised MPP model, efficiency is improved by approximately 15%.[vi] This value combines the efficiency gains demonstrated in newer models and accounts for more time travelling at a lower-weight payload, which also reduces fuel usage.[vii] These efficiency advances improve MPP's projected dates for policy-free TCO parity for urban vehicles to 2025 for Europe, the United States, and China. Parity for regional vehicles moves forward to 2025–2027, and long-haul parity comes forward to 2028–2031.

Greater ZET efficiency has the most sizeable impacts in China, offsetting some of the cost advantages of country's significantly cheaper diesel vehicles.

EXHIBIT 2: The largest parity advances are driven by fuel consumption savings for longer-haul



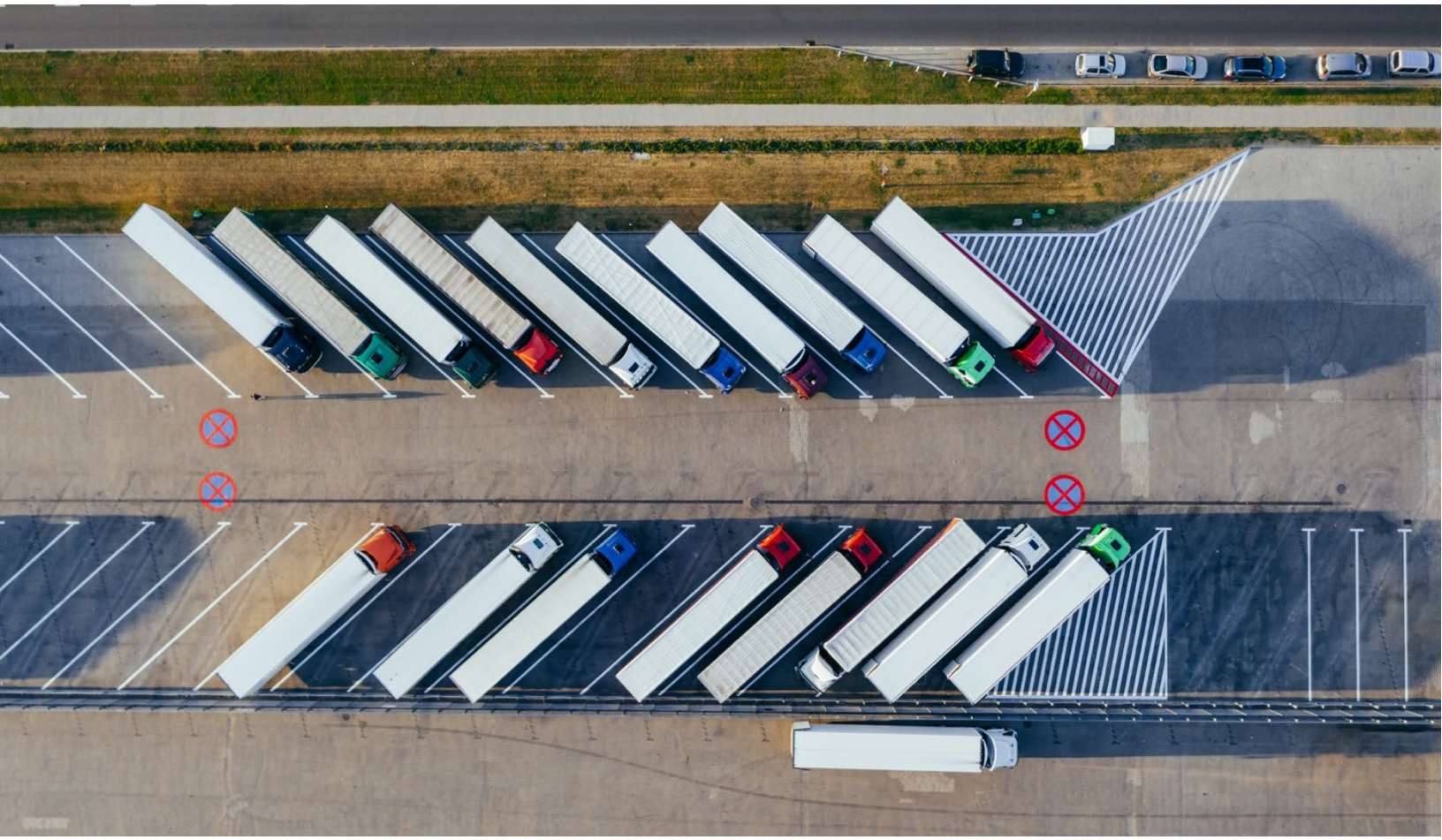
[v] For real-world truck data, see NACFE's Run on Less Electric.

[vi] In 2022, long-haul efficiency has improved from 1.4–1.6 kilowatt-hour/kilometre (kWh/km) to 1.2–1.3 kWh/km, with regional and urban trucks able to achieve the lower end of that range. Initial battery sizes are assumed to be 80–155 kWh for urban, 255–355 kWh for regional, and 720–925 kWh for long-haul, and are projected to decrease over time. See *Section 3* for analysis of smaller long-haul batteries.

[vii] Payload weight can have a large impact on efficiency, we have decreased our average payload utilization based on some routes reaching truck volume capacity before the weight limit.

These new scenarios with greater truck efficiencies will be used as the baseline for the rest of this report, in which we will show how policy will accelerate these parity dates even further.

Section 2: Policy Scenarios



Growing zero-emission truck sales create a virtuous cycle. As with most new technologies, greater sales for ZETs increase learning and investment that in turn improves future versions, increases efficiencies, and reduces costs. The cycle continues as the ZET sector grows. For that reason, subsidising early zero-emissions truck sales will jumpstart the industry, increasing the investments and efficiencies that bring costs down and give the technology a durable advantage over diesel trucks.

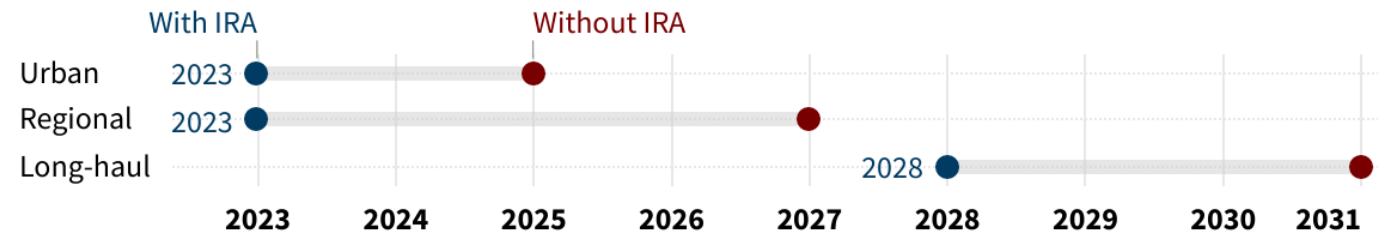
Just like subsidies for the vehicles themselves, subsidies for charging infrastructure will help the sector reach maturity sooner. Subsidising depot charging reduces capital costs, while subsidising on-route charging reduces ongoing fuel costs and creates a network of charging that allows fleets to travel farther, consider trucks with smaller batteries, or both.

The United States

Credits of up to US$40,000 per vehicle and $100,000 per site for infrastructure bring forward TCO parity by three to four years, depending on the usage scenario. With an earlier TCO break-even and subsequent learning, overall market adoption increases as well. By 2030, over 60% of new truck sales could be electric (depending on supply chain issues), leading to a cumulative reduction in US emissions of over 130 Mt CO_2 equivalent by 2050. The IRA is a particularly powerful market signal because its incentives do not expire until 2033. Businesses have already responded to the IRA, with several companies announcing vehicle production plans, investments in e-truck depots, and on-route truck-charging hubs after the law's passage.[viii]

These IRA incentives also apply to hydrogen fuel cell electric trucks (HETs), but under our modelling they do not bring the parity dates earlier than their current parity dates of the late 2030s to early 2040s. However, the IRA also includes significant investment in hydrogen production plants and subsidies for their output. This is not yet quantifiable in our model but could result in hydrogen trucks becoming economically viable in localised areas of the United States earlier than previously forecast.

EXHIBIT 3: Inflation Reduction Act has a large impact across all duty cycles



[viii] See Dan Mihalascu, "2023 Tesla Semi Gets Green Light from the EPA to Start Deliveries," *Inside EVs,* October 26, 2022, https://insideevs.com/news/618697/tesla-semi-gets-green-light-from-epa-start-deliveries/; and Emma Newburger, "TeraWatt Announces First Interstate EV Charging Network for Trucks," CNBC, October 20, 2022, https://www.cnbc.com/2022/10/20/-terawatt-announces-first-interstate-ev-charging-network-for-trucks.html.

Europe

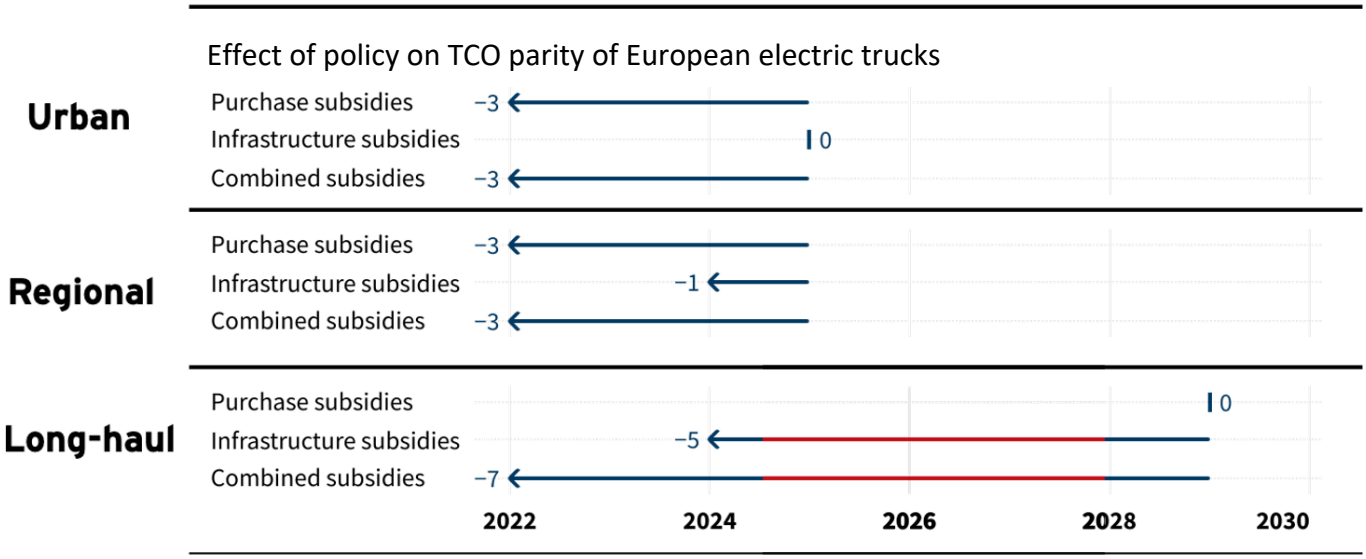
Several EU member countries offer electric truck purchase and charger incentives.[ix] Germany subsidises up to 80% of the price difference between an electric and conventional truck, whereas France pays for up to US$50,100 of the difference. Unlike the IRA incentives, these subsidies are only scheduled to last until the end of 2024. Current vehicle subsidies will jump-start the market for urban and regional trucks but will expire too quickly to improve the competitiveness of long-haul e-trucks.

Germany also subsidises up to 80% of public fast charger infrastructure costs. This incentive is particularly important for long-haul trucks, where charging infrastructure costs can account for upwards of 20% of the TCO. We have modelled the impact of these French- and German-style subsidies illustratively across all of Europe, with purchase and infrastructure incentives between 2022 and 2024.

Even in scenarios where subsidies expire, the public chargers built with incentives see ongoing usage and help long-haul vehicles reach TCO parity sooner. German-style subsidies could make long-haul trucking economical today, but if subsidies expire the trucks may no longer be at parity between 2025 and 2028. This uncertainty in the duration of incentives may make it harder for some truck manufacturers to commit to significant multiyear investments in ZET production at an earlier stage.

China

Exhibit 4: Purchase incentives drive forward TCO for shorter-haul routes, with infrastructure being more important for long-haul



Red line shows period where parity ceases after subsidies expire.

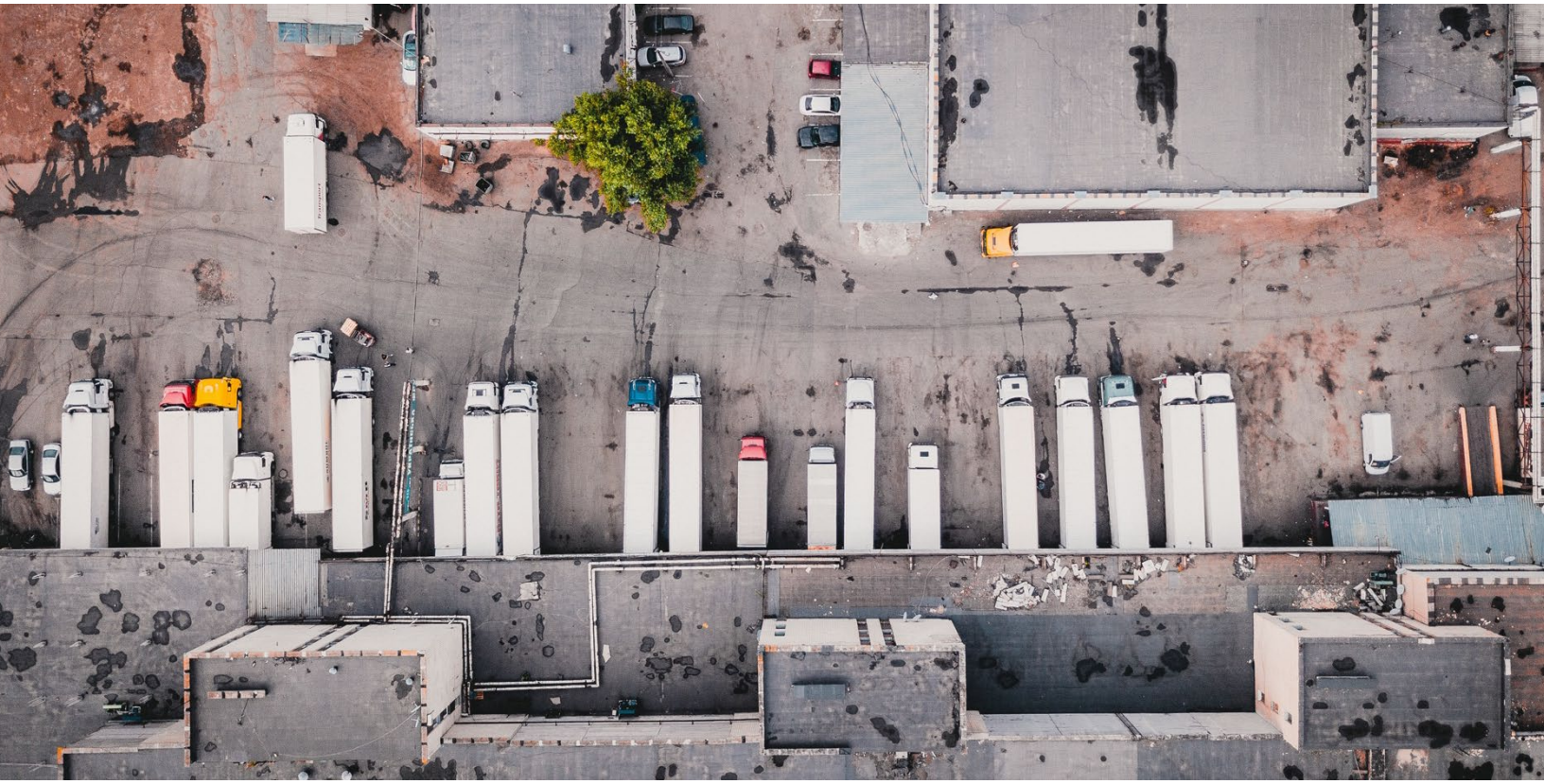
China currently offers a patchwork regional and national policies incentivising the deployment of zero-emissions HDTs. Many of these are short-term and reviewed regularly, such as a US$3,900 purchase subsidy for e-trucks available nationally until 2023 and an additional $3,300 credit available in Guangdong province until 2025. These subsidies, though modest in size, are sufficient to hasten TCO

[ix] Efforts are under way to develop EU targets for the installation of hydrogen refuelling infrastructure, but purchase incentives for HETs are not yet in place.

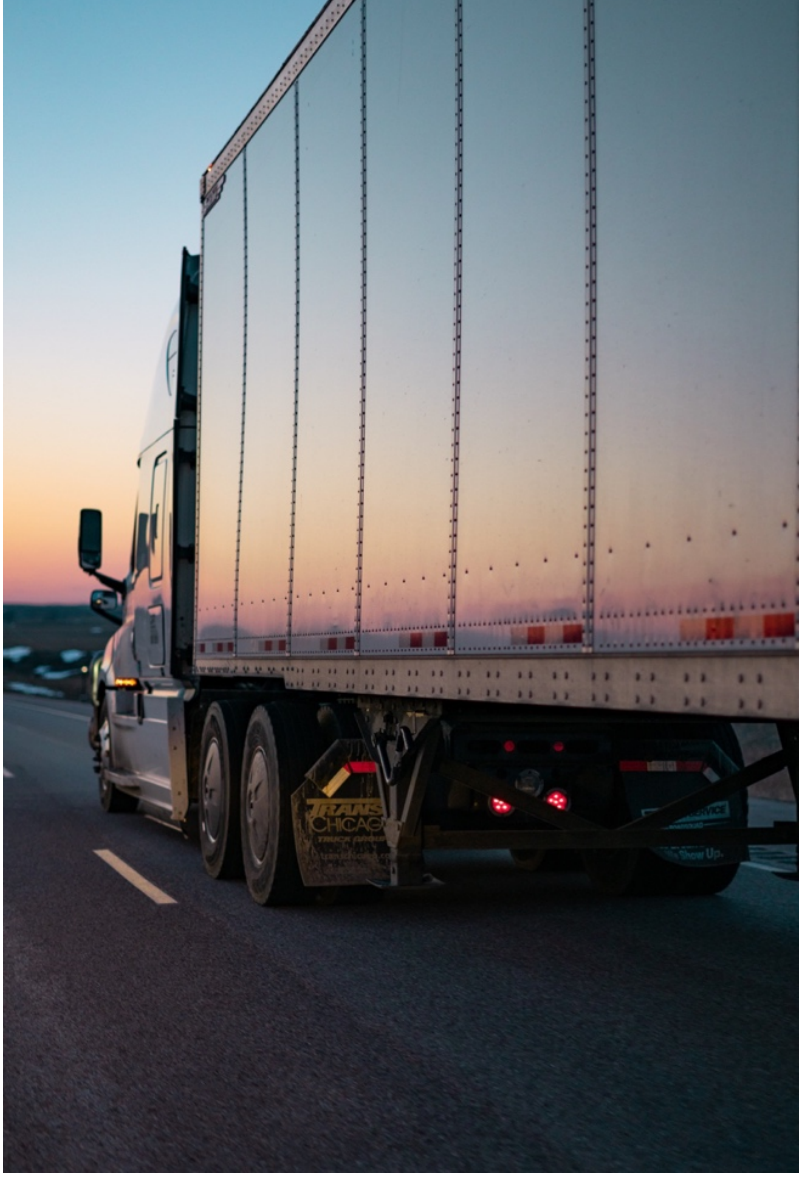
parity for urban and regional HDTs by one to two years in some provinces, but they are not long-term enough to impact long-haul HDTs.

However, government investments in novel technologies such as battery-swapping stations could significantly change the operational economics of long-haul journeys. For example, Hainan province offers upwards of $500,000 per project for these sites, and Chongqing offers approximately $112,000. Like new battery chemistries, adoption of this technology is unpredictable (and hence not modelled), but it could enable time savings compared with conventional battery charging, allowing for greater daily mileage, smaller batteries, and overall reductions in TCO.

China's policies also include more significant subsidies for HETs than are available in other regions. These include purchase incentives, which can exceed $100,000 per truck, and incentives of up to $700,000 per site for refuelling stations. These policies will likely accelerate the rollout of HETs for use cases that require longer periods between fuelling, but they expire in 2025, before the technology approaches TCO parity.



Section 3: Other Zero-Emissions Trucking Scenarios



Increasing On-Route Charging

Buyers of zero-emissions trucks can lower their total costs by optimising their truck and fuelling strategies in ways that are not possible with diesel trucks. Users can opt for a hydrogen truck that needs little in-depot fuelling infrastructure, an electric truck with a large battery that mostly charges at a depot, or an electric truck with a smaller battery that requires more energy on-route.

A truck with a smaller battery requires more charging infrastructure but also has many advantages, including lower vehicle cost, improved efficiency, and increased hauling capacity. In the MPP model, using smaller batteries advances TCO parity for long-haul trucks by one to three years, without policy incentives. With the previously modelled policy incentives, using smaller batteries enables TCO parity for long-haul trucks by 2025.

Although more charging points can lower costs for the industry, they may also create new grid infrastructure costs. The MPP model does not include all the costs incurred by electric utilities and their customers to serve high-speed chargers. Chargers should be sited to minimise grid infrastructure costs and guarantee long-lasting demand to ensure that they do not shift costs from the trucking industry to electric customers.

Green Premiums

Fleet customers with emissions targets may be willing to pay more for deliveries made by zero-emissions trucks, often called a “green premium.” This added revenue could induce some fleets to purchase zero-emissions trucks earlier. A green premium has its greatest impact on early adopter fleets when zero-emissions trucks cost more than diesel trucks. A customer willing to pay an extra US$0.08/km for green fleet operations, or approximately a 5% premium over modelled costs, would accelerate a fleet’s TCO parity date by one year for urban and regional vehicles and two years for long-haul trucks.

Conclusion

The zero-emissions trucking sector looks more promising today than it did just months ago, due to better-than-expected vehicle performance and new government policy. The overperformance of truck makers reaffirms that zero-emissions trucking technology can advance in response to investment and ingenuity. Vehicle incentives will also be very impactful over the next 10 years. While incentives can take many forms, they can play an important role in creating a clear TCO advantage for zero-emissions trucking fleets and locking in a decarbonised trajectory. Subsidies in the United States, Germany, France, the EU, and China further strengthen the case for zero-emissions trucks in the short term while reducing total industry costs in the long term and avoiding carbon emissions. Long-lasting policies like the IRA provide a stronger investment signal than one- to two-year incentives, encouraging more buy-in from fleets, infrastructure providers, and vehicle manufacturers. All policies should be calibrated to meet trucking goals while minimising costs to taxpayers and electric customers. Although the trucking industry faces challenges in decarbonisation, the path forward is clearer. New policies and continued advances in vehicle performance can make a difficult path considerably smoother.