THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

JANUARY 2025

Vision 2050

Update on the global zero-emission vehicle transition in 2024

ARIJIT SEN, JACOB TETER, AND JOSH MILLER

ACKNOWLEDGMENTS

This study was generously supported by the Crux Alliance. The authors thank all colleagues who contributed to this study, with special thanks to Ruolin Zhang for developments to ICCT's Roadmap model and Ilma Fadil, Irem Kok and Yihao Xie for providing supporting data and helpful reviews.

International Council on Clean Transportation
1500 K Street NW, Suite 650
Washington, DC 20005

communications@theicct.org | www.theicct.org | @TheICCT

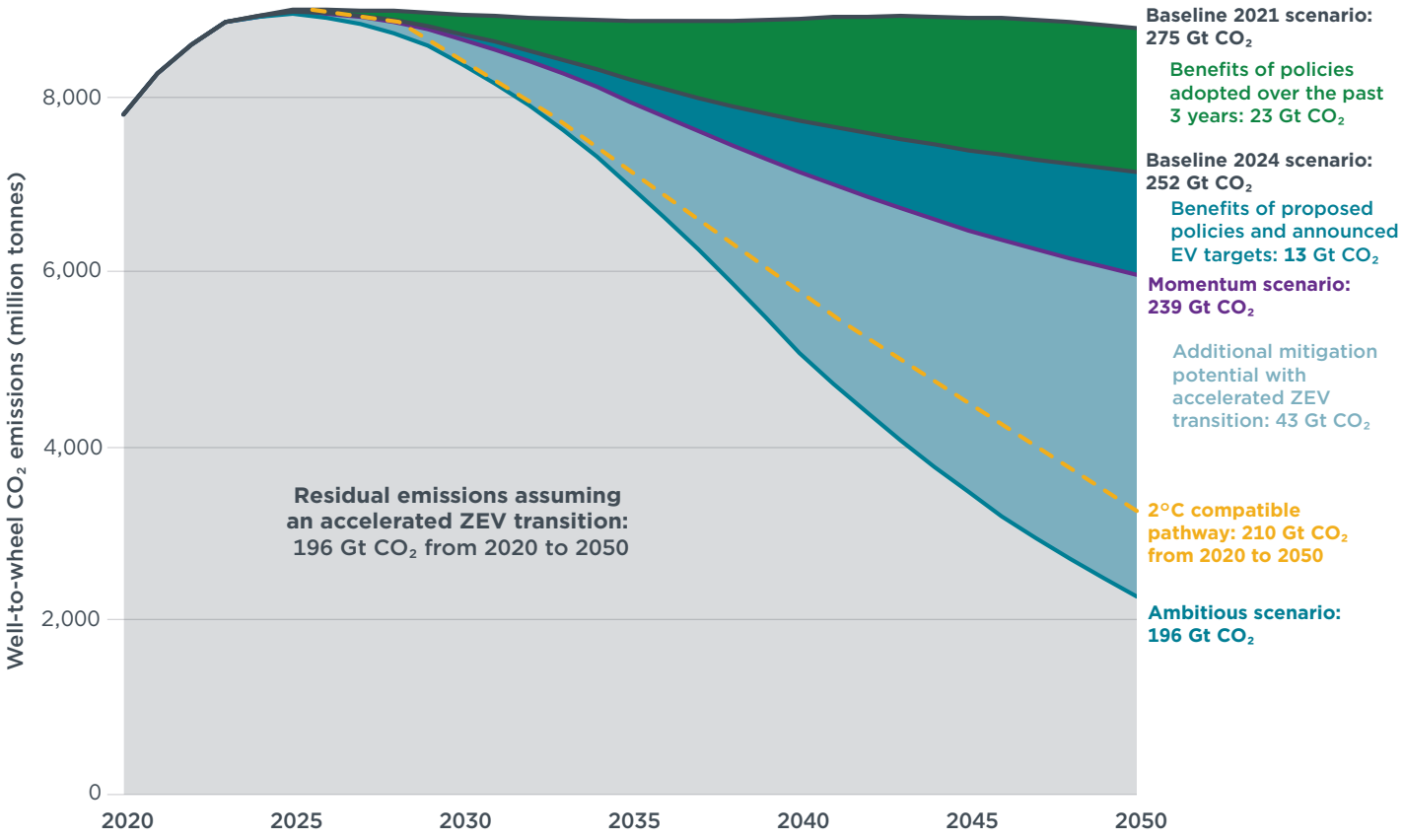
EXECUTIVE SUMMARY

Global greenhouse gas emissions must decline rapidly to limit warming to well below 2 °C, as agreed under the Paris Agreement. The road transport sector, which accounts for more than one fifth of global carbon dioxide (CO_2) emissions, offers significant opportunities for emissions reduction through the transition to zero-emission vehicles (ZEVs). Multiple major economies have recently adopted regulations aligned with reaching 100% ZEV or electric vehicle (EV) sales for new cars and vans by 2035, signaling growing momentum for this transition.

This study updates our annual assessment of global ZEV policies and market developments, analyzing their impact on projected vehicle sales, energy consumption, and emissions through 2050. In addition to policies in the Baseline scenarios designed in our previous studies (Baseline 2021 and Baseline 2023), we evaluate three updated scenarios: a Baseline 2024 scenario incorporating policies adopted through August 2024, a Momentum scenario that includes additional proposed policies and targets, and an Ambitious scenario aligned with Paris Agreement goals. The analysis reveals how recent policy developments have substantially increased projected ZEV uptake and provides insights into remaining gaps with a Paris-compatible emissions trajectory.

Figure ES1

Projected global well-to-wheel CO_2 emissions from road transport compared with an emissions pathway compatible with Paris Agreement goals of keeping warming under 2 °C



THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION **THEICCT.ORG**

Figure ES1 illustrates how policies adopted over the past 3 years have significantly reduced the projected emissions through 2050. The Baseline 2024 scenario shows projected emissions peaking by 2025 and declining thereafter, driven by regulations in major markets that require high ZEV shares for new vehicle sales along with continued market uptake underpinned by the falling costs of ZEVs. This trajectory represents a

marked improvement over the Baseline 2021 scenario, which accounts for policies as of August 2021, avoiding 23 billion tonnes of CO_2 emissions cumulatively through 2050. If governments achieve their stated ambitions (as in the Momentum scenario), cumulative emissions will fall by an additional 13 billion tonnes. However, a significant gap remains between these scenarios and the Paris-aligned Ambitious scenario, which represents a trajectory for global ZEV uptake compatible with limiting warming to well-below 2 °C in combination with other policy measures.

Based on our comprehensive analysis of policy developments, market trends, and emissions trajectories, we draw the following conclusions:

- **Countries and regions are increasingly adopting supply-side vehicle regulations to accelerate ZEV adoption.**
  Since April 2023, such regulations have been adopted in six major vehicle markets, which are increasingly aligned toward achieving 100% ZEV sales for new light-duty vehicles (LDVs) by 2035. For heavy-duty vehicles (HDVs), recently adopted regulations have paved the way for ZEV sales shares of 100% in California by 2036 and 77% in the European Union by 2040.
- **Sales shares of ZEVs grew rapidly in many markets across vehicle segments**.
  Recent trends demonstrate quick market responses across various regions and vehicle segments, with 2022–2023 seeing double-digit increases in ZEV sales shares for cars in Thailand and Vietnam and for buses in Canada, the United Kingdom, and Chile. ZEV sales shares for medium trucks more than doubled year-over-year in the European Union and the United Kingdom over the same period. These developments show that markets can respond swiftly when favorable conditions align.
- **International initiatives continue to build momentum for the global ZEV transition.**
  The ZEV Declaration and Global Memorandum of Understanding on Zero-Emission Medium- and Heavy-Duty Vehicles have garnered new signatories and now represent roughly one quarter of the global new vehicle market. The ZEV Declaration gained three new signatories between April 2023 (Baseline 2023) and August 2024 (Baseline 2024): Colombia, Costa Rica, and Nigeria. The Global HDV MOU added 11 new signatories, including Colombia, Costa Rica, Ethiopia, Ghana, and Mozambique.
- **Global road transport CO_2 emissions and liquid fuels consumption could peak as soon as 2025.**
  In the Baseline 2024 scenario, emission reductions among three of the six largest emitters—the United States, the European Union, and China—are projected to offset emissions growth in other countries. However, these peaks could be delayed if global vehicle activity grows faster than anticipated, if existing policies are weakened, or if ZEV sales slow in major markets without binding policies.
- **Despite significant progress, a gap remains between current commitments and a Paris-aligned ZEV trajectory.**
  For LDVs, recently adopted policies and commitments have nearly halved the ambition gap, in terms of ZEV sales shares projected in 2030, between the Baseline 2021 and Ambitious scenarios. The gap has shrunk by one third for HDVs and by one fifth for two- and three-wheelers. While progress has been substantial, regional disparities persist, with major economies like China, Indonesia, and Brazil showing smaller reductions in their ambition gaps.

To accelerate this progress, policymakers could consider expanding and strengthening supply-side regulations and targets and ensuring these cover all vehicle categories, in addition to supporting ZEV market growth through measures to achieve cost parity with combustion engine vehicles. By building on recent momentum and addressing remaining challenges, the global community can accelerate the ZEV transition and align road transport emissions with Paris Agreement goals.

TABLE OF CONTENTS

Executive summary i

Introduction 1

Methods 2

Data and modeling 2

Scenario definitions 3

Updates to ZEV adoption assumptions in the Baseline scenarios 4

Paris-compatible carbon budgets 6

Key policy developments 7

Proposed and adopted policies 7

Global zero-emission vehicle initiatives 9

Summary of scenario policy changes 10

Historical data and modeling results 11

Historical zero-emission vehicle share of new sales 11

Projected zero-emission vehicle share of new sales 13

Projected zero-emission vehicle share of the in-use stock 16

Road transport energy consumption 17

Well-to-wheel CO_2 emissions 19

Conclusions 21

Uncertainties and future research 22

References 23

Appendix 25

LIST OF FIGURES

Figure ES1. Projected global well-to-wheel CO_2 emissions from road transport compared with an emissions pathway compatible with Paris Agreement goals of keeping warming under 2 °C i

Figure 1. Global well-to-wheel CO_2 emission trajectories for road transport compatible with the goals of the Paris Agreement 6

Figure 2. Historical and projected passenger car EV uptake in selected leading markets with supply-side vehicle regulations 9

Figure 3. Global ZEV share in new sales by scenario and vehicle type, 2023–2050 13

Figure 4. Projected global ZEV share of new vehicle sales in 2030 and the gap between governments' stated ambitions and the Ambitious scenario 15

Figure 5. Global zero-emission and combustion engine vehicle stock projections by vehicle category, 2023–2050 17

Figure 6. Global liquid fuels consumption avoided by ZEV adoption compared with Baseline 2021 scenario 18

Figure 7. Projected global WTW CO_2 emissions from road transport compared with an emissions pathway compatible with 2 °C 19

Figure 8. Cumulative WTW road transport CO_2 emissions (billion tonnes) from major vehicle markets and the rest of the world, 2024–2050, and percent reduction in the ambition gap if governments realize their existing targets 20

LIST OF TABLES

Table 1. Vehicle classifications used in this report 3

Table 2. Estimated timing of upfront price parity and first-owner total cost of ownership parity for battery electric and conventional vehicles 5

Table 3. Baseline zero-emission vehicle sales projections by the ICCT, IEA, and BNEF 5

Table 4. Country signatories to the ZEV Declaration and the Global HDV MOU 10

Table 5. Policy changes to the Baseline 2024 and Momentum scenarios 10

Table 6. Global sales share of new zero-emission vehicle sales by vehicle category, 2022–2023 12

Table 7. Global ZEV sales share of new vehicle sales, share of global stock, and CO_2 emissions shares by vehicle type in 2023 13

Table 8. Impact of recently adopted policies on projected new zero-emission light and heavy vehicle sales shares 16

INTRODUCTION

Tailpipe emissions from on-road vehicles account for a little over 21% of global anthropogenic carbon dioxide emissions (Sen & Miller, 2023). Accelerating the sales of new zero-emission vehicles (ZEVs) is the single most promising strategy to cut global carbon dioxide (CO_2) emissions from road transport and align them with a trajectory compatible with the 2015 Paris Agreement goal of keeping global warming well-below 2 °C (Sen et al., 2023). The pace of the global ZEV transition has accelerated in the past year. In 2023, global electric vehicle (EV) passenger car sales reached 18% of new car sales (International Energy Agency, 2024).[1] The EV sales share of new two- and three-wheelers exceeds that of passenger cars in key markets where these vehicles are most prevalent, such as India. City buses have also reached high EV sales shares in China and Europe. Other vehicle segments, such as light commercial vehicles, coach buses, and medium- and heavy-duty trucks are still in the early stages of electrification, with ZEV sales shares in the single digits.

Many countries, including some of the world's largest economies and CO_2 emitters, have recently established policies and regulations to accelerate the pace of the ZEV transition. These include greenhouse gas (GHG) emission standards for light- and heavy-duty vehicles in the United States (Miller et al., 2024), revised heavy-duty vehicle CO_2 standards in the European Union (Council of the European Union, 2024), ZEV standards for light-duty vehicles in the United Kingdom (The Vehicle Emissions Trading Schemes Order 2023, 2023) and Canada (Environment and Climate Change Canada, 2023), and light-duty vehicle CO_2 standards in Australia (New Vehicle Efficiency Standard Act 2024, 2024). In addition to binding policies, 11 countries signed the Global Memorandum of Understanding on Zero-Emission Medium- and Heavy-Duty Vehicles (Global HDV MOU; Global Commercial Vehicle Drive to Zero, 2024), and three signed the ZEV Declaration pertaining to light-duty vehicles (Accelerating to Zero Coalition, 2023) since April 2023, the cutoff for policies considered in the last iteration of this study. Signatories of these international agreements commit to achieving 100% new ZEV sales by 2040. The impact of these commitments is expected to be substantial.

This report updates a previous ICCT study published in September 2023 (Sen & Miller, 2023). The objective of this series is to track on an annual basis how recently adopted and proposed policies and international commitments compare with the pace of the ZEV transition needed to align with the Paris Agreement. This update considers policy developments from April 2023 through August 2024. As in the previous study, this report features a Baseline scenario that represents the combined effect of market-led developments and adopted policies, a Momentum scenario that considers proposed policies and non-binding targets, and an Ambitious scenario that would align road transport CO_2 emissions with the goal of limiting global warming to well-below 2 °C.

Comparing the policy baseline with those from the previous studies shows the projected emission reductions that could be achieved from recently adopted policies. Comparing this with the Momentum scenario shows the additional benefits that could accrue if countries achieved their announced ambitions, including domestic EV targets and international commitments. Comparison with the Ambitious scenario shows the remaining mitigation potential that could be achieved with increased ambition in countries with existing EV policies and targets and with more countries committing to this transition.

The structure of the report is as follows: First, we outline the methods used to update our analysis, summarizing recent updates to ICCT's Roadmap model, setting out revised assumptions for the market uptake of ZEVs, and calculating the remaining

1 Electric vehicles include battery electric, plug-in hybrid, and hydrogen fuel-cell electric vehicles.

carbon budget for road transport to limit warming to below 2 °C. Next, we outline major policy developments and new signatories to international initiatives since the last iteration of this report was published. We then summarize the impacts of these developments, including on projected ZEV sales shares under each scenario and on projected ZEV shares of the in-use vehicle stock, and the resulting changes in liquid fuels consumption and well-to-wheel (WTW) CO_2 emissions. We conclude with a discussion of key findings and the implications for further efforts to close the gap with a Paris-compatible emissions trajectory. Additional data supporting the results are included in the appendix.

METHODS

DATA AND MODELING

The International Council on Clean Transportation's Roadmap model version 2.6 (International Council on Clean Transportation, 2024) was used in this analysis to calculate historical and projected vehicle sales, turnover, stock, mileage, energy consumption, and CO_2 emissions. The 2023 study used version 2.2 of the Roadmap model, which included data through 2021. Key updates to version 2.6 over the previous version are listed below. More information about these updates can be found in the model documentation.

- Historical data on stock, sales, mileage, and energy intensity were updated through 2023 for all countries using sources such as EV Volumes (n.d.), an ICCT study of EV uptake in major markets (Fadhil & Shen, 2024), Daas Auto, Gasgoo, Segment Y Automotive Intelligence (n.d.), and the International Energy Agency (IEA) Global EV Data Explorer (IEA, 2024b). The previous version of Roadmap had updated data through 2021.
- Historical emissions inventory data were updated for the United States (U.S. Environmental Protection Agency [EPA], 2024a) and the European Union (European Environment Agency, n.d.).
- Historical electricity grid emissions and future projections were updated based on IEA's World Energy Outlook (IEA, 2023).
- Historical energy balances data were updated to align with IEA's World Energy Balances (IEA, 2024d).
- The calculation of survival curves was optimized by employing minimum and maximum average retirement age values by vehicle type, based on internal research. This eliminates vehicles with unreasonable ages from historical stock statistics that may not account for retirements.
- The calculation of average vehicle kilometers traveled was optimized by employing minimum and maximum annual average mileage boundaries for each vehicle type, based on internal research.
- Activity and sales projections were updated. The older versions of Roadmap projected activity based on IEA's 2020 World Energy Outlook (IEA, 2020), EPA's MOVES3 (EPA, 2021) for the United States, the 2020 EU reference scenario (De Vita et al., 2021) for the European Union, and a dedicated market study by the ICCT for India. The revised projections are updated to align with EPA's MOVES4 (EPA, 2023) for the United States and IEA's 2023 World Energy Outlook (IEA, 2023) for other regions, with modifications based on expert judgment.

Throughout this report, road vehicles are classified according to one of two hierarchies—a broad categorization with three groups or a more detailed categorization with six groups—as shown in Table 1. Light-duty vehicles (LDVs) include cars and vans. Heavy-duty vehicles (HDVs) include buses, medium trucks, and heavy trucks.

Table 1

Vehicle classifications used in this report

Vehicle name	Vehicle category	Description
Two- and three-wheelers	Two- and -three wheelers	Mopeds, motorcycles, and three-wheelers
Cars	LDV	Passenger cars (gross vehicle weight [GVW] < 3.5 tonnes)
Vans	LDV	Light commercial vehicles (GVW < 3.5 tonnes)
Buses	HDV	Urban and coach buses and minibuses (GVW ≥ 3.5 tonnes)
Medium trucks	HDV	Medium-duty trucks (GVW 3.5–15 tonnes)
Heavy trucks	HDV	Heavy-duty trucks (GVW > 15 tonnes)

SCENARIO DEFINITIONS

This study analyzes five scenarios of market development and policy considerations: three Baseline scenarios, a Momentum scenario, and an Ambitious scenario.

The three Baseline scenarios represent the projected effects of adopted policies at different points in time: Baseline 2021 includes policies as of August 2021, Baseline 2023 includes policies as of April 2023, and Baseline 2024 includes policies as of August 2024. By comparing these scenarios, we can measure the impact of policies adopted between 2021 and 2024. Baseline 2021 and 2023 were analyzed in the previous studies in this series (Sen & Miller, 2022; 2023) and have been updated based on current market development assumptions and the latest Roadmap data to ensure consistent comparison with Baseline 2024.

All three Baseline scenarios account for the projected effects of adopted policies and anticipated market developments affecting ZEV sales through 2050. As in the two previous studies, the Baseline scenarios are not intended as a forecast of the future, but as a projection of what might happen considering the anticipated pace of market development in the absence of new policies. In this way, the scenarios are intended to serve as a reference against which more ambitious policy scenarios can be evaluated. As described in further detail below, the level of anticipated ZEV adoption in new vehicle sales has changed significantly compared with the assumptions in the 2022 and 2023 studies, which affects all three Baseline scenarios.

The Momentum scenario builds on the Baseline scenarios by considering proposed policies and targets set out in national and subnational government announcements, proposals, ZEV sales and stock targets, and international agreements. The scenario estimates the emissions reduction and ZEV adoption levels that would be achieved if these proposals and targets are adopted.

The Ambitious scenario assumes an accelerated global transition to ZEVs, with countries achieving 100% ZEV sales for two-and-three wheelers and LDVs by 2040 and for HDVs by 2045. Earlier targets are set for major markets, of 2035 for two-and-three wheelers and LDVs and 2040 for HDVs; any country with a more ambitious target in the preceding scenarios is assumed to maintain those targets. Sen and Miller (2022) provides further background on benchmarking these targets against Ambitious ZEV sales share targets developed by other research groups.

All scenarios use IEA's Stated Policies (STEPS) scenario (IEA, 2023) for grid carbon intensity with the exception of the Ambitious scenario, which uses the Net Zero Emissions (NZE) scenario (IEA, 2023), assuming that if countries are ready to phase

out new internal combustion engine (ICE) sales by 2045 or earlier, their electricity grid is also clean by 2050 or earlier.

Updates to ZEV adoption assumptions in the Baseline scenarios

Previous assessments projected ZEV adoption based primarily on regulatory requirements for all markets and assumed very conservative battery electric vehicle (BEV) sales growth beyond these requirements. At early stages of market penetration, the prospects for increasing market shares beyond what was mandated by policy were highly uncertain, and so a conservative approach was warranted. Only in regions where the ICCT had conducted very robust market assessments (namely, North America and the European Union) did the data justify projecting EV adoption beyond regulatory requirements.

Fiscal policies that reduce the upfront price differential between battery electric and conventional vehicles, whether by increasing taxation on internal combustion engine vehicles or providing subsidies or tax rebates for BEVs, will likely still be needed in many countries and contexts to ensure continued adoption. In leading markets, further policies will likely be needed to incorporate equity considerations and expand access to EVs for lower-income households.

However, rising global BEV uptake in the passenger car, two- and three-wheeler, and transit bus segments, together with fast-approaching total cost of ownership (TCO) and purchase price parity between BEVs and conventional vehicles, warrant a less pessimistic view of continued market uptake beyond regulatory requirements. In particular, the rapid uptake of new energy vehicles (NEVs) in China, driven by supportive supply- and demand-side policies across the EV supply chain, has led to NEV market shares above 50%, exceeding the targets set by national-level regulations.[2]

Table 2 shows representative global ranges of expected upfront purchase price and TCO parity in the absence of subsidies or differential taxation across the six vehicle categories modeled in Roadmap.[3] These global ranges draw upon recent price parity analyses and literature reviews conducted by the ICCT and IEA. Within each vehicle type, the parity ranges were extended to account for heterogeneity, for instance in purchase prices of electric versus conventional vehicles across segments in the case of LDVs and operations and duty-cycles for HDVs, and, for TCO parity, in vehicle usage and fuel prices.

2 NEVs include battery electric vehicles, fuel-cell electric vehicles, and plug-in hybrid vehicles.

3 The actual dates of price parity will depend on scale economies in battery manufacturing, continued cost reductions resulting from technology learning and chemistry and design innovations in battery components and cells, and scale economies and innovations in battery pack and electric vehicle assembly, among other variables. TCO parity depends also on the cost of conventional vehicle manufacturing and the relative costs of fuel (gasoline, diesel, compressed natural gas, liquefied natural gas, or liquefied petroleum gas) versus electricity delivered to the EV.

Table 2

Estimated timing of upfront price parity and first-owner total cost of ownership parity for battery electric and conventional vehicles

Vehicle type	Approximate timing of upfront price parity	Approximate timing of total cost of ownership parity[a]
Two- and three-wheelers	Mid – late 2020s; early 2030s	Present – late 2020s
Cars	Mid – late 2020s; early 2030s	Present – early 2030s
Vans	Late 2020s – early 2030s	Present –early 2030s
Urban buses	Early – mid 2030s	Present – late 2020s
Minibuses	Early – mid 2030s	Present – late 2020s
Coaches	Early – late 2030s	Present – mid 2030s
Medium trucks	Early – late 2030s	Present – early 2030s
Heavy trucks	Mid – late 2030s; 2040s	Late 2020s – late 2030s

Note: Roadmap includes minibuses, urban buses, and coaches in the broader vehicle category of buses. The respective shares of buses of these three types vary widely across countries and regions, as does data availability on sales and in-use stock shares.
[a] The first ownership period is typically 5–6 years, and the TCO is assessed without vehicle subsidies.
Sources: ZEV Transition Council (n.d.-a), IEA (2024), and ICCT internal analysis

We have revised our Baseline scenario assumptions to reflect the prospects for continued EV adoption based on the latest market conditions, focusing these revisions on vehicle segments nearing price or TCO parity and where current market adoption is highest, namely two- and three-wheelers, LDVs, and urban transit buses.

Table 3 compares our revised assumptions for the potential market uptake of ZEVs with other modeling efforts. At a global level, our projections of EV sales shares in the two- and three-wheeler segment are more conservative than those of the IEA and Bloomberg NEF (BNEF). Projections of sales shares for cars, buses, and trucks are in line with those of IEA and BNEF, but BNEF sales projections for cars include plug-in hybrid vehicles.

Table 3

Baseline zero-emission vehicle sales share projections by the ICCT, IEA, and BNEF

		China		Europe		USA		India		Global		
		2030	2035	2030	2035	2030	2035	2030	2035	2030	2035	2040
Two- and three-wheelers	**Roadmap**									32%	47%	66%
	IEA STEPS									51%	61%	
	BNEF ETS											90%
Cars	**Roadmap**	46%	56%	60%	92%	45%	72%	10%	20%	37%	52%	58%
	IEA STEPS	57%	77%	44%	83%	45%	59%	18%	25%	36%	50%	
	BNEF ETS									45%		73%
Buses	**Roadmap**	36%	40%	44%	53%	22%	44%	16%	27%	18%	26%	34%
	IEA STEPS	64%	71%	40%	61%	32%	59%	34%	60%	15%	26%	
Trucks	**Roadmap**	22%	25%	19%	27%	36%	57%	1%	3%	16%	21%	25%
	IEA STEPS	28%	45%	21%	31%	19%	47%	1%	2%	11%	21%	

Notes: IEA STEPS projections shown here were released in April 2024, and hence precede the adoption of the EPA multi-pollutant emissions standards and the Phase 3 GHG standards for HDVs in the United States and the CO_2 emissions standards for HDVs in the European Union. Europe includes EU and non-EU European countries. The shading in the table highlights higher sales shares.
[a] BNEF projections include BEVs and PHEVs; IEA sales percentages have been corrected to include only BEV and fuel-cell electric vehicle sales shares.
Sources: IEA (2024), International Energy Agency (2024a), and BNEF (2024).

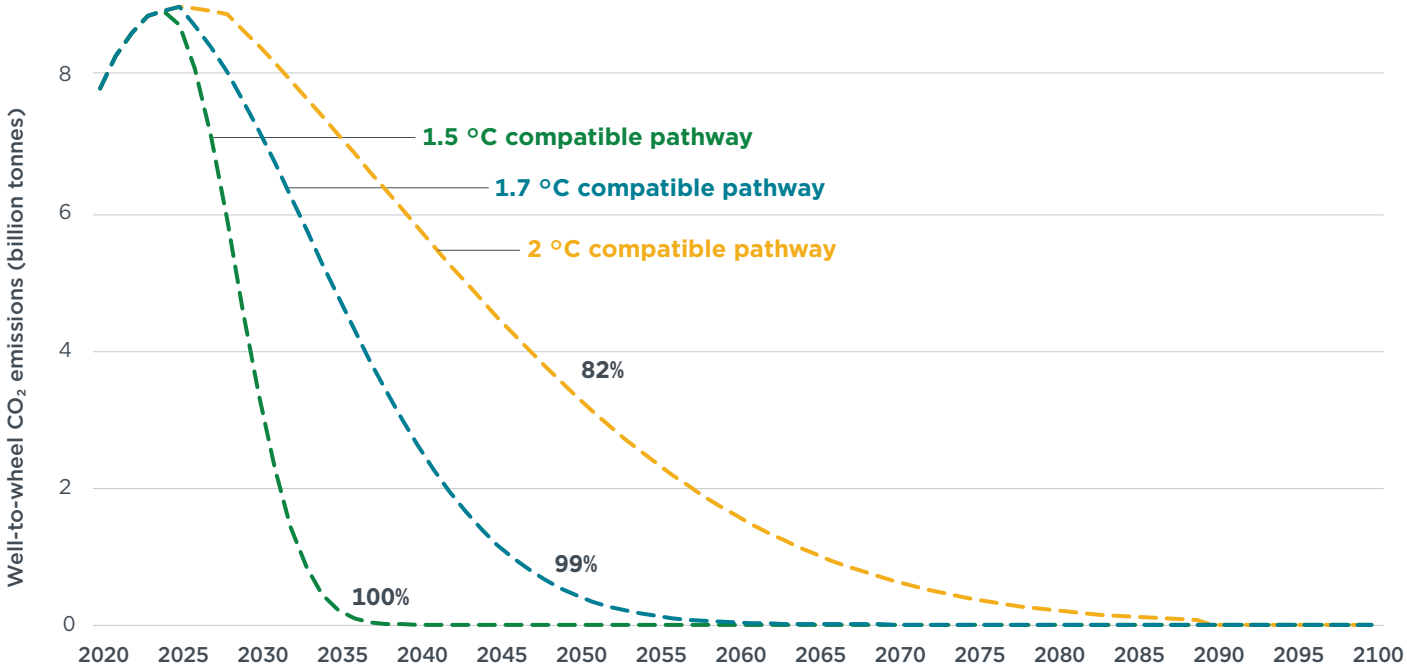
As summarized above, earlier Baseline scenarios were also revised to reflect this less pessimistic view on the prospects for ZEVs to gain market share beyond the targets set by regulatory policies, such that comparisons of Baseline scenarios isolate the impacts of recently adopted policies as opposed to reflecting changes in market expectations.

PARIS-COMPATIBLE CARBON BUDGETS

Figure 1 shows three CO_2 emission trajectories for road transport compatible with the goals of the Paris Agreement. These trajectories assume that road transport uses a share of the remaining global carbon budget that is equal to its share of global anthropogenic CO_2 emissions in 2023: 21.6%, considering WTW emissions. The resulting trajectories are based on CO_2 emissions budgets that would limit the temperature rise with 67% probability.[4]

Figure 1

Global well-to-wheel CO_2 emission trajectories for road transport compatible with the goals of the Paris Agreement



Note: Percentages indicate the share of the emission budget from January 1, 2024, onwards that would be exhausted by 2050 under each illustrative emissions pathway.

These trajectories aim to account for the inertia in road transport emissions stemming from the fact that new vehicles sold today are likely to stay in the fleet for at least a decade, after which emissions decline rapidly to reflect the reductions that could be achieved by transitioning to ZEVs. Prior studies have found that accelerating ZEV uptake could align road transport with a 2 °C trajectory; however, cutting road sector emissions to align with the 1.7 °C or 1.5 °C trajectories would require fleet renewal policies designed to curtail the operational lifetime of vehicles currently on the road, as well as other demand-side reduction measures (Sen et al., 2023; BNEF, 2024).

4 Remaining anthropogenic CO_2 emissions budgets needed to limit global average temperature rise by 2100 were taken from Table 5.8 of the Intergovernmental Panel on Climate Change (2021) Sixth Assessment Report. Cumulative emissions from January 1, 2020, through January 1, 2024, were deducted based on estimates from Friedlingstein et al. (2023).

KEY POLICY DEVELOPMENTS

PROPOSED AND ADOPTED POLICIES

A brief description of policies adopted or proposed between April 2023 and August 2024 and considered in the updated scenario analysis is provided below. The Baseline scenarios consider adopted policies, whereas the Momentum scenario additionally considers proposed policies and non-binding targets, including those set forth in international agreements and initiatives. Further details on these policies can be found on the ZEV Transition Council (n.d.-b) website.

- **Australia**: The New Vehicle Efficiency Standard sets annual CO_2 emission targets from 2025 to 2029. The targets apply to new passenger cars, sport utility vehicles, utility vehicles, and vans, and are measured using the New European Driving Cycle test procedure (New Vehicle Efficiency Standard Act 2024, 2024). (*New in the Baseline 2024 scenario*)
- **Canada**: The Electric Vehicle Availability Standard includes regulated targets for ZEVs that set increasing annual LDV sales share requirements of 20% by 2026, 60% by 2030, and 100% by 2035 (Environment and Climate Change Canada, 2023). (*Moved from the Momentum scenario to the Baseline 2024 scenario*)
- **China**: The State Council released a document stating that China aims to achieve a goal for 45% of new vehicle sales to be NEVs by 2027 (Central Committee of the Communist Party of China & China State Council, 2024). In addition, several provinces announced NEV targets as part of their carbon peaking implementation plans, or in the context of the central government's "Beautiful China Policy" (Central Committee of the Communist Party of China & China State Council, 2024). (*New in the Momentum scenario*)
- **European Union**: CO_2 emissions standards for HDVs expand the scope of vehicle classes covered compared with the previous standards and require a 45% CO_2 reduction by 2030, a 65% reduction by 2035, and a 90% reduction by 2040 (Council of the European Union, 2024). The previous standards required a 15% CO_2 reduction by 2025 and a 30% reduction by 2030. (*Moved from the Momentum scenario to the Baseline 2024 scenario*)
- **India**: India's Bureau of Energy Efficiency has shared a draft of future corporate average fuel economy (CAFE) III and IV standards for light-duty passenger vehicles with relevant stakeholders to seek their comments. The proposed standards cover model years 2027–2032 and 2032–2037, respectively, and target CO_2 emissions of 91.7 gCO_2/km and 70 gCO_2/km as measured over the Worldwide harmonized Light vehicles Test Procedure test cycle (Bureau of Energy Efficiency, 2024). (*New in the Momentum scenario*)
- **New Zealand**: The Ministry of Transport has eased its Clean Car Standard and nominally aligned it with Australia's. However, the updated CO_2 emissions standard applies the three-phase Worldwide harmonized Light vehicles Test Procedure test cycle, while Australia's standard is measured according to the New European Driving Cycle test (Gibson, 2024). (*Updated in the Baseline 2024 scenario*)
- **United Kingdom**: The Department for Transport's ZEV regulation and CO_2 emissions regulation for new cars and vans sets annual ZEV sales share requirements from 2024 and requires that 80% of new cars and 70% of new vans sold be ZEVs by 2030. Alongside the ZEV regulation, CO_2 standards for non-ZEV cars and vans aim to ensure that the average emissions of new non-ZEVs do not increase (The Vehicle Emissions Trading Schemes Order, 2023; The Road Vehicle Carbon Dioxide Emission Performance Standards, 2022). (*Moved from the Momentum scenario to the Baseline 2024 scenario*)

The Department for Transport has proposed a second stage of the ZEV regulation which would require that 100% of new cars and vans be ZEVs by 2035, but this has not yet been adopted (Department for Transport, 2021). (*Retained in the Momentum scenario*)

» **United States**: EPA's multi-pollutant emissions standards set new annual requirements to reduce criteria pollutant and GHG emissions for light- and medium-duty vehicles over model years 2027–2032. EPA projects the standards would achieve a 68% EV sales share for new LDVs by model year 2032 (EPA, 2024c). (*Moved from the Momentum scenario to the Baseline 2024 scenario*) EPA's Phase 3 HDV GHG standards set stronger emissions standards for model years 2027–2032. While the standards are technology-neutral and performance-based, they are expected to lead to increased deployment of electric and other zero-emission drive technologies (EPA, 2024b). (*Moved from the Momentum scenario to the Baseline 2024 scenario*)

At the state level, the number of states that have adopted Advanced Clean Truck or Advanced Clean Cars II standards has been updated as of 2024 (California Air Resources Board, n.d.). (*Updated in the Baseline 2024 scenario*)

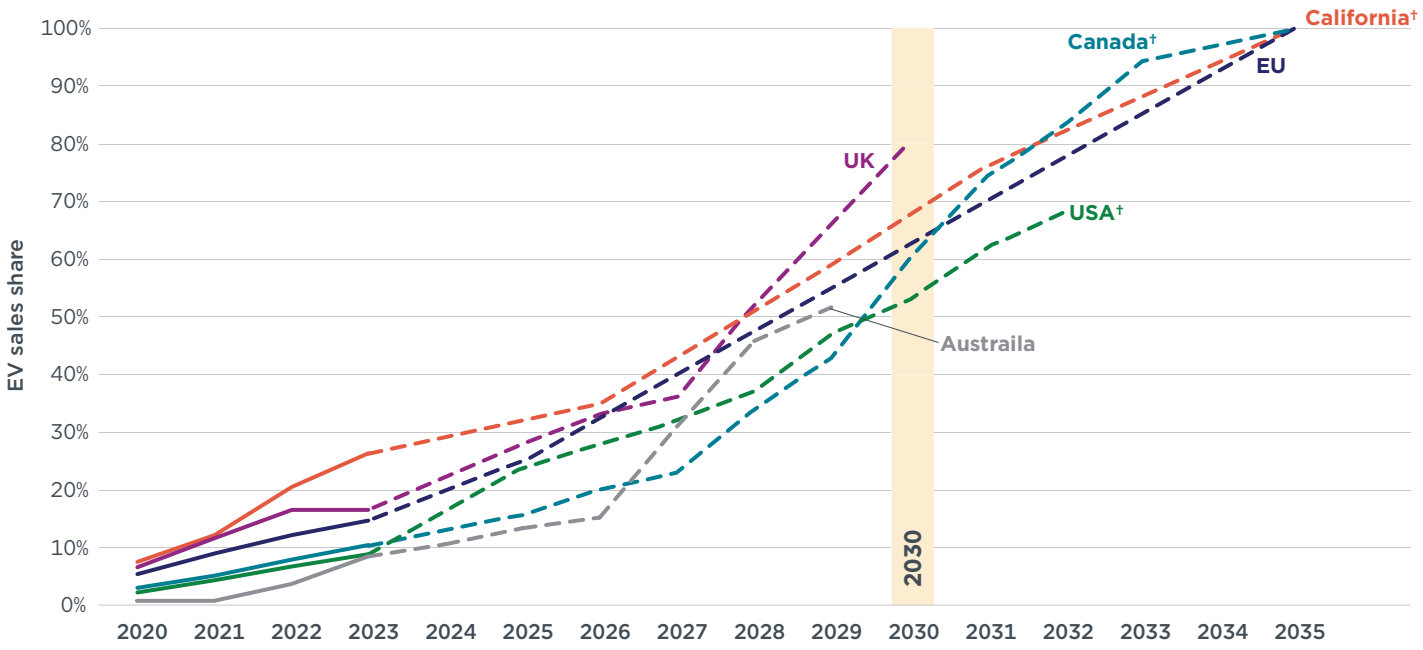
» **Vietnam**: Vietnam's Green Energy Policy targets 100% of road transport using electricity and green energy (which includes hydrogen and biofuels) by 2050. More specifically, it outlines that 100% of new buses should use electricity and green energy by 2025, 100% of new taxis by 2030, and 100% of new cars and two-wheelers by 2040 (Vietnam Action Program on Green Energy, 2022). (*New in the Momentum scenario*)

Other countries whose targets have been tracked since April 2023 include Bangladesh, Cambodia, Cuba, the Dominican Republic, Laos, Malaysia, Panama, Papua New Guinea, the Philippines, the Solomon Islands, and Tonga. The complete list of policies can be found in the policy list worksheet of the supplemental data published with this report, as indicated in the appendix.

EV shares of new car sales, which include PHEVs in select markets, are expected to reach 50%–80% in 2030 across leading markets that have recently adopted or tightened supply-side vehicle regulations. Many of these markets have also adopted other measures like industrial incentives, policies supporting charging infrastructure development, and fiscal incentives for consumers (Figure 2).

Figure 2

Historical and projected passenger car EV uptake in selected leading markets with supply-side vehicle regulations



†Indicates that PHEVs are included in future EV targets for this market.

GLOBAL ZERO-EMISSION VEHICLE INITIATIVES

As of August 2024, 31 national governments had signed the ZEV Declaration, committing to a target of 100% ZEV shares in new LDV (car and van) sales in 2035. This was one more than the number up to April 2023, the cutoff of the previous report. In addition, 12 emerging markets had committed to achieving 100% ZEV shares globally in 2040, two more than in the previous report. Meanwhile, 38 national governments, including eleven new signatories since the April 2023 cutoff, had signed the Global HDV MOU, committing to reaching 30% ZEV shares in new HDV sales by 2030 and 100% ZEV shares in new HDVs by 2040.

Table 4 presents the signatories to both initiatives, with those that signed since the April 2023 cutoff indicated in bold. For each initiative, the table also shows the combined market share of the signatory countries as a percentage of global new LDV and HDV sales. Both ZEV Declaration and Global HDV MOU commitments are considered in the Momentum scenario.

Table 4

Country signatories to the ZEV Declaration and the Global HDV MOU

Initiative	Signatories	Combined market share in 2023
ZEV Declaration National Governments	Austria, Azerbaijan, Belgium, Canada, Cabo Verde, Chile, **Colombia**, Croatia, Cyprus, Denmark, El Salvador, Finland, France, Greece, Iceland, Ireland, Israel, Liechtenstein, Lithuania, Luxembourg, Malta, Netherlands, New Zealand, Norway, Poland, Slovenia, Spain, Sweden, The Holy See, United Kingdom, Uruguay	14% (LDV)
ZEV Declaration Emerging Markets	Armenia, **Costa Rica**, Dominican Republic, Ghana, India, Kenya, Mexico, Morocco, **Nigeria**, Paraguay, Türkiye, Ukraine	9% (LDV)
Global HDV MOU	Aruba, Austria, Belgium, **Cabo Verde**, Canada, Chile, **Colombia**, **Costa Rica**, Croatia, Curaçao, Denmark, Dominican Republic, **Ethiopia**, Finland, **Ghana**, **Iceland**, Ireland, **Israel**, Liechtenstein, Lithuania, Luxembourg, **Mozambique**, Netherlands, New Zealand, Norway, **Papua New Guinea**, Portugal, Scotland, **Seychelles**, Sint Maarten, Switzerland, **Tonga**, Türkiye, Ukraine, United Kingdom Uruguay, United States, Wales	27% (HDV)

Note: Countries in bold signed after April 2023.

SUMMARY OF SCENARIO POLICY CHANGES

Table 5 summarizes the changes and additions made to the Baseline and Momentum scenarios to reflect changes in policies.

Table 5

Policy changes to the Baseline 2024 and Momentum scenarios

	Light-duty vehicles	Heavy-duty vehicles
Added to or updated in Baseline 2024	• **Australia:** New Vehicle Efficiency Standard Act • **United States:** Two states (Maine and Connecticut) no longer apply Advanced Clean Cars II rule • **New Zealand:** Regulations to harmonize closely with Australia's New Vehicle Efficiency Standard • **European Union:** Reduced adoption of PHEVs, based on adoption of on-board fuel consumption measurements and utility factor regulations	
Moved from Momentum to Baseline 2024	• **Canada:** Electric Vehicle Availability Standard	• **European Union:** HDV CO_2 emissions standards
	• **United Kingdom:** ZEV regulation and CO_2 regulation	• **United States:** Phase 3 HDV GHG standards, updated Advanced Clean Truck states
	• **United States:** Multipollutant emissions standard, updated Advanced Clean Cars II states	
Added to Momentum	• **India:** CAFE III/IV proposal	
	• New signatories to the ZEV Declaration: **Colombia, Costa Rica, Nigeria** • Updated policies on ZEV adoption: **China, Vietnam**	• New signatories to the Global MOU: **Cabo Verde, Colombia, Costa Rica, Ethiopia, Ghana, Iceland, Israel, Mozambique, Papua New Guinea, Seychelles, Tonga**

HISTORICAL DATA AND MODELING RESULTS

HISTORICAL ZERO-EMISSION VEHICLE SHARE OF NEW SALES

Globally, between 2022 and 2023, ZEV sales shares—considering BEVs and hydrogen fuel-cell electric vehicles (FCEVs)—increased across all major vehicle types except two- and three-wheelers and buses (Table 6). This follows a multi-year trend in ZEV sales share growth that is expected to accelerate over the coming decade.

The LDV segment saw increases in ZEV sales shares across most major markets. For cars, the global ZEV sales share grew by 2.2 percentage points, from 9.6% in 2022 to 11.8% in 2023, a slower rate than the 3.6 percentage-point increase from 2021 to 2022. Growth was particularly strong in Thailand, where the ZEV sales share for cars increased from 2.2% in 2022 to 15.4% in 2023, and in Vietnam, where it increased from 2.6% to 10.6%. The ZEV sales share for cars also increased in the European Union, from 11.9% to 13.6%. However, declines were observed in other European countries, where the share decreased from 13.3% to 10.3%. For vans, the global ZEV sales share rose by 1.4 percentage points, from 3.5% to 4.9%. In the European Union, ZEV sales shares are expected to reach 20%–28% to comply with the 2025 CO_2 standards, which require a 15% reduction in CO_2 emissions compared with 2021 (ZEV Transition Council, n.d.-b).

Sales shares of zero-emission buses reached double-digits in key markets such as Canada (increasing from 6.3% to 22.6%) and the United Kingdom (from 7.1% to 17.1%). The largest percentage-point increase was in Chile, where the share grew from 10.1% to 38.7%. The medium truck market saw moderate growth in ZEV sales share globally (from 1.9% in 2022 to 2.2% in 2023) with more pronounced increases in certain markets, like the European Union (from 2.4% to 5.7%) and the United Kingdom (4.3% to 10.5%; (ZEV Transition Council, n.d.-b). The ZEV sales share for heavy trucks also grew modestly, with China being the only market to exceed a sales share of 1% (5.7% in both 2022 and 2023) and accounting for a significant portion of global heavy truck ZEV sales. Sales shares of zero-emission heavy trucks in the United States decreased slightly from 0.4% to 0.3% in 2023 (ZEV Transition Council, n.d.-b).

For the second year in a row, zero-emission two- and three-wheeler sales shares declined in China, dropping from 42.3% in 2022 to 33.1% in 2023. This decreased the global average sales share, as China accounted for 31% sales. As was the case in 2023, this is likely due to continuing supply chain disruptions related to China's 2022 zero-COVID policies (IEA, 2024c). Despite this, the global ZEV sales share for two- and three-wheelers decreased only slightly, from 15.7% in 2022 to 13.3% in 2023.

Table 6

Global sales share of new zero-emission vehicle sales by vehicle category, 2022–2023

	2- and 3-wheelers		Cars		Vans		Medium trucks		Heavy trucks		Buses	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
Africa	0.2%	0.4%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Australia	2.1%	5.8%	3.7%	8.5%	1.8%	4.3%	0.1%	0.4%	0.1%	0.2%	0.0%	1.5%
Brazil	0.3%	0.3%	0.5%	1.1%	0.2%	0.2%	1.6%	1.4%	0.0%	0.1%	1.7%	0.5%
Canada	0.2%	0.1%	7.7%	8.3%	6.5%	3.1%	0.7%	1.7%	0.4%	0.2%	6.3%	22.6%
Chile	2.0%	6.0%	0.5%	0.6%	0.1%	0.3%	1.1%	1.4%	0.0%	0.0%	10.1%	38.7%
China	42.3%	33.1	19.8%	22.7%	6.9%	15.8%	6.4%	7.6%	5.7%	5.7%	31.4%	41.5%*
Colombia	0.0%	0.2%	0.8%	2.3%	0.5%	1.1%	0.0%	0.0%	0.1%	0.1%	9.1%	4.7%
EU	11.1%	7.3%	11.9%	13.6%	5.0%	6.7%	2.4%	5.7%	0.4%	0.8%	12.3%	13.3%
India	5.4%	6.9%	1.4%	2.5%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	2.1%	2.5%
Indonesia	2.2%	1.0%	1.4%	2.2%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	1.1%	0.8%
Japan	3.4%	4.8%	1.6%	2.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	1.5%
Mexico	0.3%	0.5	0.4%	1.0%	0.3%	0.6%	0.0%	0.1%	0.1%	0.1%	0.0%	4.7%
Middle East	1.6%	5.4%	1.3%	2.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.7%	1.1%
New Zealand	6.8%	6.7%	13.5%	18.9%	0.9%	1.4%	0.2%	0.4%	0.0%	0.3%	6.0%	5.1%
South Korea	2.8%	4.7%	8.7%	8.0%	15.4%	17.6%	0.0%	0.0%	0.1%	0.0%	0.3%	1.1%
Thailand	0.5%	1.2%	2.2%	15.4%	0.0%	0.0%	0.1%	0.1%	0.0%	0.2%	3.5%	2.9%
United Kingdom	5.3%	3.5%	16.6%	16.5%	5.9%	5.9%	4.3%	10.5%	0.3%	0.5%	7.1%	17.1%
United States	0.0%	0.0%	5.9%	7.9%	4.2%	6.7%	0.1%	0.1%	0.1%	0.3%	2.0%	2.8%
Vietnam	8.0%	8.2%	2.6%	10.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Other ASEAN	1.9%	1.6%	0.6%	1.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Other Europe	5.9%	3.1%	13.3%	10.3%	3.6%	3.5%	0.5%	0.5	0.2%	0.3%	1.2%	2.1%
Other Asia Pacific	6.6%	6.9%	1.4%	2.2%	0.1%	0.3%	0.0%	0.0%	0.0%	0.0%	0.4%	0.4%
Other Latin America	0.8%	0.6%	0.7%	0.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%
Global	**15.7%**	**13.3%**	**9.6%**	**11.8%**	**3.5%**	**4.9%**	**1.9%**	**2.2%**	**1.4%**	**1.7%**	**5.4%**	**4.1%**

Note: Sales shares include only BEVs and FCEVs. Shaded cells highlight higher sales shares.
* The ZEV sales share for buses in China in 2023 only considers medium- and heavy-duty buses. Global shares include light buses for China in 2023, which were not included in the 2022 China data.

Table 7 summarizes the status of ZEV adoption in 2023 across the six vehicle types covered in the Roadmap model and puts these into the context of other key metrics for the road vehicle fleet: their share of the global vehicle stock and share of WTW CO_2 emissions. The global ZEV share of new vehicle sales is highest for two- and three-wheelers and cars, having reached double digits in both these vehicle categories, while it was still below 5% for all other vehicle types. Cars accounted for nearly 60% of vehicles on the world's roads and half of total road CO_2 emissions. Collectively, medium and heavy trucks accounted for more than 30% of road CO_2 emissions, but global ZEV sales shares for these vehicle types were both less than 2.5%.

Table 7

Global ZEV sales share of new vehicle sales, share of global stock, and CO_2 emissions shares by vehicle type in 2023

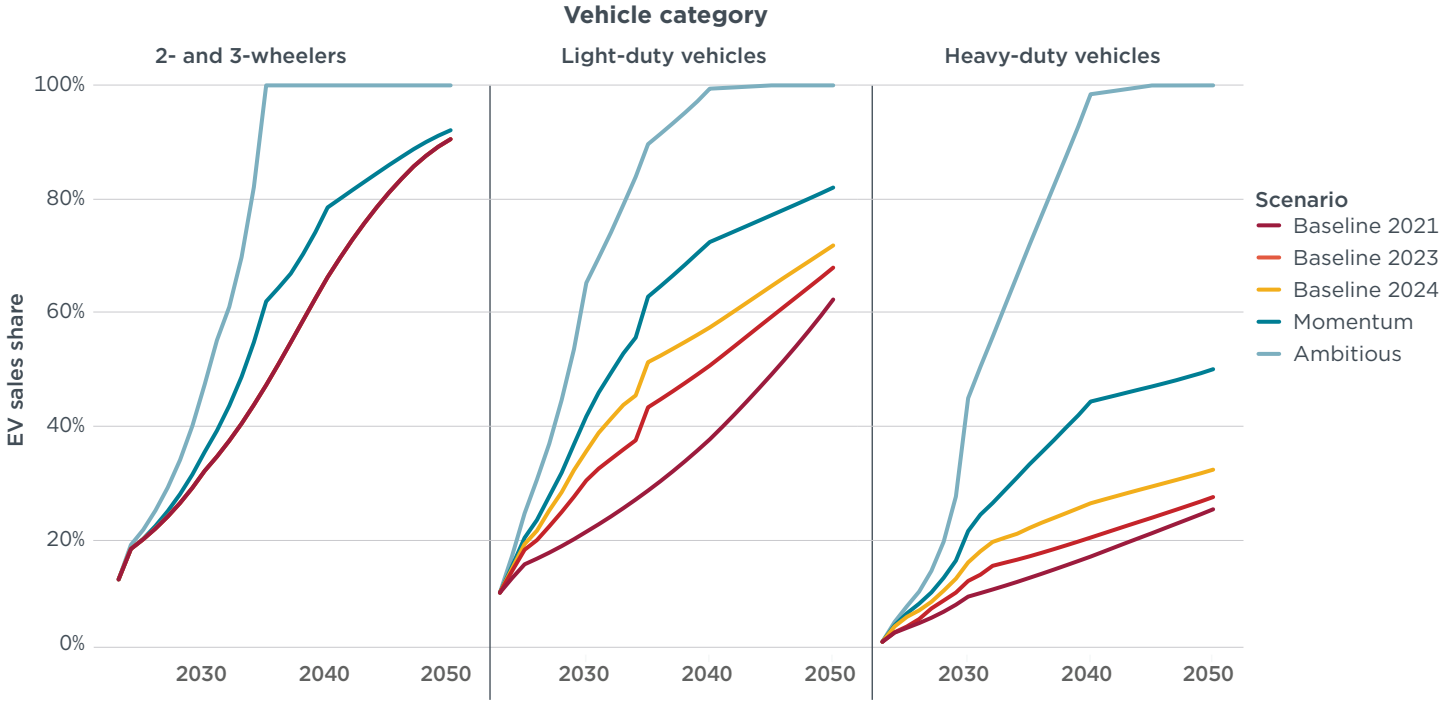
Vehicle type	ZEV share of new vehicle sales	Share of global vehicle stock	Share of road transport well-to-wheel CO_2 emissions
Two- and three-wheelers	13%	28%	3%
Cars	12%	60%	50%
Vans	5%	7%	10%
Buses	4%	1%	5%
Medium trucks	2%	2%	11%
Heavy trucks	2%	2%	21%
Total	**12%**	**100%**	**100%**

PROJECTED ZERO-EMISSION VEHICLE SHARE OF NEW SALES

Since the first global ZEV transition report, covering policies adopted through August 2021, Baseline scenario projections of ZEV adoption have been consistently updated upwards for LDVs and HDVs as new policies have been enacted (Figure 3). For two- and three-wheelers, the adoption of supply-side vehicle regulations has been limited, and further ZEV uptake is expected to be largely driven by improving TCO and purchase price parity. In contrast, for LDVs and HDVs, the recent adoption of supply-side vehicle regulations in major markets and new commitments to international initiatives like the ZEV Declaration and Global HDV MOU have substantially improved the outlook for global ZEV uptake in our scenarios, especially for the 2030–2040 timeframe.

Figure 3

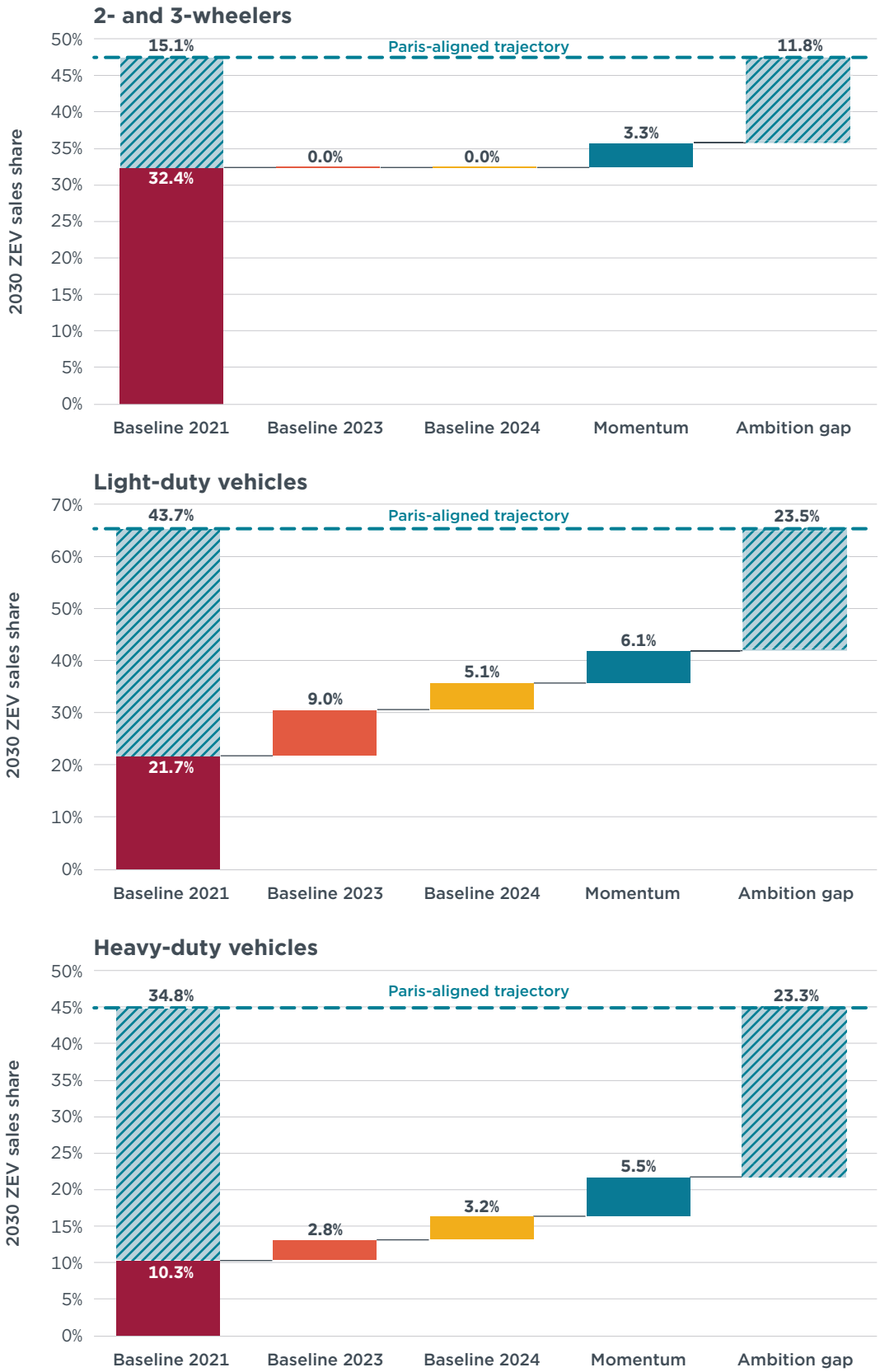
Global ZEV share in new sales by scenario and vehicle type, 2023–2050



As governments continue to adopt new policies and make commitments to accelerate the ZEV transition, the gap between governments' stated ambitions (reflected in the Momentum scenario) and a Paris-aligned ZEV trajectory (in the Ambitious scenario) is shrinking (Figure 4). For LDVs, recently adopted policies and commitments have nearly halved the projected ambition gap for 2030. For HDVs and two- and three-wheelers, the projected ambition gap for 2030 has shrunk by one third and one fifth, respectively. This gap could be further reduced if additional governments make commitments and develop policies to accelerate ZEV uptake, as well as if governments with existing policies and commitments increase the ambition of those measures.

Figure 4

Projected global ZEV share of new vehicle sales in 2030 and the gap between governments' stated ambitions and the Ambitious scenario



Note: The hashed bars show how the gap with the Ambitious scenario has declined compared with the Baseline 2021 scenario after considering recent policy developments and commitments (Momentum scenario).

Table 8 shows how recently adopted supply-side policies in major vehicle markets have substantially increased projected ZEV uptake from the Baseline 2021 to the Baseline 2023 scenario and from the Baseline 2023 to the Baseline 2024 scenario.

Table 8
Impact of recently adopted policies on projected new zero-emission light and heavy vehicle sales shares

Policy development	Vehicle category	Impact on projected ZEV sales share
Baseline 2021 to Baseline 2023		
European Union: CO_2 standards for cars and vans	LDV	18% → 58% in 2030; 24% → 100% in 2035
United States: increasing state-level adoption of Advanced Clean Trucks	HDV	Medium trucks: 9% → 32% nationwide in 2030; Heavy trucks: 6.5% → 12% nationwide in 2030
Baseline 2023 to Baseline 2024		
United States: LDV/MDV multi-pollutant standards	LDV	13% → 46% in 2030
Australia: New Vehicle Efficiency Standard	LDV	13% → 50% in 2030
Canada: Electric Vehicle Availability Standard	LDV	LDVs: 13% → 43% in 2030; Cars: 19% → 70% in 2035 (remainder PHEVs); Vans: 12% → 100% in 2035
United Kingdom: ZEV and CO_2 regulations	LDV	22% → 80% in 2030
European Union: CO_2 standards for HDVs	HDV	5% → 36% in 2030; 8% → 77% in 2040
United States: Phase 3 GHG standards; increasing state-level adoption of Advanced Clean Trucks; California Advanced Clean Fleets	HDV	Buses: 17% → 44% in 2035; Medium trucks: 44% → 61% in 2035; Heavy trucks: 29% → 38% in 2035

PROJECTED ZERO-EMISSION VEHICLE SHARE OF THE IN-USE STOCK

The ZEV share of the in-use vehicle stock tends to lag the trend in ZEV share of new vehicle sales by about a decade. As shown in Figure 4, projected ZEV penetration varies significantly across vehicle categories and scenarios. For two- and three-wheelers, the gap between the Baseline 2024 trajectory and a Paris-aligned trajectory (reflected in the Ambitious scenario) is the smallest; by 2050, ZEVs are expected to account for 75% of two- and three-wheelers on the road in the Baseline 2024 scenario and 98% in the Ambitious scenario.

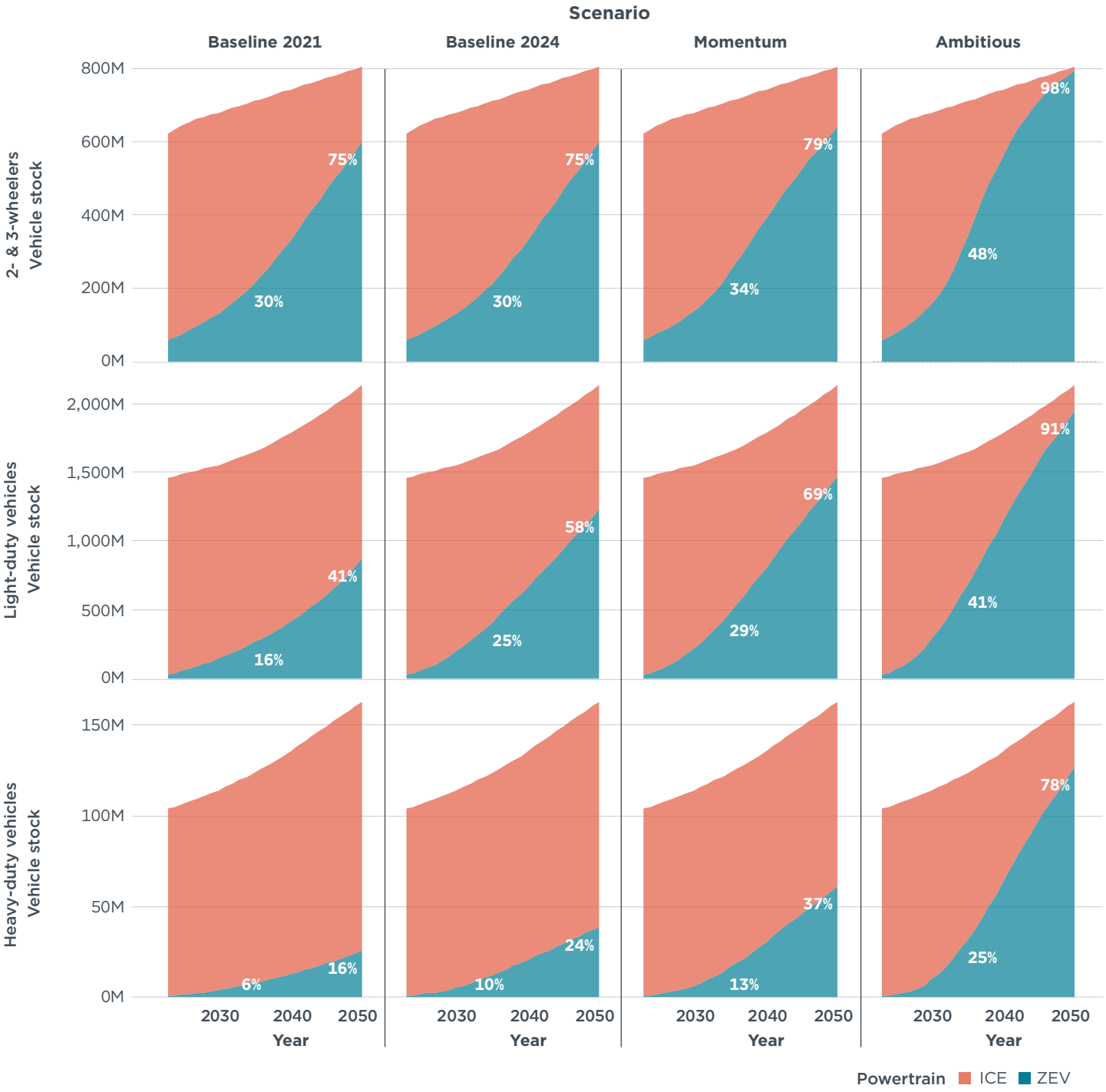
For LDVs, the projected zero-emission share of the vehicle stock has increased substantially due to recent policy developments. The Baseline 2024 scenario projects a 58% ZEV stock share by 2050, up from 41% in the Baseline 2021 scenario. The Momentum scenario, reflecting proposed policies and country commitments under the ZEV Declaration, projects a 69% ZEV stock share by 2050. To align with a Paris-compatible emissions trajectory, the ZEV stock share should exceed 90% by 2050.

HDVs face the widest gap between current policies and a Paris-aligned ZEV trajectory. In the Baseline 2024 scenario, the projected ZEV stock share for HDVs reaches only 24% by 2050. The Momentum scenario, which includes proposed policies and commitments under the Global HDV MOU, increases this share to 37%. However, to align with a Paris-compatible trajectory, the HDV ZEV stock share should reach approximately twice that level, or 78%, by 2050.

These projections highlight the significant progress made in ZEV adoption across all vehicle categories, particularly for LDVs, while also emphasizing the substantial efforts still required to align with a Paris-compatible trajectory, especially in the HDV sector.

Figure 5

Global zero-emission and combustion engine vehicle stock projections by vehicle category, 2023–2050



Note: Data labels show projected global ZEV shares of in-use vehicle stock in 2035 and 2050.

THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION **THEICCT.ORG**

ROAD TRANSPORT ENERGY CONSUMPTION

Globally, road transport consumed 92 exajoules (EJ) of liquid fuels in 2023. Based on policies adopted through August 2021 (reflected in the Baseline 2021 scenario), liquid fuels consumption by road transport would be projected to decline by about 5% by 2050 (Figure 6). In this scenario, increases in liquid fuels demand due to growth in vehicle activity are offset by vehicle fuel economy improvements and increased EV uptake.

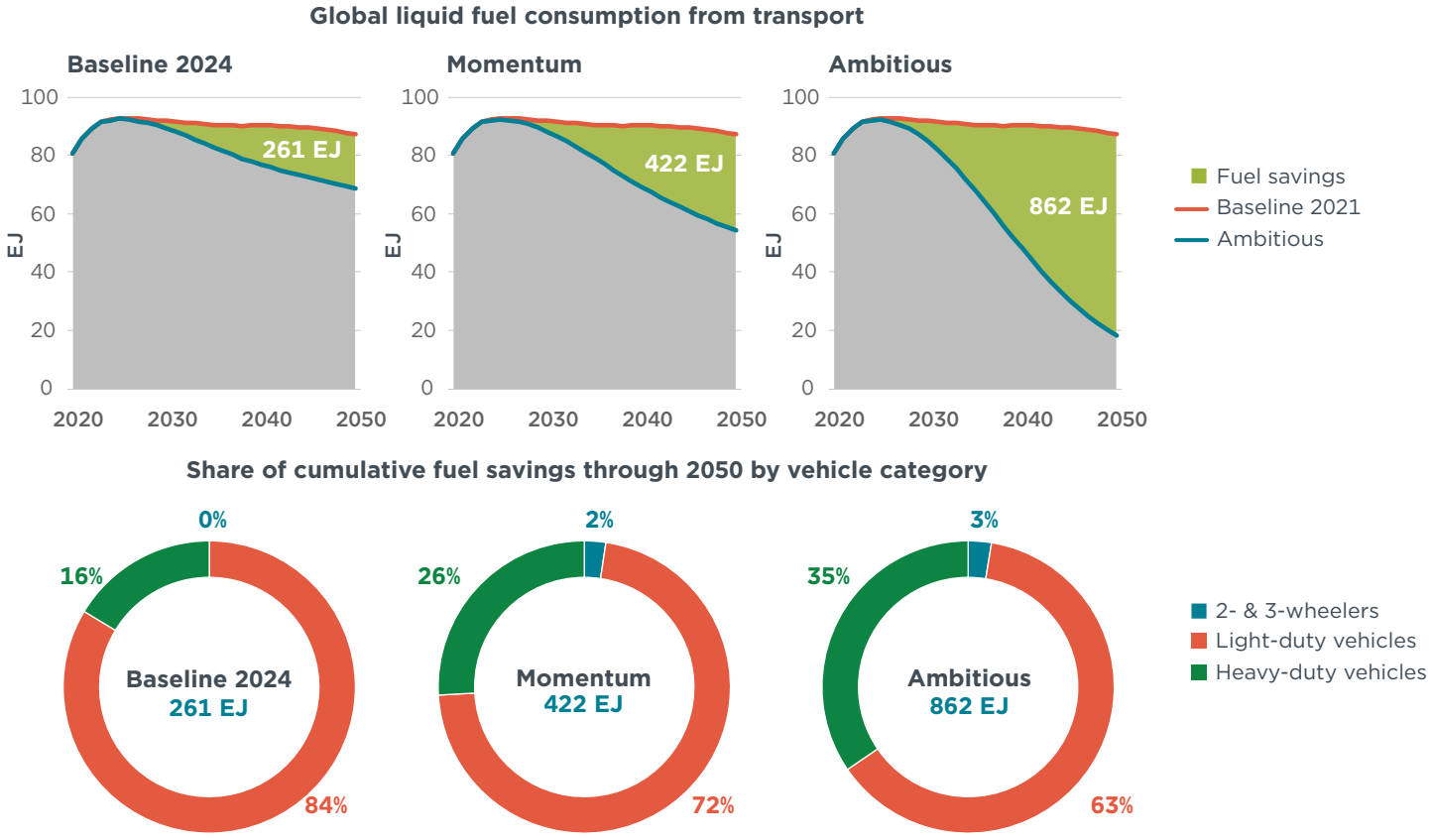
Policies adopted through August 2024 (captured in the Baseline 2024 scenario) are projected to avoid 261 EJ of liquid fuels cumulatively through 2050 compared with

Baseline 2021. This is equivalent to the lifetime fuel consumption of 380 million gasoline-powered passenger cars. For context, the total number of gasoline-powered passenger cars on the road in 2023 is around 1.1 billion. More than 80% of these fuel savings are from policies adopted for LDVs, and the remainder are from HDVs. Under the Baseline 2024 scenario, global liquid fuels consumption for road transport could peak as soon as 2025; however, this could be delayed if global vehicle activity grows faster than anticipated, if existing policies are weakened, or if ZEV sales slow in a major market like China.

If governments were to achieve their current EV ambitions (as in the Momentum scenario), they would save 60% more fuel than in the Baseline 2024 scenario, with the total savings equivalent to 4.6 years of liquid fuels demand from road transport in 2023. HDVs would contribute more than one quarter of these fuel savings, with most of the savings coming from Global HDV MOU signatories.

Closing the ambition gap between the Momentum and Ambitious scenarios would double these savings to 862 EJ, equivalent to saving 9.4 years of liquid fuels demand from road transport in 2023. HDVs would contribute more than one third of these fuel savings, reflecting the greater ambition gap for HDVs than LDVs. Two- and three-wheelers would contribute approximately 3% of these fuel savings, which is smaller than their share of road transport liquid fuels consumption in 2023. This is because two- and three- wheelers are projected to have significant ZEV uptake in the Baseline 2021 scenario, primarily driven by market developments that are expected to result in purchase price parity in the early 2030s.

Figure 6
Global liquid fuels consumption avoided by ZEV adoption compared with Baseline 2021 scenario



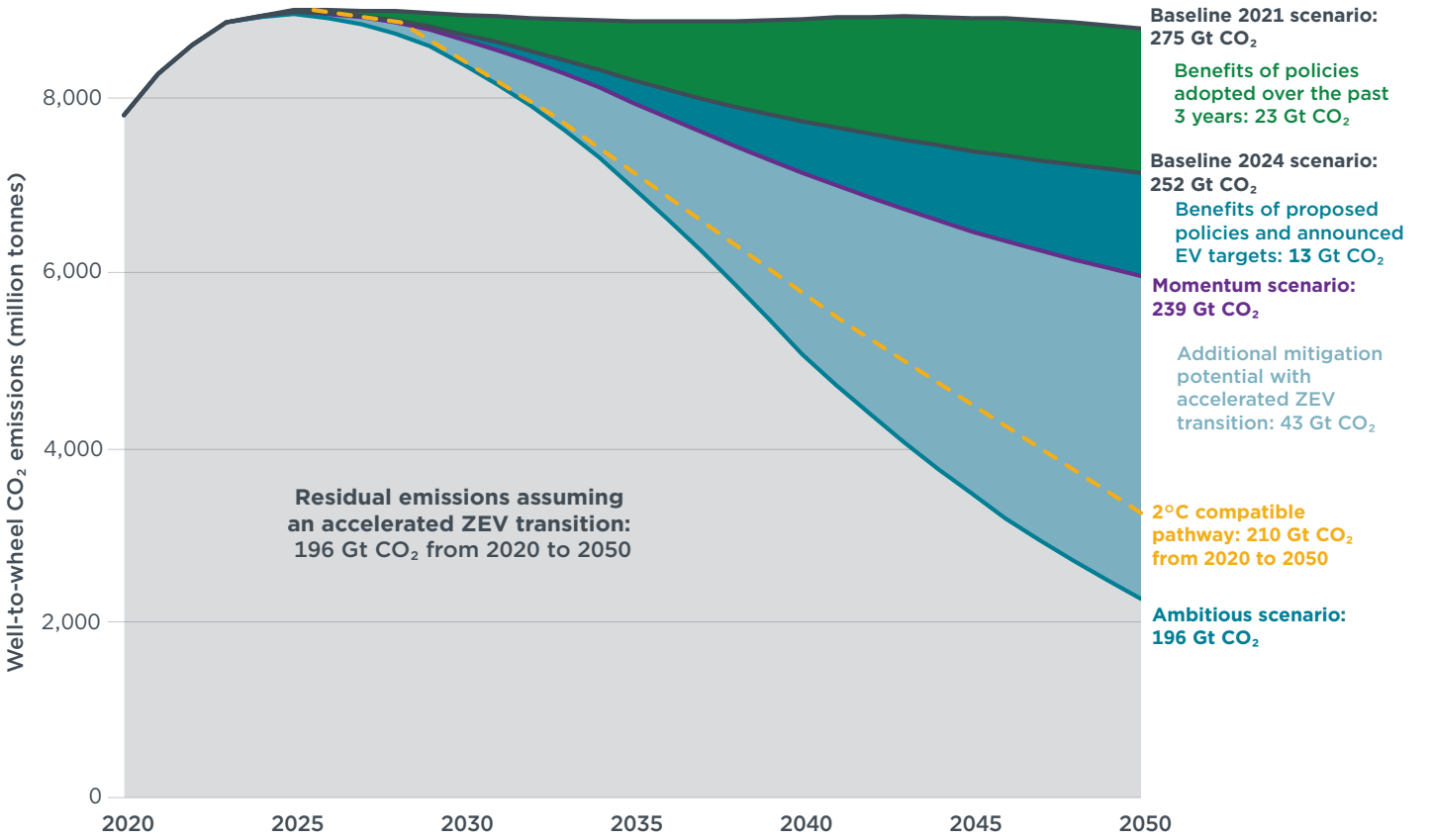
Note: Percentages are rounded to the nearest percent and may not appear to sum to 100%.

WELL-TO-WHEEL CO_2 EMISSIONS

Figure 7 shows the projected global WTW CO_2 emissions under each scenario compared with the 2 °C compatible carbon budget for road transport introduced in Figure 1. Policies adopted over the past 3 years, and the market developments that they have engendered, have led to an estimated reduction in cumulative CO_2 emissions of around 23 billion tonnes. This closes the gap between the Baseline 2021 scenario and the Ambitious scenario by nearly 30%. Realizing proposed policies, targets, and country-level commitments under global ZEV initiatives could cut cumulative CO_2 emissions to 2050 by a further 13 billion tonnes. This would effectively close the gap with the Paris-compliant Ambitious scenario by a further 16%.

Figure 7

Projected global WTW CO_2 emissions from road transport compared with an emissions pathway compatible with 2 °C

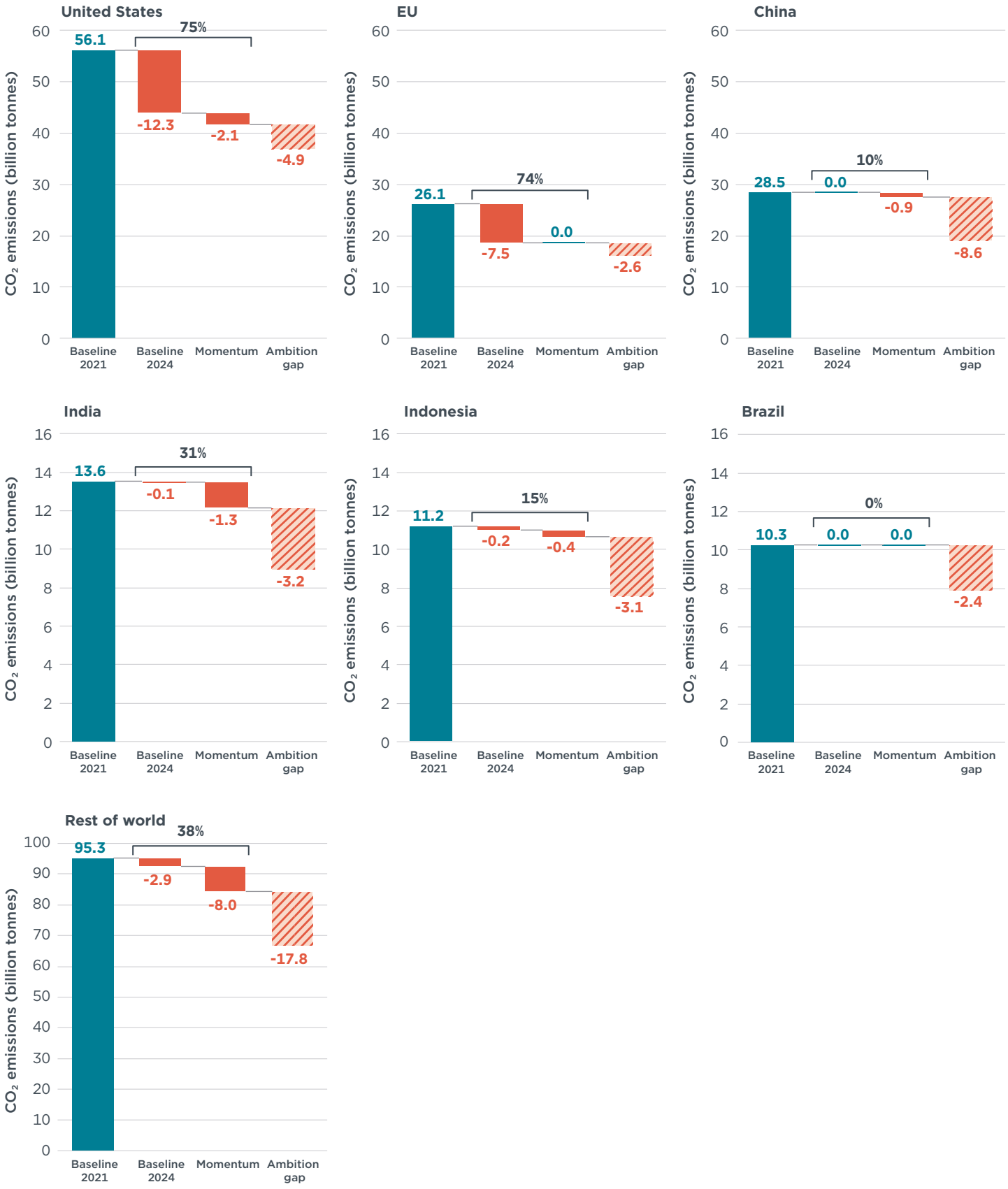


THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION **THEICCT.ORG**

Figure 8 illustrates the projected cumulative road transport CO_2 emissions for major global vehicle markets and the rest of the world from 2024 to 2050 under four different scenarios. The percentage over the bracket for each region indicate the reduction in the ambition gap between the Baseline 2021 and Ambitious scenarios if governments realize their adopted and proposed targets (captured by the Baseline 2024 and Momentum scenario). In the United States and the European Union, recently adopted policies and commitments would eliminate three quarters of the ambition gap. The United States shows the largest potential for further reductions (2.1 Gt CO_2) in the Momentum scenario, reflecting commitments under the Global HDV MOU, followed by India (1.3 Gt CO_2). In contrast, China, Indonesia, and Brazil show smaller reductions in the ambition gap (0%–15%), highlighting opportunities for these countries to propose additional policies and targets to close the gap with a Paris-aligned trajectory. The rest-of-world grouping also demonstrates the potential for considerable progress, with 38% of its ambition gap closed if these countries realize recently proposed policies and targets, though the magnitude of cumulative emission reductions that remain (17.8 Gt CO_2) highlights the opportunity for further emissions reduction in these countries.

Figure 8

Cumulative WTW road transport CO_2 emissions (billion tonnes) from major vehicle markets and the rest of the world, 2024–2050, and percent reduction in the ambition gap if governments realize their existing targets



Note: Hashed bars show the remaining ambition gap after considering governments' stated ambitions (Momentum versus Ambitious scenario).

CONCLUSIONS

This report is the third iteration of global modeling studies that ICCT has conducted to monitor the progress of the global ZEV transition since 2021. This study updates historical data though 2023, revises activity projections and market developments incorporating post-COVID realities, and reviews policy developments between April 2023 and August 2024. The global transition to ZEVs has gained significant momentum since our last assessment in 2023, driven by ambitious policies, market developments, and international commitments. This study reveals several key findings:

Countries and regions are increasingly adopting supply-side vehicle regulations to accelerate ZEV adoption. Since April 2023, such regulations have been adopted in six major vehicle markets: Australia, California, Canada, the European Union, the United Kingdom, and the United States. These standards are increasingly aligned toward achieving 100% ZEV or EV sales for new LDVs by 2035 or shortly thereafter. For HDVs, recently adopted regulations have paved the way for 100% ZEV sales in California by 2036 and 77% in the European Union by 2040.

Sales shares of ZEVs grew rapidly in many markets across vehicle segments. Double-digit increases in ZEV sales shares between 2022 and 2023 were observed for cars in Thailand and Vietnam and for buses in Chile, Canada, and the United Kingdom. ZEV sales shares for medium trucks more than doubled year-over-year in the European Union and the United Kingdom over the same period. These developments show that markets can respond swiftly when favorable conditions align.

International initiatives continue to build momentum for the global ZEV transition. The ZEV Declaration and the Global HDV MOU have each garnered new signatories and now represent roughly one quarter of the global new vehicle market for LDVs and HDVs, respectively. The ZEV Declaration gained 3 new signatories since April 2023: Colombia, Costa Rica, and Nigeria. The Global HDV MOU added 11 new signatories, including Colombia, Costa Rica, Ethiopia, Ghana, and Mozambique.

Global road transport CO_2 emissions and liquid fuels consumption could peak as soon as 2025. In the Baseline 2024 scenario, global liquid fuels consumption for road transport could peak as soon as 2025. Road transport CO_2 emission reductions in three of the largest vehicle markets—China, the European Union, and the United States—are projected to offset emissions growth in other countries. This potential early peak represents a significant shift from previous projections and underscores the growing impact of the ZEV transition. However, these peaks could be delayed if global vehicle activity grows faster than anticipated, if existing policies are weakened, or if ZEV sales slow in major markets without binding policies.

Despite significant progress, a gap remains between current commitments and a Paris-aligned ZEV trajectory. We define the initial ambition gap as the difference between the Baseline 2021 and Ambitious scenarios. For LDVs, recently adopted policies and commitments have nearly halved this projected ambition gap for 2030. For HDVs and two- and three-wheelers, the ambition gap for 2030 has shrunk by one third and one fifth, respectively. The global projected HDV ZEV sales share for 2030 will need to double to close the ambition gap.

Compared with the Baseline 2021 scenario, realizing governments' stated ambitions (as in the Momentum scenario) would eliminate nearly half the ambition gap with a Paris-compatible emissions trajectory (captured in the Ambitious scenario), avoiding 36 billion tonnes of CO_2 cumulatively through 2050. Closing the remaining gap between the Momentum and Ambitious scenarios could bring total road transport liquid fuel savings to 862 EJ through 2050. This is equivalent to taking 1.26 billion gasoline-

powered passenger cars off the road, which exceeds the total number of gasoline-powered passenger cars on the road in 2023 (1.1 billion).

While progress has been substantial, regional disparities persist. In the European Union and the United States, recently adopted policies and commitments would eliminate three quarters of the ambition gap. In contrast, Brazil, China, and Indonesia show smaller reductions (0%–15%), highlighting opportunities for these countries to propose additional policies and targets to align with a Paris-compatible trajectory.

To accelerate this progress, policymakers could consider expanding and strengthening supply-side regulations and ZEV targets, particularly in emerging markets, and ensuring supply-side regulations include HDVs and two- and three-wheelers in addition to LDVs. Moreover, establishing fiscal incentives could increase ZEV adoption by bringing forward the dates of total cost of ownership and purchase price parity.

By building on the momentum of recent years and addressing remaining challenges, the global community can accelerate the ZEV transition and make significant strides towards aligning road transport emissions with Paris Agreement goals.

UNCERTAINTIES AND FUTURE RESEARCH

Several uncertainties and limitations should be considered when interpreting these results. The projections are sensitive to assumptions about long-term vehicle activity growth and the pace of market-led ZEV uptake driven by total cost of ownership and purchase price parity with ICE vehicles. Major economic disruptions or geopolitical crises affecting supply chains could delay the transition. In markets with CO_2, GHG, or fuel economy standards, manufacturers' choices between improving conventional vehicle efficiency and increasing ZEV sales add another layer of uncertainty. This study focuses specifically on well-to-wheel emissions and does not address broader lifecycle impacts, though these have been evaluated in another ICCT analysis (Bieker, 2021). Other important considerations, such as the supply and demand for critical minerals used in EVs, will be addressed in forthcoming ICCT studies. While this analysis emphasizes the role of ZEV adoption, complementary measures like avoid and shift strategies, conventional vehicle efficiency improvements, and accelerated fleet renewal could provide additional emissions reductions, as assessed in our previous work examining strategies to align global road transport with Paris Agreement goals (Sen et al., 2023).

REFERENCES

Accelerating to Zero Coalition. (2023). *The Zero Emission Vehicles Declaration*. https://acceleratingtozero.org/the-declaration/

Bureau of Energy Efficiency. (2024). *Inviting comments on the proposal of Future Fuel Efficiency Norms i.e. CAFE-III and CAFE-IV norms.* Ministry of Power, Government of India. https://beeindia.gov.in/sites/default/files/2024-06/Inviting Comments on Proposal of Future CAFE - III and IV.pdf

Bieker, G. (2021). *A global comparison of the life-cycle greenhouse gas emissions of combustion engine and electric passenger cars*. International Council on Clean Transportation. https://theicct.org/publication/a-global-comparison-of-the-life-cycle-greenhouse-gas-emissions-of-combustion-engine-and-electric-passenger-cars/

Bloomberg NEF. (2024). *Electric vehicle outlook 2024*. https://about.bnef.com/electric-vehicle-outlook/

California Air Resources Board. (n.d.). *States that have adopted California's vehicle regulations*. Retrieved [August 31, 2024,] from https://ww2.arb.ca.gov/resources/documents/states-have-adopted-californias-vehicle-regulations

Central Committee of the Communist Party of China & China State Council. (2024, January 11). 关于全面推进美丽中国建设的意见 *[Comprehensively promoting the building of a Beautiful China].* https://www.gov.cn/zhengce/202401/content_6925405.htm

Global Commercial Vehicle Drive to Zero. (2024). *Implementation partners*. https://globaldrivetozero.org/about/implementation-partners/

Council of the European Union. (2024, January 18). *Heavy-duty vehicles: Council and Parliament reach a deal to lower CO_2 emissions from trucks, buses and trailers* [Press release]. https://www.consilium.europa.eu/en/press/press-releases/2024/01/18/heavy-duty-vehicles-council-and-parliament-reach-a-deal-to-lower-CO_2-emissions-from-trucks-buses-and-trailers/

De Vita, A., Capros, P., Paroussos, L., Fragkiadakis, K., Karkatsoulis, P., Höglund-Isaksson, L., Winiwarter, W., Purohit, P., Gómez-Sanabria, A., Rafaj, P., Warnecke, L., Deppermann, A., Gusti, M., Frank, S., Lauri, P., Fulvio, F. di, Florou, A., Kannavou, M., Forsell, N., … Kalokyris, T. (2021). *EU reference scenario 2020: Energy, transport and GHG emissions: Trends to 2050*. Publications Office of the European Union. https://data.europa.eu/doi/10.2833/35750

Department for Transport. (2021). *Heavy goods vehicles: Ending the sale of new non-zero emission models*. https://www.gov.uk/government/consultations/heavy-goods-vehicles-ending-the-sale-of-new-non-zero-emission-models

Environment and Climate Change Canada. (2023, December 19). *New Electric Vehicle Availability Standard will give Canadians better access to more affordable cars and cleaner air* [Press release]. https://www.canada.ca/en/environment-climate-change/news/2023/12/new-electric-vehicle-availability-standard-will-give-canadians-better-access-to-more-affordable-cars-and-cleaner-air.html

European Environment Agency. (n.d.). *EEA greenhouse gases—Data viewer* [Dashboard]. Retrieved [August 31, 2024], from https://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer

EV Volumes. (n.d.). *EV Data Center*. Retrieved [April 30, 2024], from https://www.ev-volumes.com/datacenter/

Fadhil, I., & Shen, C. (2024). *Electric vehicles market monitor for light-duty vehicles: China, Europe, United States, and India, 2023*. International Council on Clean Transportation. https://theicct.org/publication/ev-ldv-major-markets-monitor-2023-may24/

Friedlingstein, P., O'Sullivan, M., Jones, M. W., Andrew, R. M., Bakker, D. C. E., Hauck, J., Landschützer, P., Le Quéré, C., Luijkx, I. T., Peters, G. P., Peters, W., Pongratz, J., Schwingshackl, C., Sitch, S., Canadell, J. G., Ciais, P., Jackson, R. B., Alin, S. R., Anthoni, P., … Zheng, B. (2023). Global carbon budget 2023. *Earth System Science Data*, *15*(12), 5301–5369. https://doi.org/10.5194/essd-15-5301-2023

Gibson, E. (2024, July 9). Government eases "too stringent" Clean Car Standard rules. *Radio New Zealand*. https://www.rnz.co.nz/news/political/521675/government-eases-too-stringent-clean-car-standard-rules

International Council on Clean Transportation. (2024). ICCT Roadmap model v2.6 [Computer software]. https://theicct.github.io/roadmap-doc/versions/v2.6/

International Energy Agency. (2023). *World energy outlook 2023*. https://www.iea.org/reports/world-energy-outlook-2023

International Energy Agency. (2024a). *Global energy and climate model: Documentation - 2024.* https://iea.blob.core.windows.net/assets/89a1aa9a-e1bd-4803-b37b-59d6e7fba1e9/GlobalEnergyandClimateModelDocumentation2024.pdf

International Energy Agency. (2024b). *Global EV data explorer – Data Tools*. https://www.iea.org/data-and-statistics/data-tools/global-ev-data-explorer

International Energy Agency. (2024c). *Global EV outlook 2024: Moving towards increased affordability*. https://www.iea.org/reports/global-ev-outlook-2024

International Energy Agency. (2024d). *World energy balances 2024*. https://www.iea.org/data-and-statistics/data-product/world-energy-balances

Intergovernmental Panel on Climate Change. (2021). *The Earth's energy budget, climate feedbacks, and climate sensitivity supplementary material*. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter07_SM.pdf

Miller, J., Sen, A., & Teter, J. (2024). *Status of vehicle standards in Europe and North America – May 2024*. International Council on Clean Transportation. https://theicct.org/wp-content/uploads/2024/06/TTDS24-Policy-Brief-WEB-A4-65008-v5.pdf

New Vehicle Efficiency Standard Act 2024, Federal Register of Legislation no. 34, 2024 (2024). https://www.legislation.gov.au/C2024A00034/asmade/text

Prime Minister, Socialist Republic of Vietnam. (2022). *Approving the action program on green energy transformation, reducing carbon and methane emissions of the transport sector (decision no. 876/QD-TTg)*. https://thuvienphapluat.vn/van-ban/Giao-thong-Van-tai/Quyet-dinh-876-QD-TTg-2022-chuyen-doi-nang-luong-xanh-giam-khi-cac-bon-nganh-giao-thong-523057.aspx

Segment Y Automotive Intelligence. (n.d.). *Vehicle data systems* [Dataset]. Retrieved April 30, 2024, from https://www.segmenty.com/vehiclevolumessystem.html

Sen, A., & Miller, J. (2022). *Emissions reduction benefits of a faster, global transition to zero-emission vehicles.* International Council on Clean Transportation. https://theicct.org/publication/zevs-global-transition-benefits-mar22/

Sen, A., & Miller, J. (2023). *Vision 2050: Update on the global zero-emission vehicle transition in 2023*. International Council on Clean Transportation. https://theicct.org/publication/vision-2050-global-zev-update-sept23/

Sen, A., Miller, J., Alvarez, G. H., & Rodrigues, P. F. (2023). *Vision 2050: Strategies to align global road transport with well below 2 degrees*. International Council on Clean Transportation. https://theicct.org/publication/vision-2050-strategies-to-reduce-gap-for-global-road-transport-nov23/

The Road Vehicle Carbon Dioxide Emission Performance Standards (Cars, Vans and Heavy Duty Vehicles) (Amendment) Regulations 2022 (2022). https://www.legislation.gov.uk/uksi/2022/1361/introduction/made

The Vehicle Emissions Trading Schemes Order 2023, UK Statutory Instrument 2023 No. 1394 (2023). https://www.legislation.gov.uk/uksi/2023/1394/contents/made

U.S. Environmental Protection Agency. (2021). *Population and activity of onroad vehicles in MOVES3*. https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1011TF8.pdf

U.S. Environmental Protection Agency. (2023). *Overview of EPA's Motor Vehicle Emission Simulator (MOVES4)*. Office of Transportation and Air Quality. https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P10186IV.pdf

U.S. Environmental Protection Agency. (2024a). *Inventory of U.S. greenhouse gas emissions and sinks: 1990-2022* [Dataset]. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2022

U.S. Environmental Protection Agency. (2024b, February 1). *Final rule: Greenhouse gas emissions standards for heavy-duty vehicles – Phase 3* [Overviews and Factsheets]. https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-greenhouse-gas-emissions-standards-heavy-duty

U.S. Environmental Protection Agency. (2024c, April 18). *Final rule: Multi-pollutant emissions standards for model years 2027 and later light-duty and medium-duty vehicles*. https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-multi-pollutant-emissions-standards-model

ZEV Transition Council. (n.d.-a). *ZEV cost: Total cost of ownership*. Retrieved August 31, 2024, from https://zevtc.org/tracking-progress/zev-cost-total-cost-of-ownership/

ZEV Transition Council. (n.d.-b). *Tracking progress*. Retrieved August 31, 2024, from https://zevtc.org/tracking-progress/

APPENDIX

Supplemental data for this report can be found at https://theicct.org/publication/vision-2050-global-zev-transition-2024-jan25. This spreadsheet has numerical data in a long format for the following parameters, each in their individual worksheet:

- Policy List: Policies considered in the scenario modeling
- ZEV Sales Shares (6 segments): ZEV shares of new sales by scenario, region, segment, and year for each of the six vehicle types modeled in Roadmap
- ZEV Sales Shares (3 segments): ZEV shares of new sales by scenario, region, vehicle category and year aggregated to three vehicle categories (2- and 3-wheelers, LDVs, and HDVs)
- ZEV Stock Shares (6 segments): ZEV shares of vehicle stock by scenario, region, segment, and year
- ZEV Stock Shares (3 segments): ZEV shares of vehicle stock by scenario, region, segments, and year
- Energy Savings: Energy savings in terms of liquid fuel consumption (million barrels of oil equivalent) by scenario, region, vehicle type (6 types), vehicle category (3 categories), and year
- Annual Emissions: Annual WTW CO_2 emissions (million tonnes) by scenario, region, vehicle type, vehicle category, and year
- Cumulative Emissions: Cumulative WTW CO_2 emissions (million tonnes) by scenario, region, vehicle type, and vehicle category from 2024 to 2050
- Global Emissions: Annual and cumulative global WTW CO_2 emissions (million tonnes) by scenario compared with global road transport carbon budgets for 1.5 °C to 2 °C limits in increments of 0.1 °C
- Activity: Annual vehicle activity (measured in vehicle-kilometers traveled) by scenario, region, vehicle type, and year for two powertrain categories: ZEV and ICE + PHEV

www.theicct.org

communications@theicct.org

@theicct.org

icct
THE INTERNATIONAL COUNCIL
ON CLEAN TRANSPORTATION

BEIJING | BERLIN | NEW DELHI | SAN FRANCISCO | SÃO PAULO | WASHINGTON DC