WHITE PAPER

CALSTART | GLOBAL COMMERCIAL VEHICLE DRIVE TO ZERO™ | Ministry of Infrastructure and Water Management of the Netherlands | GLOBAL MEMORANDUM OF UNDERSTANDING

GLOBAL PROGRESS TOWARD DECARBONIZING TRANSPORTATION:

MULTI-COUNTRY ACTION PLAN 2024 UPDATE

Owen MacDonnell, CALSTART
Stephanie Kodish, CALSTART

November 2024



ACKNOWLEDGMENTS

This work was conducted with generous support from the ClimateWorks Foundation, the William & Flora Hewlett Foundation, the Government of The Netherlands, and New York Community Trust.

The authors would like to thank key CALSTART staff and consultants for their critical review of and contributions to this report, including Bill Van Amburg, Emily Varnell, Rowana Legito, Adrian Serna Tamez, Aria Wang, Ricardo Garcia Coyne, Sita Holtslag, Joseph Teja, Valerie Lee, and Daniela Day.

In addition, the authors would also like to thank Alejandra León Amaya, Stephen Healey, Aideen Morrissey, Otto Frommelt, Rui Velasco Martins, Anders Pagh Pedersen, Sofie Io Schibye, Dennis Zaitsev, Sonja Munnix, Hasan Umur Alsancak, Sinan Oğuz, Robin Krutak, and Bora Plumptre for their review of a draft version of this report.

This document is based on information gathered as of October 2024. Any errors are the authors' own.

Cover images: Dennis Zaitsev (top right), Pamela Abreu (center), and electric bus and street sweeper on display at the Global MOU In-Person Summit held June 2024. Credit: Julian Gonzalez.

No part of this document may be reproduced or transmitted in any form or by any means—electronic, mechanical, photocopying, recording, or otherwise—without prior written permission by CALSTART. Requests for permission or further information should be addressed to CALSTART, 48 S. Chester Ave, Pasadena, CA 91106 or Publications@CALSTART.org.

Global Commercial Vehicle Drive to Zero

www.globaldrivetozero.org
LinkedIn

CALSTART

www.calstart.org
LinkedIn

All rights reserved.
© Copyright 2024 CALSTART

TABLE OF CONTENTS

Acknowledgments ii
List of Acronyms v
Figures vii
Executive Summary viii

Section I: Global Progress Snapshot 1
Transportation, Climate, and Health 1
Global MOU Countries and Endorsers 2
ZE-MHDV Sales Update 4
Section II: Architecture for Transforming Transport 7
Moving Commitments into Regulation 8
Supply-Side Regulations 9
Beyond Supply-Side Regulations 11
Actionable Insights: Regulation 13
Building the Charging and Clean Power Network 13
Infrastructure Regulations 14
Long-Term Strategies on Charging Infrastructure for ZE-MHDVs 14
"As-a-Service" Models 16
Interoperability Standards 17
Actionable Insights: Infrastructure 17
Funding the ZE-MHDV Transition 18
Vehicle Subsidies 18
Tax Benefits and Exemptions 19
Reducing Financing Risks Through Guarantees 19
Soft Loans 20
Aggregated Procurement 21
Public-Private Partnerships 21
Actionable Insights: Finance 24

TABLE OF CONTENTS

Section III: Implementation Activities **25**
Green Road Corridors 25
Global Implementation Hub Network 27
Regional Taskforces 28
Short-Term Technical Assistance 28
Section IV: Priority Actions **30**
Secure Supply-Side Regulations Aligned with Global MOU Goals 30
Drive Faster Action via Targeted Infrastructure and Global Green Road Corridors 31
Accelerate the Economic Viability of ZE-MHDVs 32
Conclusion **33**
References **34**

LIST OF ACRONYMS

ACF	Advanced Clean Fleets regulation
ACT	Advanced Clean Trucks regulation
AFIF	Alternative Fuels Infrastructure Facility
AFIR	E.U. Alternative Fuels Infrastructure Regulation
CaaS	Charging-as-a-Service
CO_2	Carbon dioxide
COP	United Nations Climate Change Conference
EaaS	Electrification-as-a-Service
EPA	U.S. Environmental Protection Agency
ETS	Emissions Trading System
EV	Electric vehicle
E.U.	European Union
GGRC	Global Green Road Corridors Initiative
GHG	Greenhouse gas
IaaS	Infrastructure-as-a-Service
ICCT	International Council on Clean Transportation
km	Kilometer
LDV	Light-duty vehicle
MOU	Memorandum of Understanding
NGO	Non-governmental organization
NOx	Nitrogen oxides
OEM	Original equipment manufacturer
PM	Particulate matter
PPP	Public-private partnerships
TCO	Total cost of ownership
TEN-T	Trans-European Transport Network

LIST OF ACRONYMS

U.S.	United States
ZETI	Zero-Emission Technology Inventory
ZEV	Zero-emission vehicle
ZEVIT	Zero Emission Vehicle Island Taskforce
ZE-MHDVs	Zero-emission medium- and heavy-duty vehicles
ZEV-RRF	Zero Emission Vehicle Rapid Response Facility
ZEV-TC	Zero-Emission Vehicle Transition Council

FIGURES

Figure ES-1. Global MOU on ZE-MHDVs Progress Dashboard

Figure 1. Impact of HDVs on Global Fuel Consumption and NOx Emissions

Figure 2. National Government Signatories of the Global MOU

Figure 3. ZE-MHDV Sales in Global MOU Countries, Other Regions, and China

Figure 4. Global MOU on ZE-MHDVs Progress Dashboard

Figure 5. Available Models by Vehicle Type in Major Regions (2024)

Figure 6. 6-Stage Strategy to Enable 100% ZE-MHDVs by 2040 (and 30% by 2030)

Figure 7. Global Examples of Supply-Side Regulations

Figure 8. U.S. National Zero-Emission Freight Corridor Strategy

Figure 9. Types of "As-a-Service" Models

Figure 10. Impact of Residual Value on Affordability of Financing Terms in 5-Year Vehicle Financing Case

Figure 11. Government of Chile Public-Private Partnerships Model

Figure 12. TransMilenio Business Model

Figure 13. Global Green Road Corridors

Figure 14. Global Implementation Hub Network

EXECUTIVE SUMMARY

2024 was a powerful year of progress and growth for the nations, industry, and stakeholders working to achieve the critical decarbonization goals of the Global Memorandum of Understanding (Global MOU) on Zero-Emission Medium- and Heavy-Duty Vehicles (ZE-MHDVs). The number of Global MOU-committed nations grew by 40 percent and includes a meaningful addition of countries from emerging markets and developing economies. This growth brings impact: Roughly one in every five new commercial vehicles on the planet are covered by the Global MOU commitments, and market volumes for zero-emission trucks have grown by more than 50 percent. Led by successes in the first "beachhead" market segments, such as urban delivery, zero-emission trucks now represent almost 2 percent of new sales. Nearly one-third of Global MOU nations now have binding regulations cementing their goals in law. And the next stage of action to reach 2040 goals—the launching of the first long-haul green freight corridors—is underway on five continents.

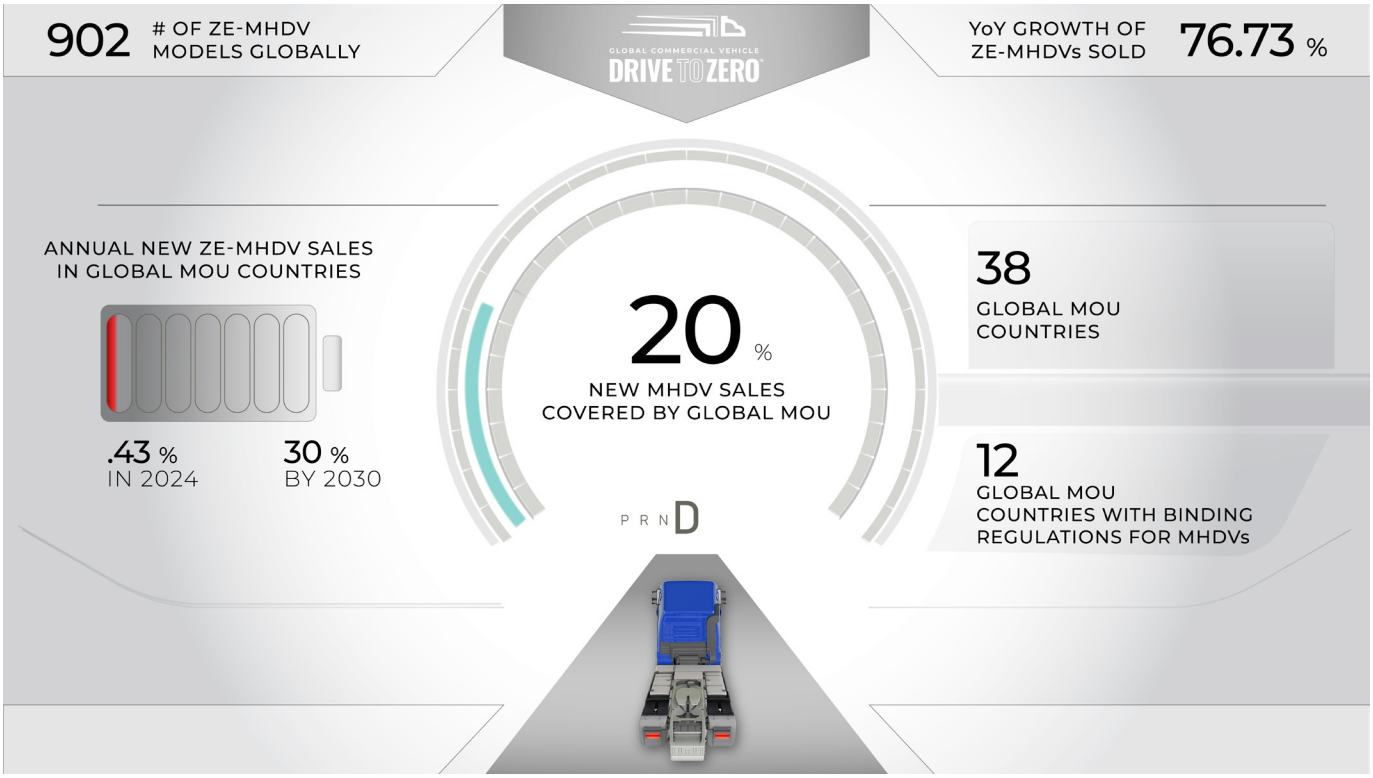
Progress and milestones achieved this past year include these meaningful actions:

- Eleven additional countries (Colombia, Cape Verde, Costa Rica, Ethiopia, Ghana, Iceland, Israel, Papua New Guinea, Mozambique, Seychelles, and Tonga) became Global MOU signatories, bringing the total number of national government signatories to 38.
- These nations now represent five major world regions (Africa; North America, including the Caribbean; South America; Europe; and Oceania) and, when sub-national government endorsers are included, six continents (Asia).
- These 38 nations contain approximately 20 percent, or one in every five, new MHDVs sold on the planet, and 39.5 percent of the world's GDP,[1] an incredibly powerful market share to influence global production and supply chains.
- As of this year, 12 out of the 38 countries are now covered by binding regulations for MHDV decarbonization that set Global MOU-aligned standards on greenhouse gas emissions.
- In the wake of the new rules adopted by the European Union (E.U.) on HDV carbon dioxide (CO_2) emissions, electric truck registrations grew by a robust 51.6 percent in the first half of 2024, increasing their market share to almost 1.9 percent, up from 1.3 percent last year.[2] New E.U. electric bus registrations rose by 45.4 percent in the first half of 2024, with the market share increasing from 13.7 percent to 15.5 percent.[3]
- In California, zero-emission truck sales hit the state's sales goal two years ahead of schedule, accounting for approximately one in six new MHDVs in the lead up to the Advanced Clean Trucks regulation enforcement.[4]

- A cumulative 7.8 gigatons of CO_2 from MHDVs will be avoided from 2024–2050[5] if ambitions of current signatories are achieved, subject to grow as additional nations join this effort.

This global action can be summarized and tracked via these key metric monitors, which highlight progress made against these critical-path outcomes (Figure ES-1).

Figure ES-1. Global MOU on ZE-MHDVs Progress Dashboard



Yet despite real progress, the illustration above shows a steep climb ahead and the need for accelerating and greatly multiplying actions in the coming years to meet 2040 vehicle goals and 2050 net-zero economy imperatives. Achieving the next level of outcomes will require targeting three foundational areas of action:

1. **Lock in regulation:** Secure supply-side regulations aligned with the targets adopted through the Global MOU.
2. **Roll out infrastructure planning:** Drive faster action in the most impactful and polluting applications, plus catalyze direct involvement of the transportation and energy sector, to develop zero-emission freight routes that consider the whole ecosystem, providing relief to the most pollution-damaged communities living near ports, logistics hubs, and highways.
3. **Unleash finance:** Accelerate the economic viability of ZE-MHDVs by establishing programs that use public and concessional funding to unleash private-sector investment in deployments and supportive infrastructure, mitigating the most pressing risks holding back financing, such as credit and residual value guarantees.

To succeed in this transformation, long-term planning implicating all stakeholders is not just a nice-

to-have but a need. Regulations that are in alignment with the Global MOU and grounded firmly in data and demonstrated feasibility are vital to achieve the global decarbonization goals established by the Paris Agreement. A systems-level approach is necessary to move the transport and energy sectors faster to achieve a resilient, carbon-free grid that supports the needs of businesses and communities. Recognizing the unique challenges that all fleets face, particularly small and medium fleets, there must also be a focus on new business models that better support the operational realities of ZE-MHDVs. Likewise, additional measures must be deployed to bring down the cost of financing to fleets and reduce the risk to financiers lending capital, especially for small-fleet borrowers.

Today, transportation stands as the world's second largest contributor to global emissions, second only to the power sector. According to this year's 2024 United Nations Environment Programme Gap Report, which takes stock of each country's nationally determined contributions, the world is not on track to limit warming to 1.5 degrees Celsius.[6] This crossroad marks a pivotal moment in which the world must choose progress or profits and pollution. With transportation relying on oil products for nearly 91 percent of its final energy consumption, a coordinated, global transformation must take place to decouple harmful externalities from transportation.[7]

SECTION I

GLOBAL PROGRESS SNAPSHOT

In 2021, the Global Memorandum of Understanding (Global MOU) on Zero-Emission Medium- and Heavy-Duty Vehicles (ZE-MHDVs) was launched at the United Nations Climate Change Conference (COP26) in Glasgow, Scotland. The landmark agreement calls for signatories to achieve 30 percent new sales of ZE-MHDVs by 2030 and 100 percent new sales by 2040. With 15 governments forming the initial cohort in 2021, it marked a major step forward in elevating the ambitions for global MHDV decarbonization.

Today, the number of country signatories has grown to 38 strong, with more than 200 endorsers and knowledge partners encompassing the private sector, non-governmental organizations (NGOs), and sub-national governments. With action accelerating across the world, but not yet at the pace and scale required, it is more important than ever to focus collective efforts to realize the ambitions set forth in the Global MOU to enable healthy communities, clean air, and thriving business—and decouple the movement of goods and people from the emissions contributing to climate change and harming public health.

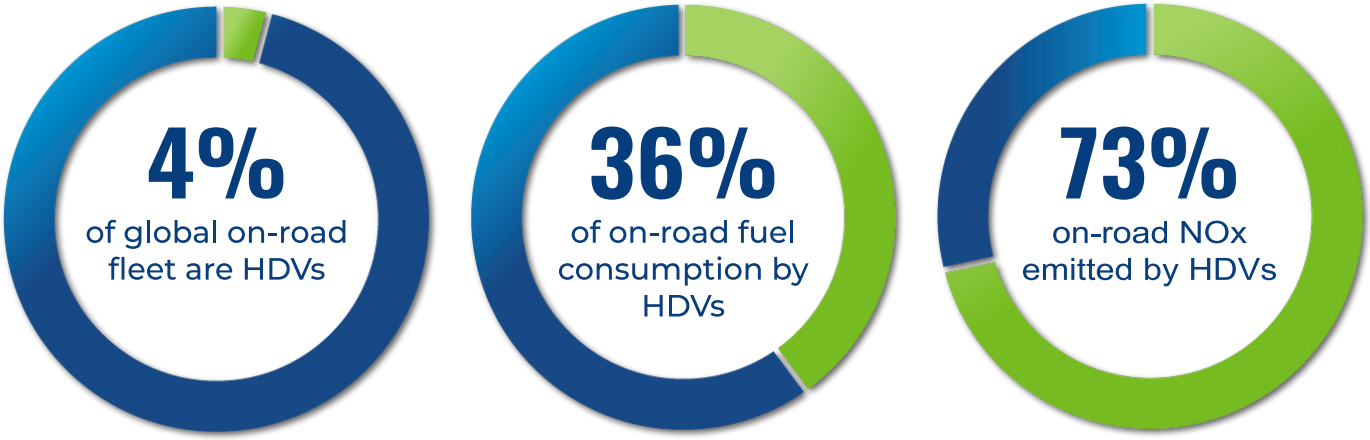
TRANSPORTATION, CLIMATE, AND HEALTH

Overall, transportation accounts for approximately 21 percent of global anthropogenic carbon dioxide (CO_2) emissions and more than one-third of CO_2 emissions from consumers.[8] In 2022, cars, trucks, and other road vehicles were responsible for approximately three-quarters of the total CO_2 emissions from transportation.[9] Diesel-burning trucks and buses are one of the most rapidly growing sources of deadly air pollution. From 2020 to 2050, greenhouse gas (GHG) emissions from freight are expected to double, and harmful particulate matter (PM2.5) associated with combusting diesel is predicted to increase by more than 40 percent in this time frame.[10] Contributing 73 percent of nitrogen oxide (NOx) and 60 percent of particulate matter from on-road vehicles, diesel contributes to more than 330,000 deaths annually and over $1 trillion in annual monetized health damages.[11] [12] This pollution impacts everyone, especially disadvantaged communities living near cities, highways, and ports where emissions are concentrated.

While just 4 percent of on-road vehicles globally, trucks and buses are responsible for 36 percent of on-road fuel consumption and GHGs—a critical barrier to global 2050 net-zero carbon goals (Figure

1). Working together to realize the goals of the Global MOU will result in an estimated cumulative 7.8 gigatons of CO_2 avoided from 2024–2050 if ambitions of current signatories are achieved.[13] This is the emissions equivalent of 877 billion gallons of gasoline consumed. Transportation, specifically MHDVs, must be the focus of rapid decarbonization and unprecedented action to ensure the measures of the Paris Agreement are met within the ever-shortening timeframe.[14] [15]

FIgure 1. Impact of HDVs on Global Fuel Consumption and NOx Emissions

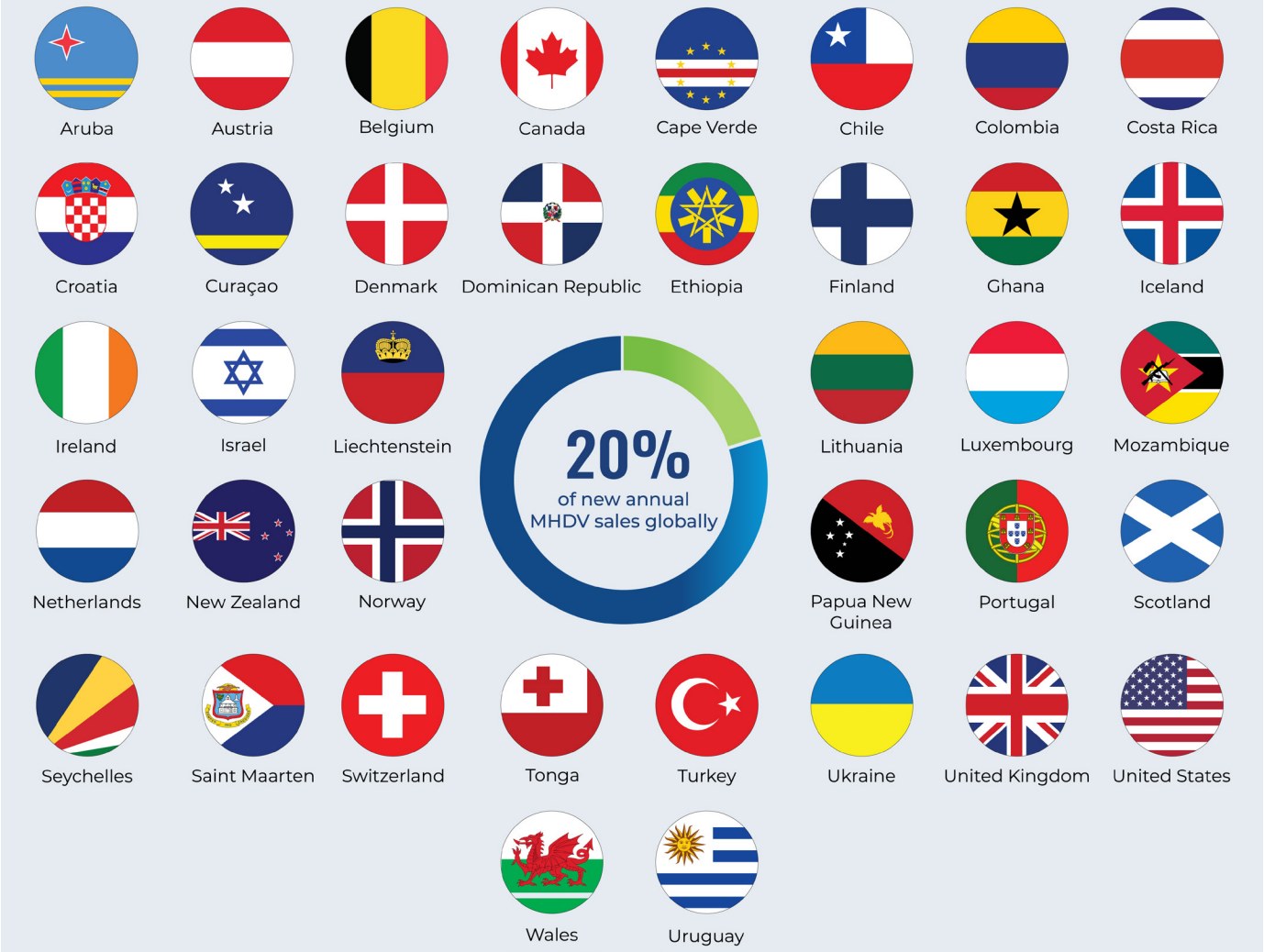


GLOBAL MOU COUNTRIES AND ENDORSERS

Since the last edition of this report in November 2023, Global MOU signatory nations, endorsers, and knowledge partners have made significant progress to accelerate the transition to ZE-MHDVs. Eleven additional nations have pledged their support to achieve the goal of 100 percent new sales of ZE-MHDVs, bringing the total to 38 nations. It is with tremendous accolades that Colombia, Cape Verde, Costa Rica, Ethiopia, Ghana, Iceland, Israel, Papua New Guinea, Mozambique, Seychelles, and Tonga are the newest signatories of the Global MOU. These signatories represent a remarkable growth in island nations and countries in emerging markets and developing economies, significantly broadening the knowledge base of the Global MOU network and making the absence of nations contributing the highest historic GHG emissions apparent and needed in joining this solemn commitment. The deepening of the community has yielded more robust perspectives and considerations of key challenges and opportunities faced by countries with different development statuses and governance structures and to help ensure the zero-emission transition is equitable and shared.

Importantly, these countries now represent 20 percent of the annual new MHDVs on the planet (Figure 2), making their signals, decisions, and regulations a powerful market force and driver of global supply-chain change.

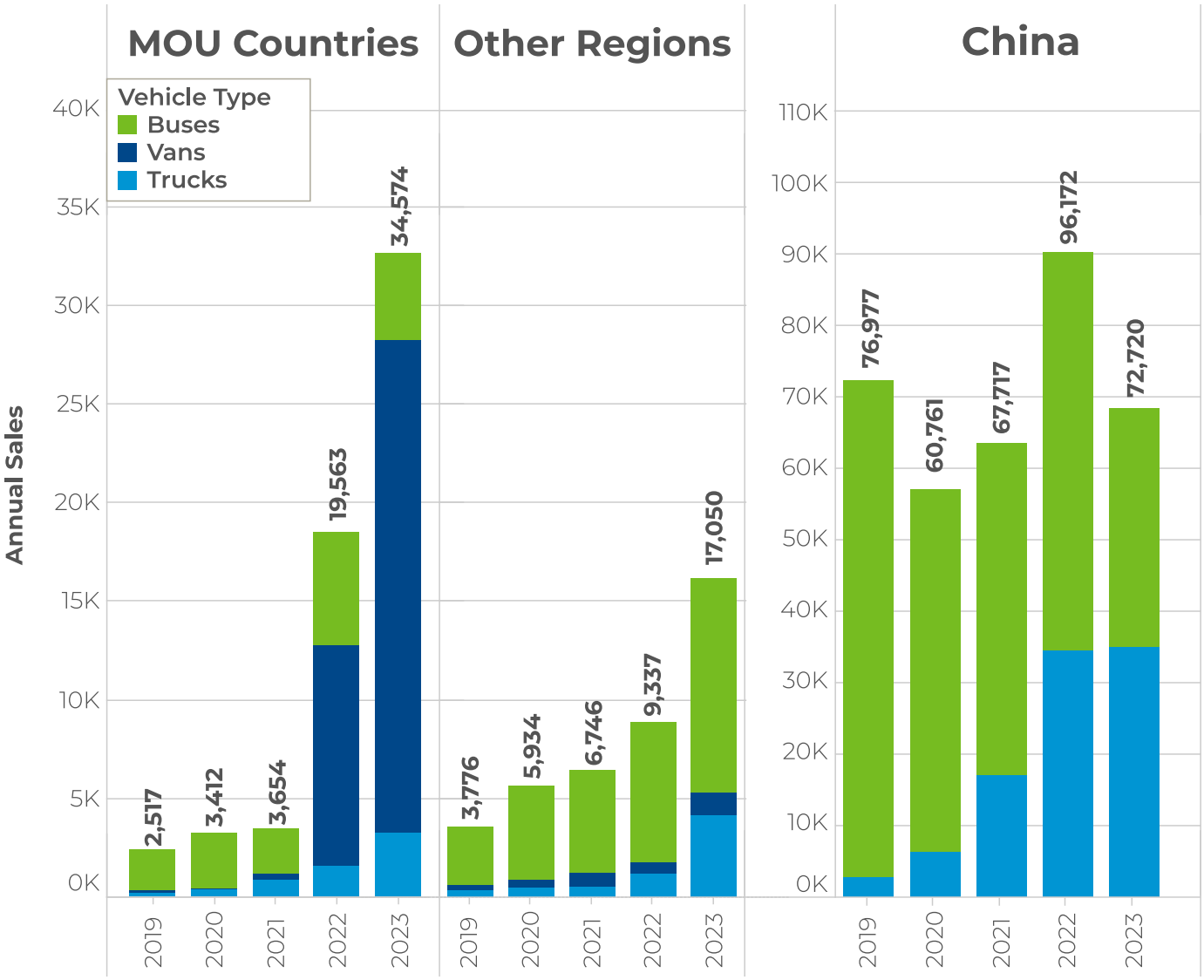
Figure 2. National Government Signatories of the Global MOU



ZE-MHDV SALES UPDATE

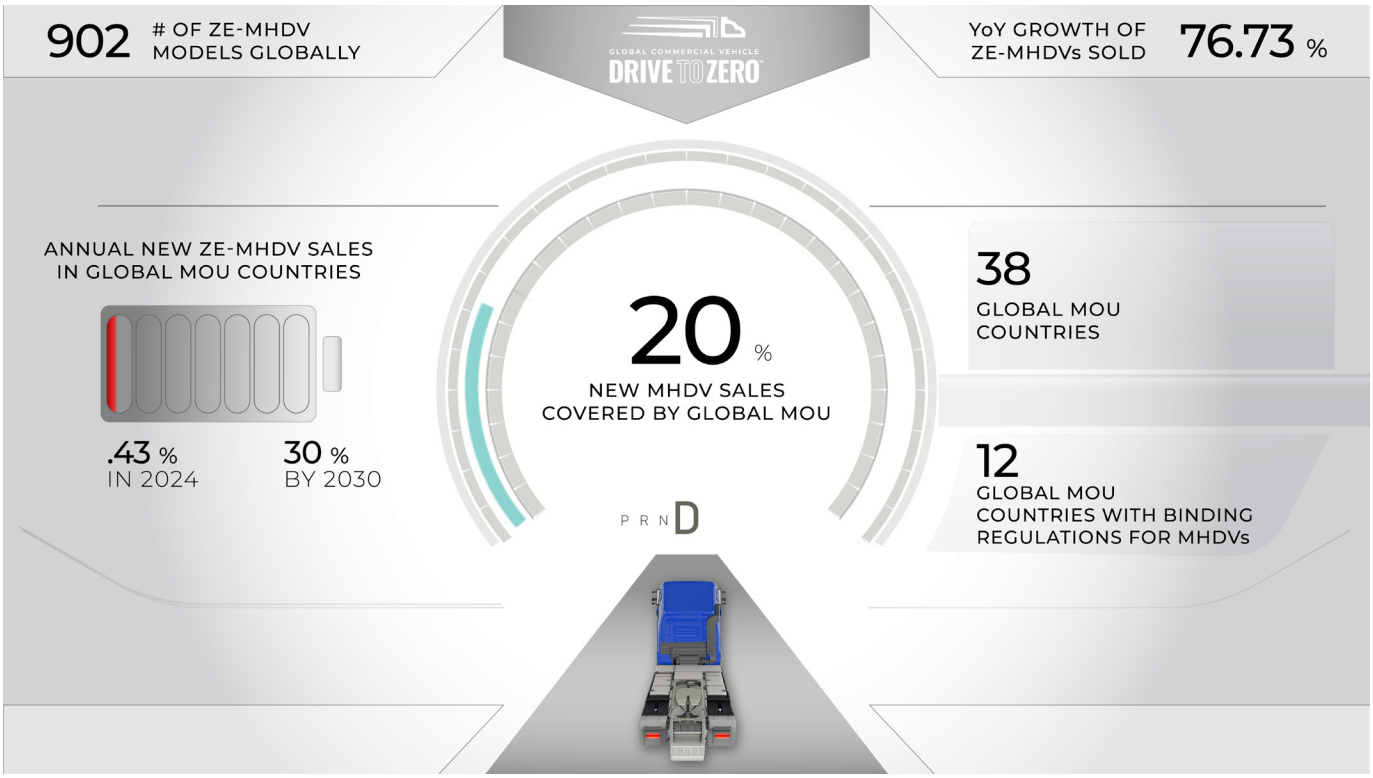
While the world has seen growing momentum behind MHDV electrification, current actions still fall short to hit key milestones that will fulfill the Paris Agreement. With a recognition that truck fleets can take anywhere from 10–15 years to turn over, there must be expedited action to ensure the last diesel vehicles are sold before 2040. In 2023, the Global MOU countries collectively achieved sales of approximately 34,574 ZE-MHDVs (Figure 3), marking 76.73 percent growth from last year—an encouraging indicator of progress.

Figure 3. ZE-MHDV Sales in Global MOU Countries, Other Regions, and China



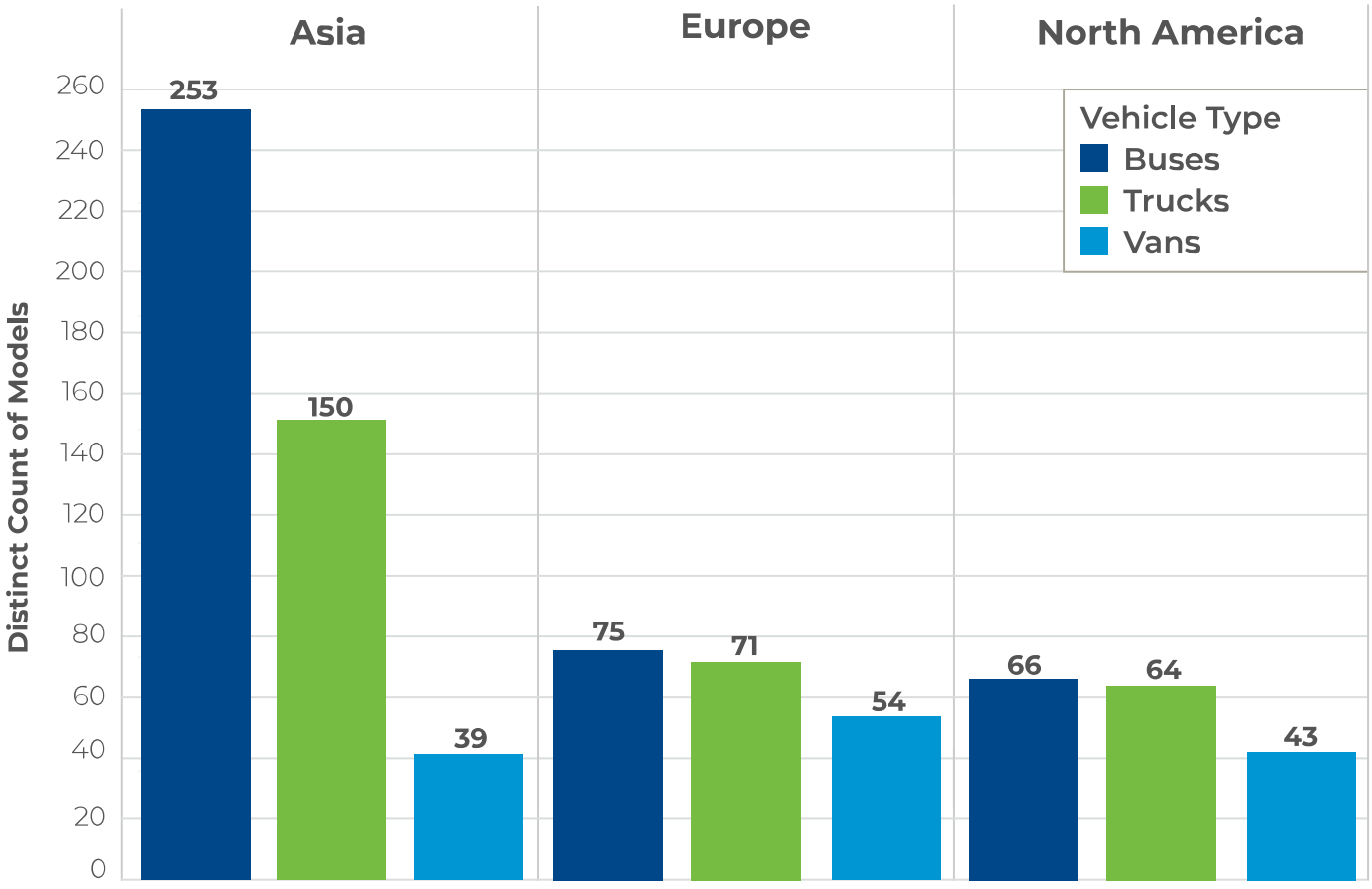
Even so, progress must accelerate. There must be an annual growth of ZE-MHDV sales of 44.59 percent each year to achieve 30 percent by 2030. By today's projections, this equates to approximately 456,798 ZE-MHDVs sold in 2030. Figure 4 below will be updated periodically to reflect progress made and will serve as the accountability tracker to reach the 2030 and 2040 goals.

Figure 4. Global MOU on ZE-MHDVs Progress Dashboard



According to the Zero-Emission Technology Inventory (ZETI), model availability of ZE-MHDVs shows encouraging growth year-over-year at 7.13 percent, bringing the total number of unique models of zero-emission trucks, buses, and vans (U.S. Class 2b–8) to an impressive 902 count as of July 2024 (Figure 5).[16] While nearly half of these vehicles are available primarily in China—many are available for order in other parts of the world—there has been robust growth in specific regions, with the European market adding 20 new ZE-MHDVs, bringing their total to 178. Due to some overarching market consolidation, the number of U.S. models decreased from 212 in 2022 to 164 in 2023. However, as of October 2024, that number has already increased to 189.

Figure 5. Available Models by Vehicle Type in Major Regions (2024)

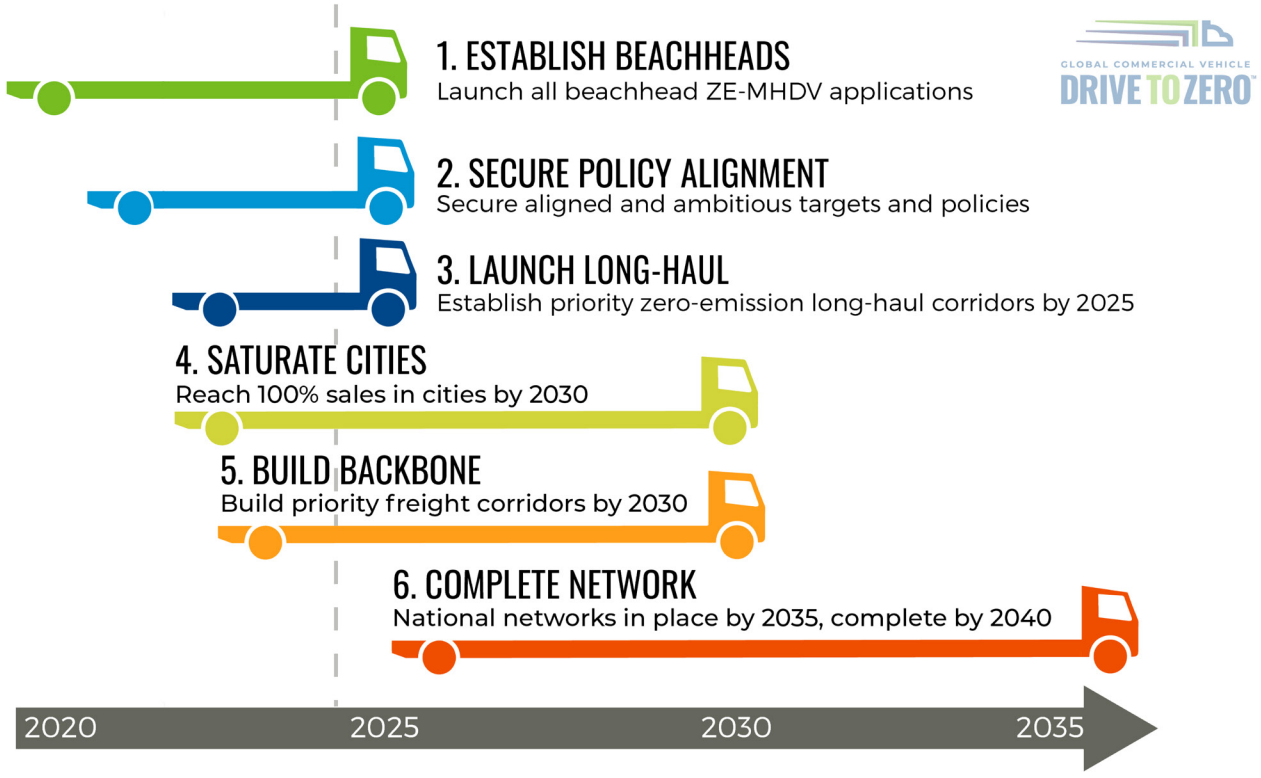


SECTION II

ARCHITECTURE FOR TRANSFORMING TRANSPORT

To outline the action and timeline necessary to achieve Global MOU goals, in 2022, the Global Commercial Vehicle Drive to Zero (Drive to Zero) program published a six-stage strategy (Figure 6) in the report *Global Roadmap for Reaching 100% Zero-Emission Medium- and Heavy-Duty Vehicles by 2040*.[17]

Figure 6. 6-Stage Strategy to Enable 100% ZE-MHDVs by 2040 (and 30% by 2030)



Note: Design modifications were made to reflect present day (dashed line).

To date, most actions have focused on the first two stages of this roadmap: 1) establishing the first "beachheads" (i.e., first success applications for ZE-MHDVs), and 2) securing policy alignment globally around the Global MOU goals and enacting the regulations and policies that drive them. Building on this strategy and the direction for action, this section is divided into three focus areas—Policy, Infrastructure, and Finance—that provide the basis to meet the goals of the Global MOU and eliminate harmful emissions from transportation.

Clear policy and firm regulatory measures provide certainty, signaling to industry that this transition is well underway. Regulations solidify the technology pathway, reduce risks for stakeholders, and spark market innovation. With greater confidence facilitated through regulatory measures, stakeholder actions accelerate and rise with ambition. In tandem, anchoring, ecosystem-level approaches are taking shape in the development of green corridors—a depiction of comprehensive planning across transport and energy sectors for inclusive and resilient infrastructure. This forward movement demands a tremendous amount of capital investment that goes far beyond the role that government subsidies can play. With the pace of the transition accelerating, there is a growing unmet need for private-sector involvement, new business models, and innovative financing measures that can meet the needs of small and large fleets alike. Already, novel public-private partnerships have been able to take advantage of the beneficial operating conditions that ZE-MHDVs bring. The convergence of these three critical topics begets the need for stakeholders across the value chain to champion their respective roles in establishing the rules for commercial vehicle transformation, designing and developing plans for the vehicles to obtain reliable, clean power with investments that match the market opportunity. The pace and scale of the needed transition requires leadership, decisive action, and truly unprecedented collaboration to succeed.

MOVING COMMITMENTS INTO REGULATION

Policy and regulation that are aligned to achieve Global MOU goals is foundational for a successful transformation to a carbon-free commercial vehicle sector. To provide market certainty and ensure progress toward these goals, aligned regulations are needed to delineate stakeholder action on a specific timeline. The Global MOU takes the first step and sets the bar for global ambition around ZE-MHDVs.

Regulations that limit harmful emissions such as GHGs and NOx, establish fuel economy standards, or create sales mandates for manufacturers are the most effective tools to accelerate the transition to ZE-MHDVs. While there are several ways that regulation on vehicle supply can ensure reduced pollution from the tailpipe, the most straightforward policy approach is to set a requirement that the technology be zero-emitting.

Policy Insights: Tracking Tools

Drive to Zero hosts and maintains a regularly updated Global MOU Policy Tracker that assesses the progress of Global MOU signatories (and limited selection of other nations) to build a complementary and comprehensive suite of policy elements.

Sub-national governments also have a large role to play. A new tool used in the United States tracks the actions of sub-national state governments to spur ZE-MHDVs in their borders. The ZET Ahead Dashboard tracks progress across six market dimensions similar to the Global MOU Policy Tracker and can serve as a model for sub-national government action worldwide.

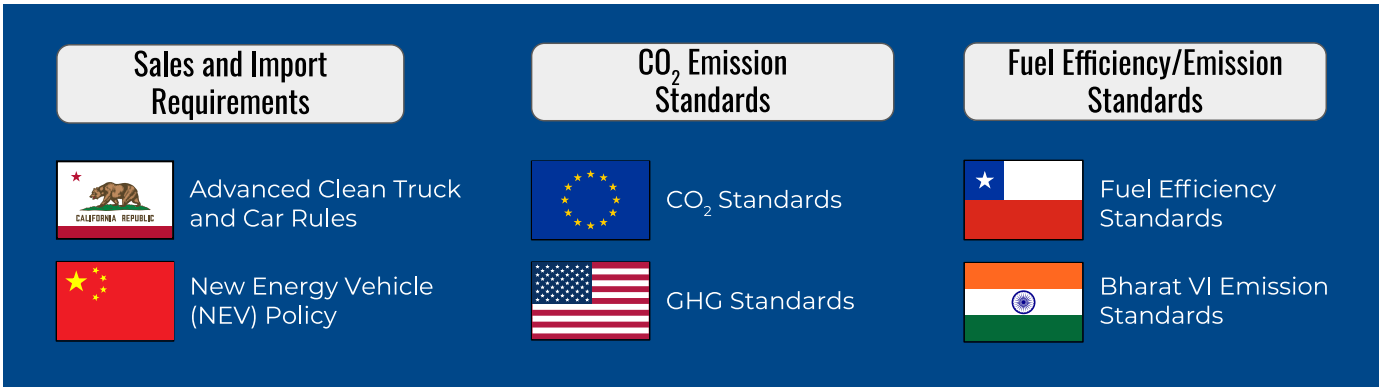
Such regulations create industry certainty, as they lay out clear expectations for future operations and compliance requirements, which allow manufacturers, fleets, and utilities to plan for the long term. While regulatory obligations will not succeed in a vacuum and must be joined by investment, planning, collaboration, and enforcement, they are a vital precursor to consistent action and a fair playing field. They also come with timelines and allocate responsibility for action or inaction.

These policies must include both "sticks" (e.g., supply-side regulations) and "carrots" (e.g., incentive and funding programs) to be effective given the rapid timescale of change required. The more simple and aggressive elements a nation can enact, the more successful its transition can be.

SUPPLY-SIDE REGULATIONS

Most regions around the world have some combination of requirements for MHDVs to limit what can be emitted, and these standards will vary depending on the country and kind of policy. Supply-side regulations, with three leading examples listed below, increase the stringency of emissions or outright require gradually increasing sales of ZE-MHDVs (Figure 7).

Figure 7. Global Examples of Supply-Side Regulations



These kinds of requirements place the responsibility on the manufacturers (i.e., the supplier) to make improvements or allocate additional investments toward zero-emission technologies. In turn, these policies create greater certainty in the direction of the industry, which help facilitate infrastructure deployment and the development of innovative financing measures to ensure affordability for all fleets. Further, as supply increases through economies of scale, the costs of ZE-MHDVs will fall while demand for carbon-free grid upgrades will grow, facilitating the transformation of the full ecosystem. The following are leading examples of supply-side regulations:

- **Fuel economy and GHG standards** aim to increase the fuel efficiency of vehicles (i.e., how many miles a vehicle can travel with one gallon of fuel) and reduce the amount of GHGs a vehicle emits during operation. Improving the fuel economy of MHDVs may take several forms, but the requirements are typically technology-neutral, thus allowing automakers (i.e., the subject of the

regulation) some flexibility on how to meet the minimum standards. Automakers are penalized if they are unable to meet the standards.

- **Emission standards** refer to regulations that establish limits on the harmful criteria pollutants that MHDVs emit as a result of the combustion of fossil fuels. Such pollutants like NOx, PM2.5, and hydrocarbons are common byproducts of combustion and contribute to smog, air pollution, and harmful health impacts.
- **Sales requirements for manufacturers** require vehicle manufacturers to sell zero-emission vehicles (ZEVs) as an increasing percentage of their annual sales. ZEV mandates—aimed at MHDVs—create a minimum market for ZEV manufacturers to grow their businesses, develop their supply chains, and innovate to meet new operational needs.

U.S./E.U. Supply-Side Regulations in Place

In last year's Multi-Country Action Plan, the proposed regulations in the United States (U.S.) and the European Union (E.U.) were yet to be finalized. In May 2024, the European Commission adopted new standards for MHDVs, requiring a 45 percent reduction in CO_2 emissions by 2030, 65 percent reduction by 2035, and 90 percent reduction by 2040. The regulation also includes more accelerated timelines for buses, requiring 100 percent new sales to be zero-emission by 2035. These actions significantly advance the previous standards that required 15 percent CO_2 emissions reduction from MHDVs by 2030 and 30 percent reduction by 2030.[18] The European Commission has also adopted the next phase of the Euro pollutant standards for MHDVs, with Euro 7 to enter into effect in 2028. Euro 7 will further restrict the amount of other kinds of pollutants that are harmful for air quality and public health, such as NOx.[19] The Global MOU nations covered by this newly passed legislation include: Austria, Belgium, Croatia, Denmark, Finland, Ireland, Lithuania, Luxembourg, Netherlands, Portugal, and Norway, and policies referring to the E.U. are inclusive of these nations. However, implementation plans and processes may differ, as well as country-specific programs and priorities. In this context, Türkiye also continues its harmonization efforts with the Euro 7 regulation for MHDVs, which is planned to enter into force gradually between 2026 and 2029.

In the U.S., the Environmental Protection Agency (EPA) finalized the Phase 3 Standards for MHDVs beginning in 2027 that establishes trajectories for CO_2 reductions based on vehicle type and vocation. The rule covers U.S. Class 2b–8, and while technology neutral, it is expected to significantly boost sales of ZE-MHDVs especially in U.S. states that have already adopted the more ambitious Advanced Clean Trucks (ACT) regulation spearheaded by California.[20] Based on initial projections and modeling, the Phase 3 standards are expected to yield $13 billion in net benefits by 2055, including $10 billion in climate benefits, $300 million in health benefits, and $2.4 billion in net savings for the HDV industry due to lower fuel and maintenance costs. In terms of emissions reductions, the standards are expected to cut roughly 1 billion tons of GHG emissions by 2055.[21] Alongside the Phase 3 regulation, the EPA also finalized their Multi-Pollutant Emission Standard beginning with model year 2027 that will limit air pollutants for MHDVs similar to Euro 7.[22]

Sales Requirements in California: ZEV Mandates

A specific highlight must be made for California and the ACT regulation, a first-of-its-kind sales requirement for manufacturers beginning in model year 2024.[23] Each following year, manufacturers will be required to sell an increasing number of ZE-MHDVs depending on the vehicles class and type. In California, ACT is complemented by a demand-side regulation, Advanced Clean Fleets (ACF), that requires fleets to purchase zero-emission trucks, with the stringency of the purchasing requirements varying by fleet type and size starting with model year 2036.[24] Eleven other U.S. states have adopted these two measures, constituting approximately 27 percent of the U.S. MHDV market. Analysis indicates that by 2030, ACT and ACF compliance will lead to the deployment of at least 461,000 ZE-MHDVs in the 11 ACT/F states.[25] Preliminary results from California show that they have met their ZE-MHDV sales target two years ahead of schedule and that every one out of six trucks sold in the state is zero-emission, representing a doubling from 2022 to 2023.[26]

Proposed Chilean MHDV Standard

Chile's National Electromobility Strategy aims to transition fully to electric vehicles (EVs) by 2035, focusing on achieving carbon neutrality by 2050.[27] The strategy proposes mandates that would require 100 percent of light and medium vehicles, public transport (i.e., buses, taxis, shared taxis), and large machinery sold must be zero-emission by 2035. By 2040, all small mobile machinery (i.e., construction, agriculture, forestry) will also be zero-emission, and by 2045, freight transport and intercity buses will follow.[28]

This transition is supported by regulations such as the Energy Efficiency Law and new incentive programs. Key initiatives include the reduction of circulation permit costs for EVs, enabling vehicle-to-grid charging, where EVs can supply energy to the grid, and accelerated depreciation of EV or plug-in hybrid EV for a 10-year period.[29]

Chile's regulation on EV charging infrastructure sets clear requirements to ensure efficient and interoperable public and private charging networks. Technical requirements mandate compliance with safety standards like Supreme Decree N° 8 (2019) and Pliego 15, which cover the design, construction, and maintenance of charging stations.

BEYOND SUPPLY-SIDE REGULATIONS

Supply-side regulations have the unique capacity to significantly expedite the transition to ZE-MHDVs. At the same time, these measures must be paired with and complimented by a mix of other interventions for a more robust ecosystem that will support the uptake of ZE-MHDVs. Different policy levers will be more applicable to certain countries based on the market conditions and overall differences in governance structure and capacity for enforcement and implementation.

Road Pricing in Europe

As more ZE-MHDVs are deployed, countries are exploring how to best implement mechanisms that will incentivize fleets and operators to utilize ZEVs in their operations. Consistent with polluter-pays principles, the European Commission has introduced a framework to encourage member states to leverage taxation and user fees as an instrument to accelerate the adoption of ZE-MHDVs. These measures will expand funding for the Trans-European Transport Network (TEN-T) and facilitate more widespread availability of charging and hydrogen refueling stations.[30] This framework considers distance-based charges (tolls), as well as time-based charges (vignettes) and requires that these fees be reduced for vehicles that are zero-emission—unless the distance-based toll consists only of a flat infrastructure charge. Thus far, several countries have adopted the framework such as Denmark, Netherlands, Lithuania, Lichtenstein, and Switzerland, but more are expected soon.[31] [32] [33] [34] Notably, the revenues from road pricing can be incorporated into countries' upcoming budgets, such as the Netherlands has done to finance subsidy programs for ZE-MHDVs and supporting infrastructure in the near term.[35]

Import Restrictions

For the many countries that do not domestically manufacture MHDVs, effective regulatory and management options can serve to limit emissions of the vehicles entering their borders. Older vehicles predominantly have worse emissions control systems and are less fuel efficient, leading to a commonly observed dilemma of secondary markets where vehicles from developed economies are sold in countries with weaker or nonexistent criteria for efficiency or roadworthiness.[36] Earlier in 2024, Global MOU signatory the Dominican Republic announced prohibitions on automobiles older than five years and goods movement vehicles, like trucks, that are more than 15 years old.[37] While not specific to MHDVs, Global MOU signatory Ethiopia recently announced a ban on diesel light-duty vehicles (LDVs) in alignment with their goal of 152,800 EVs in the country by 2030.[38] However, the timeline and enforcement mechanisms remain unclear. While these measures are being explored for MHDVs, they will have an important role to play in what kinds of vehicles may enter a country.

E.U. Emissions Trading System 2.0 (ETS 2)

A key fixture of the E.U. Green Deal is the Emissions Trading System (ETS) that leverages a "system of allowances" or permits for industry to emit CO_2.[39] These allowances can be traded, and certain industries receive free allowances. However, the number of allowances across industry is capped each year and progressively reduced annually. The revenue generated from the ETS is then reinvested to fund climate investments within the E.U. Up until 2024, the ETS covered only large industry, aviation, and fossil fuel-based energy generation, resulting in a CO_2 emissions reduction of 47 percent from 2005 levels. Moving forward, ETS is being enlarged and strengthened. Most notably, from 2027 onwards, road transport will be covered under the ETS2, requiring fossil-fuel providers to buy allowances and comply with the limits and caps. Member states will then decide how to prioritize the funds in various areas of climate action and mitigation. Notably, this will strengthen the cost-competitiveness of ZE-MHDVs by assigning costs to pollution. This will advance country-level programs through additional funding and revenue and accelerate the transition by instituting limits on polluters that will result in fees if surpassed.

ACTIONABLE INSIGHTS: REGULATION

Regulations that are in alignment with the Global MOU and grounded firmly in data and demonstrated feasibility are vital to achieve the global decarbonization goals established by the Paris Agreement. Supply-side regulations like California's ACT and the E.U. HDV CO_2 standard have exhibited early successes in boosting the supply and sales of ZE-MHDVs in the regions where they have been adopted. The impact goes beyond these short-term victories, however, to establish firm timelines and benchmarks for the whole industry. In other words, strong supply-side regulations ensure an even playing field for competition and innovation. Even so, other interventions must also be considered as a part of the whole ecosystem approach to drive action forward on all fronts. Different ways to levy fees or impose restrictions on polluting technologies with avenues for reinvestment in clean technologies have been effective levers to catalyze change. Ensuring the availability of chargers and hydrogen refueling stations and the right mix of financial support will be discussed in the following sections to make sure that regulatory action is backed up by a robust set of supportive policy.

BUILDING THE CHARGING AND CLEAN POWER NETWORK

A tremendous effort is required to grow and scale an entirely new energy system to recharge and refuel ZE-MHDVs. Global MOU nations are actively working to implement the necessary enabling conditions to ensure that this vital aspect of the transition does not become a hinderance to the uptake of ZE-MHDVs now and in the future. Recognizing that this topic now intersects two massive sectors, inclusive of transportation/road infrastructure and power generation/distribution, there must be a fundamental transformation in approaching this challenge, driven by unprecedented proactive planning and collaboration between governments, NGOs, and private-sector actors. The opportunity to comprehensively plan across energy and transportation presents an opportunity for robust infrastructure planning across a country unlike any other. By accounting for additional energy demand stemming from the deployment of ZE-MHDVs, larger scale investments can be made that go beyond additional energy generation. Domestic energy security, investments in grid resilience against disasters, and accelerated timelines for renewable energy projects all lay the groundwork for a just and equitable transition that seeks to empower local communities and provide access to a clean, accessible grid that does not necessitate harmful externalities like air pollution.

Volumes of electric trucks are growing rapidly, not just in the U.S. and Europe but in every region of the world. To support and enable these vehicles to integrate seamlessly into the logistics system, there must be accelerated action to advance the deployment and maintenance of charging stations and refueling infrastructure for ZE-MHDVs.

INFRASTRUCTURE REGULATIONS

Regulations for infrastructure are an important part of a complete ecosystem for ZE-MHDVs. By establishing requirements and timelines for the planning and buildout of charging and refueling stations, fleets and shippers gain confidence in the reliability of the public network. With greater confidence and expanded operational range, more routes can be covered with ZE-MHDVs, as the nominal range of those vehicles continues to grow.

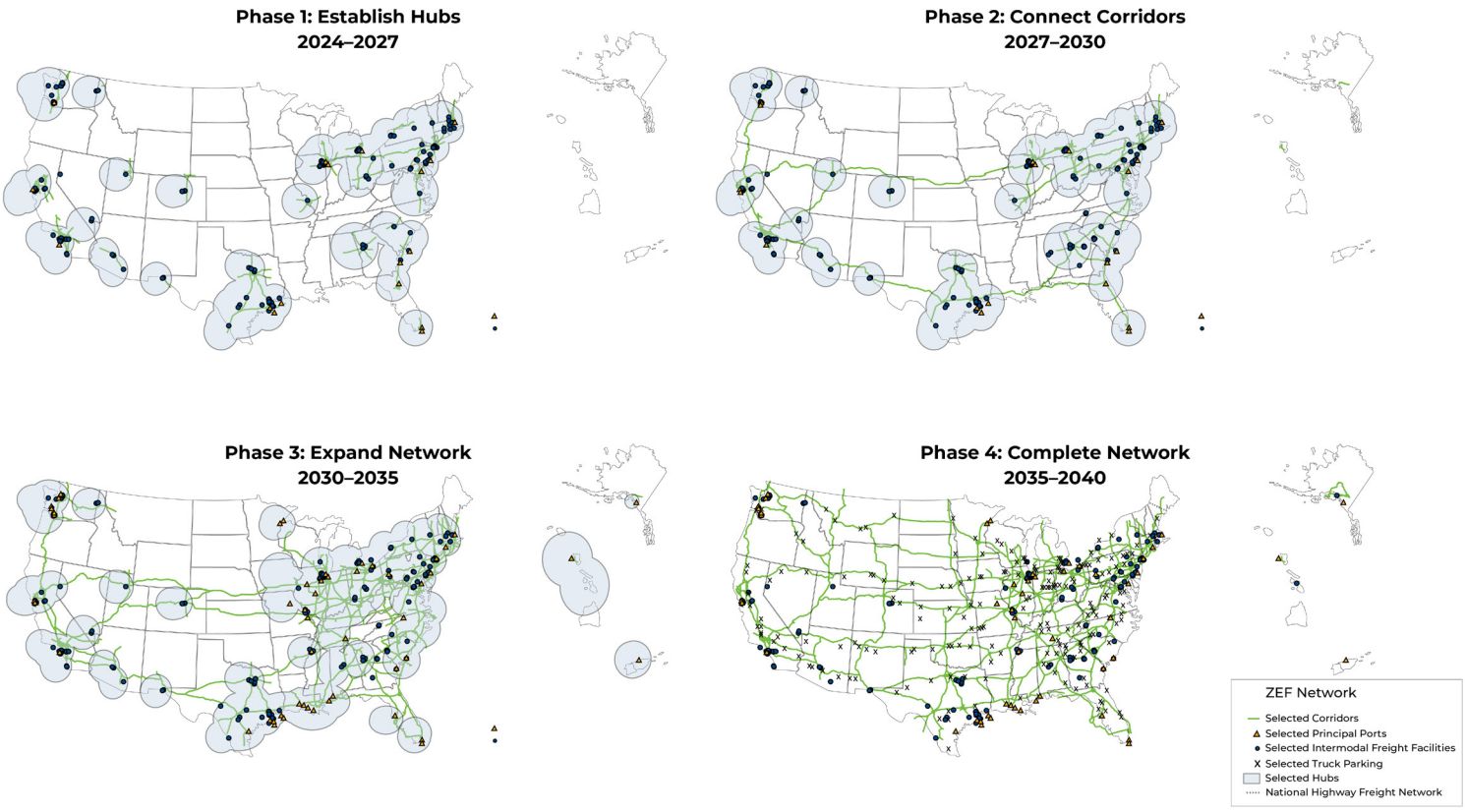
The E.U. Alternative Fuels Infrastructure Regulation (AFIR), which came into force in 2024, sets minimum binding requirements for distance between recharging pools that can accommodate ZE-MHDVs along the E.U.'s primary road system (TEN-T core and comprehensive road network), and that these recharging or refueling stations must meet specific capacity targets (e.g., power output).[40] AFIR's intent is for publicly accessible ZE-MHDV infrastructure to be deployed progressively from 2025, with a vision of covering the entire TEN-T network by 2030. The regulation specifies that charging stations for ZE-MHDVs must be located along the TEN-T core network with a maximum distance of 60 kilometers (km) for HDVs and 100 km on the comprehensive network, and sets requirements for a minimum individual power output of 350 kilowatts. It also sets provisions for supporting urban and regional ZE-MHDV fast-charging and reliability metrics. To accelerate and enable reaching the alternative fuels targets in AFIR, the E.U. announced the second wave of funding for the Alternative Fuels Infrastructure Facility (AFIF) to compliment AFIR. A total of €1 billion will be disbursed to member states between 2024 and 2026 to support implementation of AFIR and network buildout.[41] The AFIR regulation is a key fixture of the E.U. policy ecosystem and provides an advanced level of certainty for shippers, fleet users, financiers, and other stakeholders that the supporting infrastructure will be ready as ZE-MHDV volumes increase.

LONG-TERM STRATEGIES ON CHARGING INFRASTRUCTURE FOR ZE-MHDVS

Long-term planning for ZE-MDHV infrastructure provides a clear scheme for transition and coordinating structure, enabling all stakeholders across the transportation and energy ecosystem to know and assume their role. Establishing a comprehensive blueprint or strategy allows stakeholders to navigate the complexities of transitioning to ZEVs with greater confidence and send clear signals of needs, timing, and location to investors and operators, ideally enabling more efficient, cost-effective, and rapid infrastructure rollout.

In March 2024, the U.S. launched its comprehensive National Zero-Emission Freight Corridor Strategy, a collaborative effort by the recently formed Joint Office of Energy and Transportation. The strategy outlines a national vision for country-wide deployment of supportive public infrastructure for ZE-MHDVs in alignment with the goals of the Global MOU (Figure 8).[42] The strategy describes in detail the phased approach needed to move from priority hub locations to the buildout of the complete network by 2040. The strategy is one of the most robust examples of proactive network planning from a government and specifically ties the outcomes to the objectives of the Global MOU.

Figure 8. U.S. National Zero-Emission Freight Corridor Strategy



Source: Joint Office of Energy and Transportation (2024). National Zero-Emission Freight Corridor Strategy. https://driveelectric.gov/files/zef-corridor-strategy.pdf. Design modifications made by CALSTART.

By prioritizing logistics and freight hubs, and gradually expanding the network through corridor development to connect hubs and nodes, the strategy effectively scales as greater volumes of vehicles are deployed. The strategy is an effective piece of high-level planning and coordination that in turn provides private-sector actors with an anticipated trajectory to further plan for and invest in. The Joint Office of Energy and Transportation that published the strategy is also one of the first-of-its-kind collaborative efforts between agencies to accelerate transportation electrification.

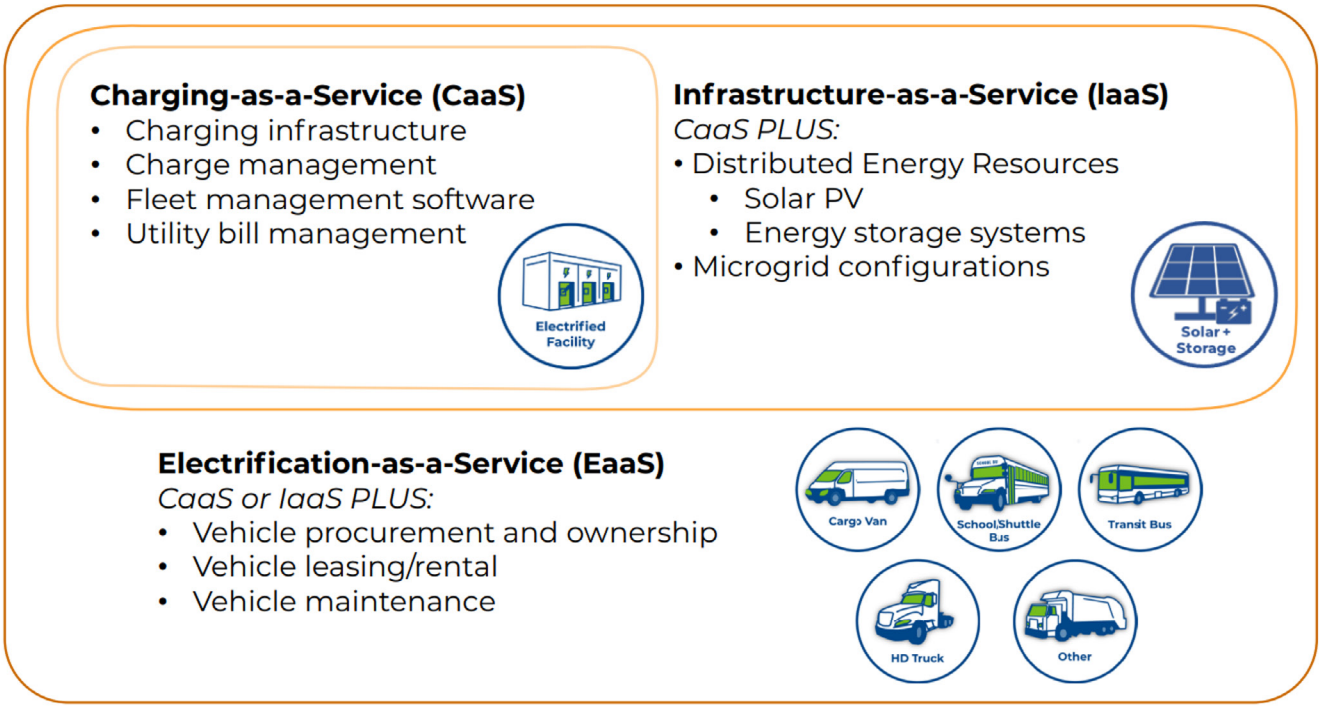
In a similar way, other countries have also been pushing forward efforts to plan for infrastructure deployments. In Türkiye, the Heavy Commercial Vehicles Charging Infrastructure Working Group was established under the coordination of the Ministry of Industry and Technology to conduct a detailed study and assess infrastructure needs. The group is currently conducting a needs analysis along the part of the road network connecting the E.U. and Türkiye, and work has also begun on designing a support program based on these needs.

"AS-A-SERVICE" MODELS

There are significant efforts underway to rethink business models that will lead to cost-effective deployments of ZE-MHDVs.[43] Among those emerging are the "As-a-Service" models that may take shape in a few different ways (Figure 9):

- **Charging-as-a-Service (CaaS)** is a turnkey EV charging offering in which a developer installs, owns, and maintains all charging equipment and infrastructure and provides the charging service to the fleet operator for a specified term and for a fixed fee. This eliminates the cost of charging infrastructure as a capital expense for a fleet, instead transferring it to a fleet's operating budget, which should have extra flexibility owing to reduced vehicle operating and maintenance costs.
- **Infrastructure-as-a-Service (IaaS)** encompasses the elements of CaaS with the addition of distributed energy resources, such as solar photovoltaic systems and/or stationary energy storage systems, and possibly configured as a microgrid to enhance energy resiliency.
- **Electrification-as-a-Service (EaaS)** refers to a full-service arrangement that bundles EV procurement and operation into the same fixed-fee arrangement with charging infrastructure and potential additional energy infrastructure. This model resembles traditional vehicle leasing in many respects but with the addition of enabling infrastructure specific to an EV project.

Figure 9. Types of "As-a-Service" Models



Looking ahead, there is anticipation for a shared commercial vehicle charging infrastructure model, where several fleets work together to develop and share a common infrastructure charging hub. In practice, this could apply to specific locations such as airports, marine ports, or terminals, each of

which would feature several disparate EV fleets sharing a more cost-effective, centralized charging infrastructure installation.[44]

INTEROPERABILITY STANDARDS

For the growth and expansion of ZE-MDHVs, charging processes must be seamless and user-friendly. This requires that charging stations are not only safe, available, and reliable but also interoperable at both software and hardware levels for the growing number of available vehicles. Achieving interoperability offers significant advantages, benefiting not just users but also companies. By adopting standards, manufacturers can avoid the complexities of producing varied equipment, leading to cost savings that can be passed on to customers. The two standards from Chile and Portugal highlighted below pertain to LDVs, but the lessons and insight they provide can inform the design of similar standards for ZE-MHDV interoperability.

In 2023, Chile enacted regulations aimed at establishing the guidelines for the interoperability of EV charging systems. These regulations outline the information and operational requirements needed for the implementation and functionality of such systems, as well as the criteria for delivering EV charging service.[45] They apply to charging infrastructure owners, charging point operators, electromobility service providers, and other stakeholders within the EV charging ecosystem. The regulations mandate that key information about charging stations—including their location, nominal power, types and number of connectors, simultaneous charging capacity, and communication protocols—must be declared. For publicly accessible chargers, owners are required to register on the designated interoperability platform, and non-compliance with these regulations can result in sanctions.[46]

In Portugal, Mobi.E, the public organization responsible for managing the Electric Mobility Network, provides a robust and extensive charging infrastructure network throughout the mainland and islands. The network provides interoperability between the various charging point operators and charging point owners, allowing any user with a valid contract from an electric mobility service provider to charge their vehicle at any station in the system.[47] This interoperability ensures a unified and easy charging experience for EV users, regardless of which operator manages the specific charging point.

ACTIONABLE INSIGHTS: INFRASTRUCTURE

A systems-level approach is vital to transform transport and energy to achieve a resilient, carbon-free grid that supports the needs of businesses and communities. To succeed in this transformation, long-term planning implicating all stakeholders is not just a nice-to-have but a need. Regulatory models like AFIR show how nations can take steps to firmly set rules in place that give rise to market certainty. Actionable and cross-collaborative strategies that represent a shared vision of the future and integrate measures such as interoperability, firm regulatory standards, innovative business models, and pathways for financing support the network building that will serve as the future backbone of road freight networks.

FUNDING THE ZE-MHDV TRANSITION

A key challenge for many fleets is accessing affordable capital to make a purchase. This is particularly prevalent for small fleets, defined by the ownership of one to six trucks, which account for approximately 84 percent of fleets in operation.[48] These numbers may shift slightly by geography, but this trend is prevalent across the globe and manifests significant barriers to invest in ZE-MHDVs even to those that are highly motivated. Compounding fiscal challenges, beyond access to capital, small fleets often encounter knowledge gaps when it comes to understanding how to operate, recharge, and fuel ZE-MHDVs, and how to ensure the supporting infrastructure is right-sized for their needs, as well as what models are available for purchase and the various subsidies or tax benefits available to them.

While the upfront cost of ZE-MHDVs remains relatively higher today, the total cost of ownership (TCO) in some markets has achieved price parity with diesel or other combustion engine equivalents.[49] TCO parity for the resounding majority of ZE-MHDVs is expected before or by 2030, including heavy-duty long-haul, cross-border tractor trucks.[50] Ultimately, regulations and technology innovation will spur the supply of ZEVs and reduce costs in the medium term through economies of scale and nature of competitive markets. In the near term, however, there is a need for interventions inclusive of incentives, tax exemptions, and de-risking interventions that can accelerate TCO parity between zero-emission and combustion engine technologies. Programs that drive down costs, enable access to capital, and reduce risks for investors should all be considered in finding the right combination of policies that suit specific market needs. Approaches will vary from country to country, recognizing differences in economic status and that there is not a one-size-fits-all solution.

VEHICLE SUBSIDIES

Many countries, regions, and cities have already rolled out incentives in different formats and scales, the most common of which are direct vehicle purchase subsidies, providing cost reductions to the upfront price of a new ZE-MHDV. While vehicle incentives and subsidies are an important part of a robust ecosystem to support the acceleration to ZE-MHDVs, they are most effectively used to spur the market forward and to help achieve TCO cost parity in the near term. There are other effective uses of government dollars to reduce costs that are less capital intense and explored in later sections.

Examples of programs that are in effect and have seen success are Canada's iMHZEV program, offering point-of-sale cost reduction up to $200,000 for zero-emission trucks and buses.[51] The AanZET program in the Netherlands is offering a maximum subsidy of €115,200 for ZE-MHDVs over the next year.[52] Finland's program is offering subsidies from €6,000 to €50,000 for zero-emission vans and truck, and in Austria, the ENIN program funds up to 80 percent of the difference in cost between diesel and zero-emission.[53] [54] Similarly, in Ireland the ZEHDV grant funds a portion of the cost differential between diesel and zero-emission.[55] While these are just a sampling of the kinds of subsidy programs that have been deployed by Global MOU countries, thoughtful design and revision of programs based on market realities must be prioritized in their implementation. Set-asides for small fleets or specific vehicle types can be effective in stimulating a specific sector as has been seen through the HVIP program, unique to California.[56]

TAX BENEFITS AND EXEMPTIONS

Preferential taxation schemes are another pathway that many Global MOU countries have implemented to advance TCO of ZE-MHDVs in the near term. In countries like Lithuania, New Zealand, Austria, and Aruba, ZE-MHDVs are exempt from select road taxes, boosting operational savings. In Ireland, under the Vehicle Registration Tax for commercial electric vehicles, a lower rate will be introduced for vehicles with lower emissions thresholds. Denmark will introduce a kilometer-based and CO_2-differentiated road toll for trucks above 12 tons used for transportation of goods from January 1, 2025.[57] In Austria, ZE-MHDVs benefit from a 75 percent discount on the mileage-based motorway toll. Countries like Uruguay and Ukraine have reduced or eliminated value-added taxes on ZE-MHDVs, and Switzerland and Lichtenstein have eliminated the performance-based heavy-vehicle charge (kilometer-based road fee). Similarly, other countries have chosen to exempt ZE-MHDVs from purchase taxes or offer tax credits (for example, the U.S. offers 30 percent of a vehicle's cost as a tax credit, up to $40,000). In Switzerland, certain cantons offer tax rebates, and Uruguay offers a zero percent internal tax for EVs. In Türkiye, motor vehicle taxes and excise duties have been reduced for ZE-MHDVs as well. Incorporating novel taxation mechanisms that reward innovation are an important element to craft a robust policy ecosystem within a country. This is especially true for countries that may not have dedicated resources for large-scale subsidy programs. Ireland, for example, introduced a carbon tax in 2010, now at €56 per tonne, that will fund green initiatives through the revenue generated.[58] As technology costs decline, tax incentives can be rolled back, allowing governments to recover their tax revenues.

REDUCING FINANCING RISKS THROUGH GUARANTEES

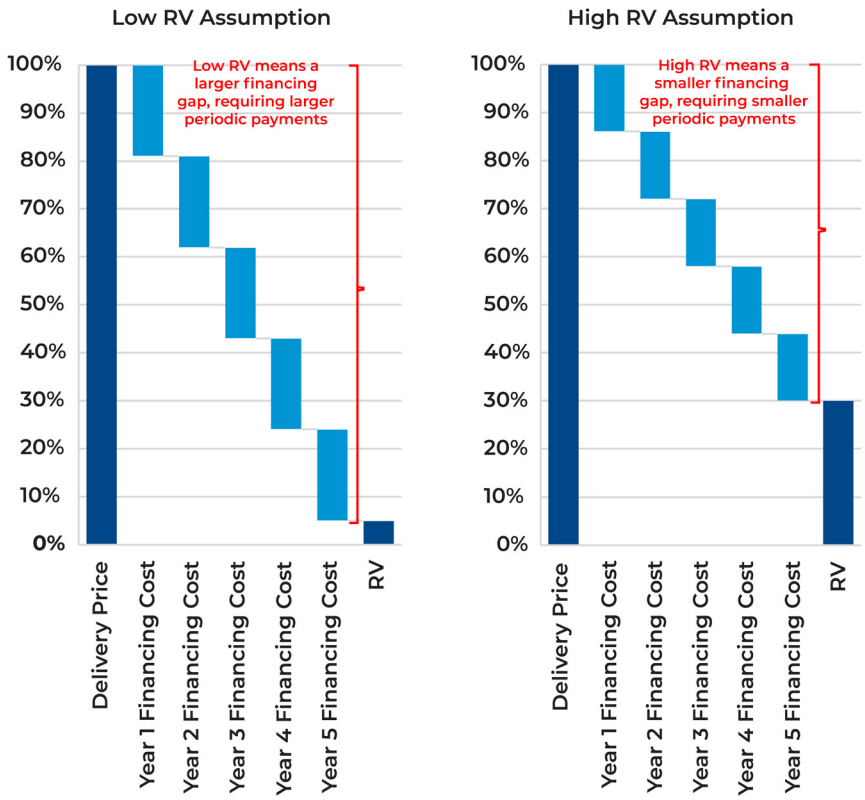
In finance, guarantees seek to improve financing conditions for projects to attract investment by protecting private investors against risks that they are usually not well suited to assess or manage.[59] Small fleets are often viewed as a greater financial liability than large fleets due to their lack of collateral, good credit, and liquidity, which results in financial institutions either rejecting their loan applications or offering poor loan terms with high interest rates, which impact TCO. Through the implementation of programs that effectively manage risks, such as credit and residual value guarantees, governments can broaden access to capital with significantly more favorable terms. Guarantees are highly effective in bringing in private investment with limited public spending, as funding is disbursed only when the guarantee conditions are triggered (e.g., a fleet is unable to make a loan repayment or the resale value of a truck falls below a certain threshold).[60]

In California, the Zero-Emission Truck Loan Pilot Project establishes a loan-loss reserve system to improve the credit profile of small businesses wishing to access loans for ZE-MHDV procurement. The loans are provided by third-party lenders, who are protected by the program against potential losses that could occur if the business is unable to make a payment.[61] For each qualified ZE-MHDV loan made, the California Air Resources Board contributes 25 percent of the loan amount into a participating lender's loan-loss account.[62] In the event of a qualifying loan default (i.e., the borrower is unable to repay), the lender can request reimbursement for the principal loss from the loan-loss account.[63] The previous iteration of this program, which was in place since 2009 and not exclusive to zero-emission technologies,

mobilized $11 in private investment for every $1 spent, financing more than 45,000 low-emission vehicles and demonstrating the efficacy of such measures to leverage private capital.[64]

In asset-backed financing, commonly used for trucks and other commercial vehicles, the value of the vehicle at the end of its first use is an important factor to define the amount of capital that will be provided, as well as the collateral that the lender or lessor can rely on in case of a default. Combustion engine vehicles have well-known residual values, given by decades of historical data on the price of used vehicles on the secondary market. This is not the case yet with ZE-MHDVs. As adoption is still in early stages, very few vehicles have entered the used market and technologies are rapidly improving. This uncertainty drives financiers to assign very low to zero residual values, which makes financing more expensive and harder to access. Thus, guarantees for the residual value of the vehicle can be effective and impactful measures to enable access to capital for fleets (Figure 10).[65]

Figure 10. Impact of Residual Value on Affordability of Financing Terms in 5-Year Vehicle Financing Case



Source: Nadkarni, K. (2024). Financing Fleet Electrification: Battery-Electric Truck Component Resale Highlights Residual Value Update. CALSTART. https://calstart.org/bet-component-residual-values.

SOFT LOANS

ZE-MHDVs cost more upfront but make up for this investment through the savings they generate when used. As such, fleets require financing solutions that allow them to borrow larger amounts, and to extend the repayment periods in a way that more accurately accounts for the multiple years that

the vehicle will be in operation to maximize savings. Soft loans (i.e., loans that offer lower interest rates, longer repayment periods, low upfront fees, and/or complementary incentives) can allow fleets to adopt these technologies and pay for them as they save. For emerging markets and developing economies, where public funding may be limited, development finance institutions can play a big role in facilitating access to finance by blending concessional resources with public- and private-sector funds.[66]

AGGREGATED PROCUREMENT

Aggregated procurement for ZE-MHDVs is an approach to vehicle acquisition that leverages the combined buying power of a group of companies or buyers that can effectively reduce the upfront purchase cost due to increased order size and economies of scale. By aggregating demand, strong signals are sent to original equipment manufacturers (OEMs) that there is demand for ZE-MHDVs in large volumes, providing those suppliers with greater certainty. Not only does this signal reach the private sector, it also sends the message to policymakers that fleets are ready to move beyond pilot deployments and acquire vehicles in significantly greater volumes.

In India, NITI Aayog and Convergence Energy Services Limited carried out an electric bus tender aggregating demand across cities, homogenizing procurement specifications, and requesting a procurement on a fully bundled (Gross Cost Contract) basis. The prices per km received were 23–27 percent lower than the equivalent cost of diesel or compressed natural gas buses without subsidies, and 31–25 percent lower when considering the subsidies. The first tender aggregated 5,450 electric buses across five cities.[67] The successful model has been replicated two additional times, facilitating procurement of 6,465 and 4,675 buses.[68]

In the U.S., a demand aggregation study carried out by the Fleet Electrification Coalition in partnership with Amazon identified a demand of more than 60,000 heavy-duty trucks over the next several years from the world's largest fleets across Europe and the U.S.[69] Similar efforts are unfolding in other parts of the world in countries such as India through the E-FAST program where a demand of approximately 7,750 zero-emission trucks has been identified.[70]

PUBLIC-PRIVATE PARTNERSHIPS

Electric buses, often seen as the precursor to electric trucks, are one of the most tested segments of the ZE-MHDV market. With consistent and fixed routes, stop-and-go urban duty cycles, and predominant return-to-base operations, electric buses lead the charge for MHDV electrification in many regions around the world. Like trucks, electric buses' higher upfront capital expenditure is offset by their significantly lower operating costs, making them financially viable over their useful life.

City transit buses can also take advantage of public-sector funding to facilitate effective public-private partnerships (PPP) to further advance viability. Through PPP, private energy companies supply buses and charging infrastructure while operators lease these buses, avoiding high upfront costs. This unique structure separates asset ownership and management from the day-to-day operation and maintenance of the bus fleet. The model effectively addresses the high initial costs associated with deploying electric buses by leveraging the financial capabilities of private investors and fleet providers. These private entities

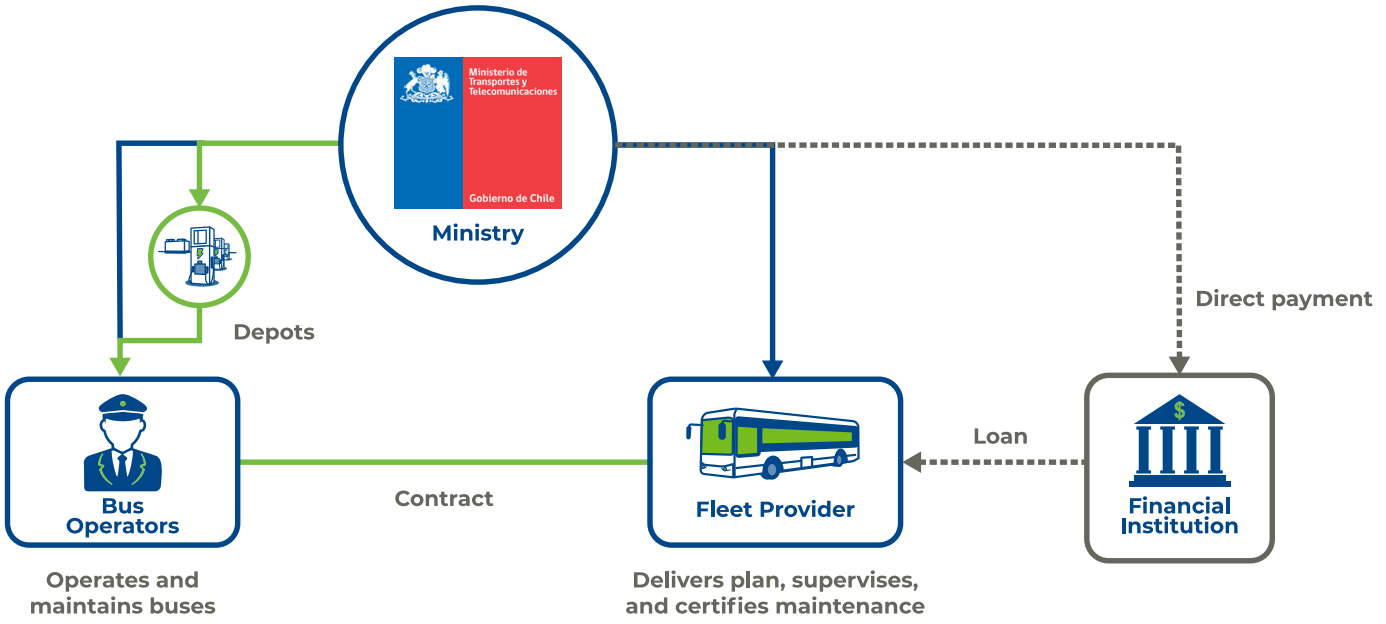
are responsible for acquiring, financing, owning, and maintaining the electric buses and charging infrastructure.

Chilean Bus Fleets

Chile's transition to electric buses, as part of its broader National Electromobility Strategy, focuses on achieving carbon neutrality by 2050. In Santiago, the PPP system for electric buses involves collaboration between the Ministry of Transport and Telecommunications and private electricity companies.[71] These private companies provide buses, charging infrastructure, and energy, while public transport operators lease the buses rather than purchasing them outright. The operators pay monthly leasing fees that cover fleet provision, charging infrastructure, and energy supply through this system.[72]

The leasing model separates ownership from operation and maintenance, with contracts lasting 10 to 15 years. More extended contracts for electric buses reduce monthly payments and increase competitiveness based on TCO. Moreover, government incentives such as tax exemptions, subsidies, and regulatory support further bolster and accelerate the financial feasibility of e-bus adoption.

Figure 11. Government of Chile Public-Private Partnerships Model



Source: Saka, F. (2020). How we made e-bus a reality in Santiago, Chile. C40 Knowledge Hub. https://www.c40knowledgehub.org/s/article/How-we-made-e-bus-a-reality-in-Santiago-Chile?language=en_US. Design modifications made by CALSTART.

The government plays a critical role in managing revenues from public transportation fares, ensuring that a portion is allocated toward the leasing payments, making the system financially sustainable for private investors and public operators. A third-party financial entity is typically involved in handling fare

revenue, deducting leasing fees from the operators' income to guarantee steady payments to the private investors. This minimizes financial risks for private companies, as the state guarantees that the buses will remain in operation until the debt is repaid.

By leveraging this PPP structure, the state ensures the availability of the latest electric bus technology and mitigates financial and operational risks for public transport operators and private-sector partners. Leasing contracts are central to this model, providing a stable and predictable revenue flow for the private companies that invest in the fleet and infrastructure.

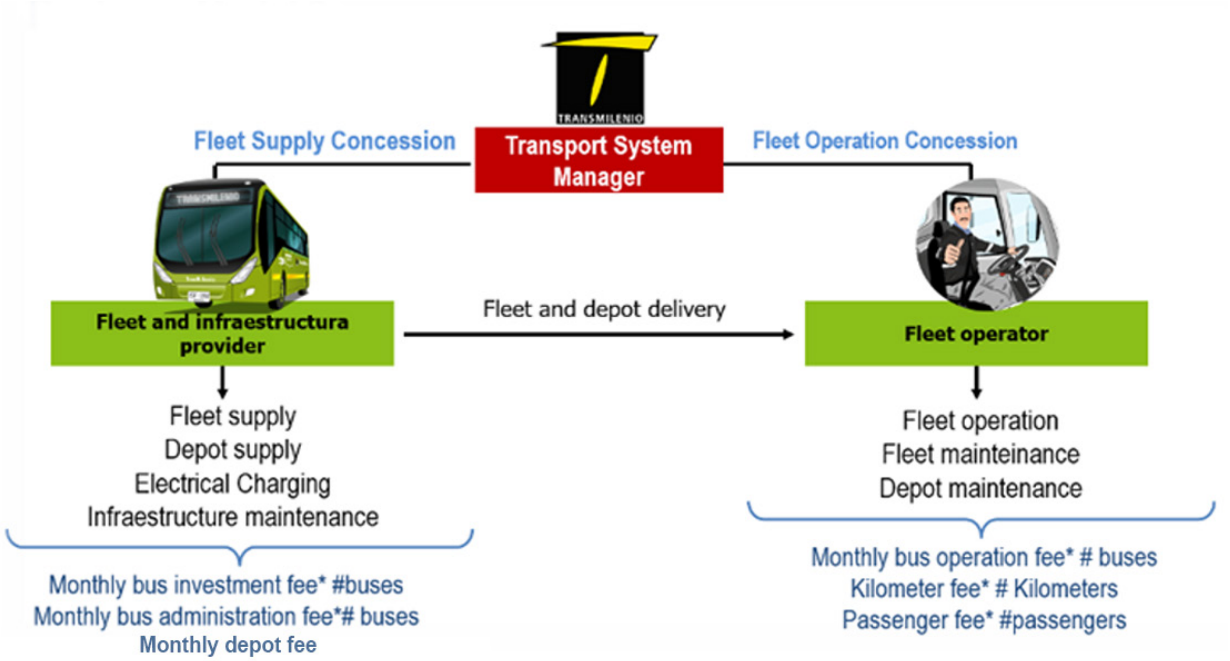
Colombian Bus Fleets

Colombia has implemented leasing and financing models to address the high upfront costs of ZE-MHDVs and the necessary infrastructure, specifically through PPP.[73] In this system, like in Santiago, Chile, private fleet providers own the buses and charging stations, while public transport operators contracted through TransMilenio oversee the buses' everyday operations.

TransMilenio implemented a new business model due to two main reasons. First, many areas in Bogotá were still not covered due to concessionaries' financial problems under the traditional model. Concessionaries were then unable to provide service to passengers. Second, concessionaires did not pay credits, so commercial funding was not willing to enter the transport business. With the traditional model, the asset ownership and operation was under the same concessionaire, many of whom did not pay their debts. A pivotal aspect of the new model is the concession contracts with operators, which extend to 15 years for electric buses (compared to 10 years for diesel buses).[74] This new model demanded many discussions with the financial and insurance sector about risk allocation, guarantees, and bankability. This longer concession period provides stability for investors and allows for a longer duration to recoup the higher initial investment costs of electric buses.

For the first business model, TransMilenio structured the concessions under three specific agents, each responsible for a different aspect of operations. Notably, this model was designed through contracts with a time frame of 15 years. Through proactive assessment and improvement, TransMilenio has simplified and restructured the business model to better address efficiency, bankability, flexibility, and the overall experience to the end user. For the second business model some changes were included, namely simplifying the structure and operations to two agents instead of three (Figure 12).

Figure 12. TransMilenio Updated Business Model



Source: TransMilenio S.A. (2023). Energy Transition in Transport Sector: Successful Case Study Bogota. Internal presentation.

This model has facilitated the rapid scaling of Bogotá's electric bus fleet, with 1,485 electric buses deployed as of 2024, and contributed to Colombia's GHG reduction goals and improvement in urban air quality.[75] Other Colombian cities are following this lead, as Medellín and Cali have deployed 69 and 36 buses respectively, bringing Colombia's total to approximately 1,590 electric buses in operation.

ACTIONABLE INSIGHTS: FINANCE

Investment in the ZE-MHDV transition must significantly increase to meet the goals of the Global MOU and the Paris Agreement. Recognizing the unique challenges that all fleets face, particularly small and medium fleets, there must also be a focus on new business models that better support the operational realities of ZE-MHDVs. Likewise, additional measures must be implemented to bring down the cost of financing to fleets and reduce the risk to financiers lending capital, especially for small-fleet borrowers. While there is no one-size-fits-all solution, guarantee mechanisms (i.e., credit and residual value) as well as soft loans have demonstrated significant potential for improving financing conditions. Direct subsidies for vehicles such as California's HVIP, the Dutch AanZET, and Canada's iMHZEV have been impactful early on, but at this stage, these programs must be deployed in conjunction with regulations or other policy measures and be compatible with leasing and "As-a-Service" models to ensure the greatest impact given their high cost of implementation.

SECTION III

IMPLEMENTATION ACTIVITIES

As the ambition for an accelerated transition to ZE-MHDVs increases, so must efforts around implementation. No single country, state, or city has the answer to the multitude of complexities surrounding such a massive systemic change to the fundamental way goods and people are moved. As such, this circumstance demands collaboration between stakeholders to maximize success, minimize risk, and ensure lessons learned are carried forward to avoid progress stalling due to challenges that others may have already successfully navigated. The momentum and support for the goals of the Global MOU by national governments and endorsers has enabled the formation of specific efforts aimed at tackling key roadblocks to unleashing greater, systemic change. In this section, these efforts are highlighted as examples of ways to get engaged and to showcase actions necessary to achieve a clean transportation future. With 38 countries aligned in Global MOU goals, a dozen countries advancing aligned regulations, and more contemplating a shift toward ZE-MHDVs, there is no time left to delay action—getting zero-emission trucks, buses, and infrastructure successfully on the map in every region is imperative. Whether it is the development of green road corridors, fleet transition planning, or regional stakeholder project collaboration, implementation time is now. The successes and failures learned will contribute to the transformation of a transportation system that is clean, equitable, and defining of a carbon-free era.

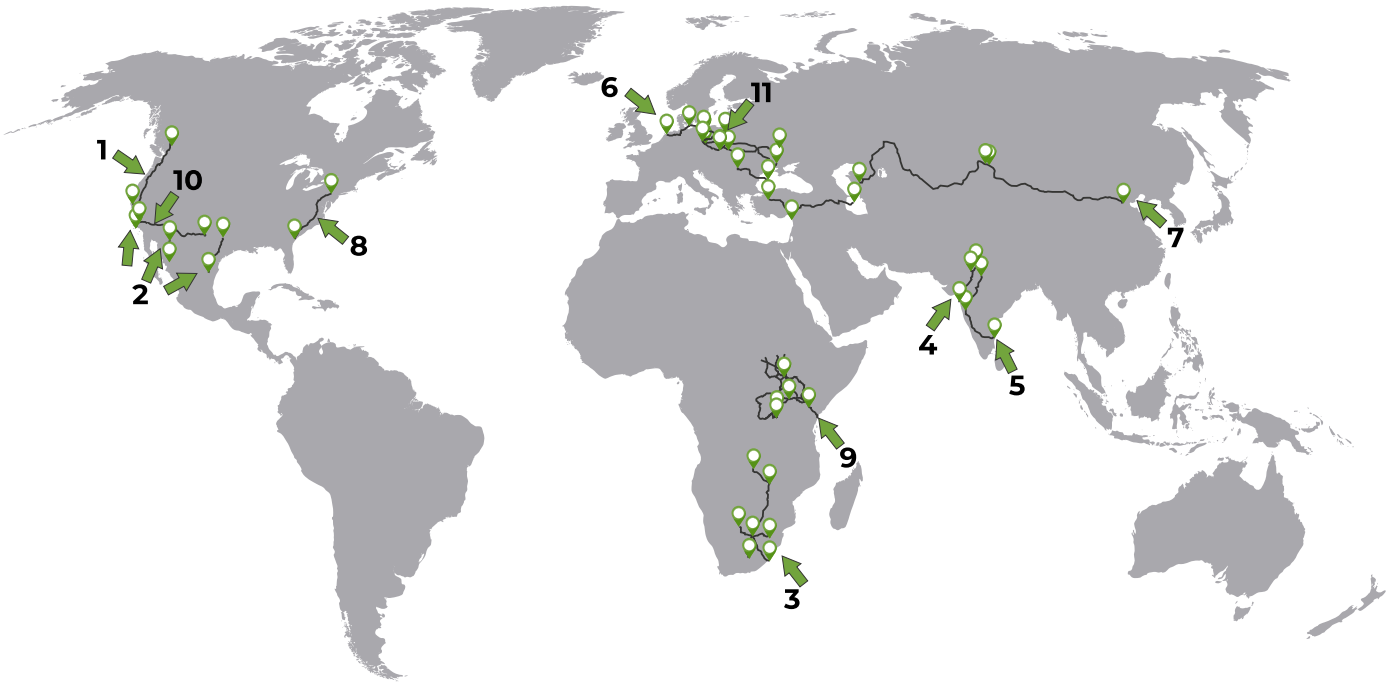
GREEN ROAD CORRIDORS

Road corridors are the backbone of the interconnected world. Building capacity around and ultimately launching corridor ecosystems inclusive of the ports, cities, and hubs they connect will support the needs of ZE-MHDVs enabling seamless long-haul freight operations and providing a pillar of action to achieve Global MOU 2040 goals. Establishing foundational conditions and understanding key enabling success factors that drive effectiveness, as well as identifying, organizing, and coordinating multiple stakeholders, is required to make an entity as complex as a zero-emission corridor succeed. By engaging, coordinating, and acting toward this concrete outcome, stakeholder action will become highly visible and produce vital lessons, giving rise to scaled transition.

This year, CALSTART's Global Drive to Zero program, alongside partners and allies in the ZEVWISE coalition, launched an ambitious Global Green Road Corridors (GGRC) initiative to advance a diverse set of the world's road corridors to transition to a ZE-MHDV ecosystem. As of this writing, eleven GGRCs have been announced with the support of broad networks, including government, industry, and financiers.

These corridors, each led by an array of different partners worldwide, will establish the basis for replicable, adaptable models that will accelerate global ZE-MHDV deployment (Figure 13) shared through a set of public briefings, internal clinics, and online resources rolling out in 2025.[76] GGRCs will serve as a real-time resource and framework for growth and success. Beyond the scope of the initiative, Drive to Zero has identified nearly 30 green road corridors in development worldwide and will continue building out and on the momentum, scale, and benefit of this effort.

Figure 13. Global Green Road Corridors



1	**FIFA 2026 Corridor:** Canada – USA – Mexico *(U.S.)*
2	**USA-Mexico Border Corridors:** California – Baja California, Texas – Nuevo Leon, Arizona – Sonora *(WBSCD)*
3	**Southern Africa Container Corridor:** Port of Durban, including South Africa, Lesotho, Eswatini, Zimbabwe, Botswana, and Zambia *(UNEP (ZEVWISE Focal Point))*
4	**India Corridor:** Mumbai – Delhi and Delhi – Jaipur *(WBSCD)*
5	**India Corridor II:** NH48: Delhi – Mumbai – Chennai *(ICCT)*
6	**European Corridor to Zero:** Netherlands, Germany, Poland, and Ukraine *(AVERE Ukraine / EVConsult)*
7	**Trans-Caspian International Transport Route (TITR) Corridor:** China, through Kazakhstan, Azerbaijan, Georgia, and Turkey to Europe *(UNEP (ZEVWISE Focal Point))*
8	**USA I-95 Corridor:** Georgia – New Jersey *(CALSTART)*
9	**Northern Corridor:** Kenya, Uganda, South Sudan, Rwanda, Burundi, and DRC *(NCTTCA)*
10	**I-10 Corridor:** California – Los Angeles, Palm Springs, Blythe, Arizona – Tuscon, New Mexico – Lordsburg, Vado *(Smart Freight Centre)*
11	**Poland Corridor:** Poznan, Warsaw, Wroclaw, Krakow *(Smart Freight Centre)*

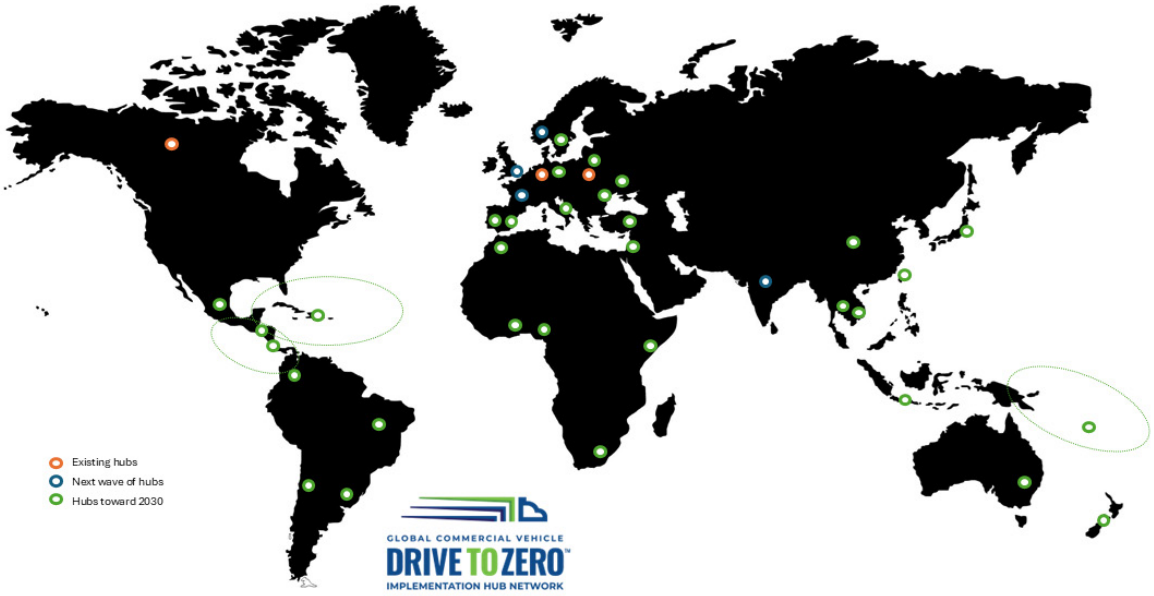
Learn more about the GGRC corridors, key stakeholders, and success factors in the recently published Global Green Road Corridors: Enabling Factors for Successful Launch, Development, and Scale.

GLOBAL IMPLEMENTATION HUB NETWORK

Recognizing the specific need to accelerate the deployment of ZE-MHDVs and unique barriers around costs and financing, implementation hubs seek to facilitate connections between the different entities involved in advancing solutions. Ensuring project bankability, access to affordable capital, and engaging partners that are looking to invest in this rapidly growing industry are all ways that implementation hubs will get more ZE-MHDVs on the road. Residing in the middle between fleets, financiers, governments, and other private-sector actors, there is significant capacity for matchmaking between those that need support in specific areas, and those with business models, financing mechanisms, and innovative approaches that can address those needs.

Drive to Zero is working collaboratively with fleet electrification experts around the world to build out a Global Implementation Hub Network that supports countries and fleets who set ambitious zero-emission transport goals (Figure 14).[77] As ZE-MHDVs are deployed with fleet support from the implementation hubs, the Global Implementation Hub Network gains insight into how policies and regulations are impacting adoption and the kind of technical support needed. These learnings are channeled toward government agencies, creating a feedback loop for policy improvement and accelerated adoption.

Figure 14. Global Implementation Hub Network



Each implementation hub is powered by a local organization that utilizes tools and tailored resources, co-developed with Drive to Zero, to provide information to fleets about replacement schedules, deployment costs, charging infrastructure requirements, model availability, financing solutions, and potential partners. The first hub was launched in the Netherlands in collaboration with Fier Sustainable Mobility in 2023, and another hub was launched earlier this year in Poland in collaboration with PSNM. New hubs will soon be launched in the United Kingdom and India.

Learn more about the Global Implementation Hub Network and the project's goal to encompass at least 30 local hubs by 2030 to enable the targets set by the Global MOU.

REGIONAL TASKFORCES

Local governance structure, socio-economic conditions, and physical geography are crucial to consider in designing solutions for creating a successful ZE-MHDV ecosystem. By embedding locale context in policy, regulation, and implementing programs, decision-makers will be positioned to effectively engage their constituencies, increasing the likelihood of success in entrenching new or improved rules and their implementation.

The Zero-Emission Vehicle Island Taskforce (ZEVIT) is one such example of this bespoke approach. ZEVIT convenes leaders from island nations who have signed the Global MOU, committing to work together to ensure all new sales of trucks and buses are zero-emission by 2040.[78] While the island nations' contributions to climate change are marginal, the impact that many of these countries will face due to sea level rise and more extreme weather patterns is disproportionate. As such, the imperative for action is even more pronounced and must begin now. For island nations specifically, there are numerous benefits to advancing zero-emission truck and bus deployments in these geographies, including reduced dependence on fossil fuels, improved air quality, cost-savings, and resilience against natural disasters. Members of ZEVIT come together to share their experiences, challenges, and opportunities related to truck and bus decarbonization, and they collaboratively work together to advance the transition. These exchanges will help to propel global, inclusive achievement of the goals set forth by the Global MOU.

This year, the taskforce has expanded participants' familiarity with the technological capabilities and deployment of electric buses in island contexts, learning from first-mover countries, importers, and research institutions to inform their ongoing deployment plans. Many island states are not eligible for Official Development Assistance despite being at the forefront of the climate crisis and sharing the many challenges of emerging markets. A first step in this direction was the expansion of the Zero Emission Vehicle Rapid Response Facility (see the Short-Term Technical Assistance subsection) to include countries located in developing regions as defined by the United Nations Statistical Division, in addition to those eligible for Official Development Assistance.[79]

Learn more about ZEVIT members and their areas of focus, including electric bus deployments, long-term infrastructure planning, supply-side mandates, and more.

SHORT-TERM TECHNICAL ASSISTANCE

Recognizing the imbalance in resources available to emerging markets, short-term technical assistance plays an important role in jumpstarting action to decarbonize MHDVs. Launched at COP27, the Zero Emission Vehicle Rapid Response Facility (ZEV-RRF) is an initiative of the Zero-Emission Vehicle Transition Council (ZEV-TC) aimed at providing targeted and simplified short-term technical assistance to emerging markets and developing economy (EMDEs) countries that are decarbonizing their road transportation sectors and transitioning to zero-emission vehicles.[80]

ZEV-RRF aims to execute short-term (18 months or less) tangible projects that develop and implement strategies, policies, and regulations to advance the global ZE-MHDV transition. ZEV-RRF operates in a "Hub and Spoke" model to create a single point of entry. The International Council on Clean Transportation (ICCT), secretariat of ZEV-TC, serves as the Hub; the Spokes are partner organizations with technical expertise in topics related to the transition and various geographies served. Drive to Zero/CALSTART, for example, is a spoke. The Hub collects requests from eligible countries and connects these countries' governments to the appropriate Spoke(s) able and willing to assist. The ZEV-RRF supports technical projects like research and scenario development, development of policies and regulations, project formulation, and technical trainings.

Emerging markets signatory to the Global MOU are eligible for support through the ZEV-RRF and are strongly encouraged to submit a request by filling out this form.

SECTION IV

PRIORITY ACTIONS

Global MOU nations are making important progress toward their 2040 goals, but the work ahead must accelerate with increasing momentum and scale. Based on analysis of underlying barriers and roadblocks for faster action, the Drive to Zero program, through detailed input and feedback from Global MOU countries and endorsers, has identified and refined the three primary pillars of action required over the next several years to keep the countries on track to transport decarbonization goals:

1. **Lock in regulation**: Secure supply-side regulations aligned with the targets adopted through the Global MOU.
2. **Roll out infrastructure planning**: Drive faster action in the most impactful and polluting applications, catalyzing direct involvement of the transportation and energy sector to develop zero-emission freight routes that consider the whole ecosystem, providing relief to the most pollution-damaged communities living near ports, logistics hubs, and highways.
3. **Unleash finance**: Accelerate the economic viability of ZE-MHDVs by establishing programs that use public and concessional funding to unleash private-sector investment in deployments and supportive infrastructure, mitigating the most pressing risks holding back financing, such as credit and residual value guarantees.

SECURE SUPPLY-SIDE REGULATIONS ALIGNED WITH GLOBAL MOU GOALS

The Global MOU establishes the international standard for achieving 100 percent zero-emitting trucks and buses by 2040. To move these policies into enforceable requirements, countries must promulgate regulations as done this past year in the U.S. and E.U. Regulatory options and lessons in the rulemaking process shared between nations within the Global MOU community have demonstrated that knowledge transfer is powerful for countries that may be just starting the process. Navigating opposition, working to build strong public-private coalitions, and making the benefits of the transition known to policymakers, businesses, and the public are all strategies employed by the Global MOU community to add value and insight to achieve Global MOU goals. Actions to progress Global MOU goals into aligned regulations include:

1. Pursue ZEV mandates as the simplest and cheapest regulation to set up, monitor, and enforce, locking in the pace of the transition and accelerating cost reductions through increased investments in innovation and production at scale. Other options include fuel efficiency standards and CO_2 regulations.
2. Identify and share the benefits of transportation decarbonization driven by regulatory measures with decision-makers by uplifting or commissioning robust studies that highlight job creation, TCO parity with diesel, and public health savings associated with cleaner air alongside meeting country climate targets.
3. Engage with Global MOU signatory countries and/or regions to learn about their policy choices and experiences with obstacles to understand how they tackled challenges.
4. Elevate information and case studies to decision-makers that demonstrate the availability of ZE-MHDVs and presence of innovative business models like the "As-a-Service" model to meet all use cases and showcase how leading businesses are adopting the zero-emitting trucks, buses, and infrastructure in the region.
5. Integrate diesel phase-out requirements (or restrictions on imports) implicating secondary markets to support a just and inclusive transition away from carbon-polluting vehicles.

DRIVE FASTER ACTION VIA TARGETED INFRASTRUCTURE AND GLOBAL GREEN ROAD CORRIDORS

ZE-MHDVs are finding great success operating in and around cities and between hubs, showcasing the proficiency of the technology in action. At this stage, the refueling network needs to expand at the pace of vehicle deployments. Corridors are the key to enabling longer trips without the need for additional battery capacity, effectively modulating costs associated with larger batteries while increasing the operational range that ZE-MHDVs can travel. When it comes to charging and hydrogen refueling stations, given they intersect both the transportation and energy sectors and often cross local or national borders, significantly more effort must be placed on collaboration and coordination between governments and other stakeholders—national and sub-national, the private sector, grid operators and utilities, and local communities. With this understanding, these large projects with multi-year time horizons must begin in earnest now if they are to support the 2030 goals of the Global MOU and enable the full transition by 2040. The following recommendations have been synthesized to ensure forward progress is made:

1. Identify national and local stakeholders. The first step is to firmly identify and understand the role of government agencies, the private sector, NGOs, grid operators, and others involved in the development of infrastructure for ZE-MHDVs.
2. Create roadmaps to forecast infrastructure demand and identify priority deployment locations. Infrastructure roadmaps are needed to align national progress through the identification of high-capacity freight corridors and urban hubs that result in highest impacts.
3. Create regulatory structures that direct utility investment toward ZE-MHDV infrastructure. Organize

a governance structure and accountable agency to oversee the timely buildout of infrastructure and coordinate efforts for near- and long-term grid modernization.

4. Identify future electricity needs inclusive of ZE-MHDVs to develop comprehensive plans for clean and resilient grid modernization.
5. Collect and standardize data that will feed infrastructure development strategies and plan the network buildout.
6. Direct utility action toward beneficial rate structures for fleet charging. Electric utilities must adjust electricity rate structures to ensure that fleets will not incur demand fees or higher costs from ZE-MHDV charging, particularly when charging off-peak. Utilities define different rates for different industries and must adjust similarly for MHDV charging.

ACCELERATE THE ECONOMIC VIABILITY OF ZE-MHDVS

With regulations establishing firm, actionable timelines for commercial vehicle decarbonization, the economic viability of ZE-MHDVs increases and invites actions to rapidly achieve TCO parity with diesel. Regulation helps plan across a long-time horizon and increases comfort to more risk-averse financiers; in tandem, financial products and approaches toward financing and residual value need to be baked into policy and practice to expedite TCO parity. Small and medium fleets must be a key consideration in the interventions deployed to reduce upfront costs, recognizing the unique roadblocks these fleets face as small enterprises. New business models have emerged that provide robust solutions to many of these challenges, but governments can do more to facilitate these efforts. While there is no single one-size-fits-all solution, governments are in a unique position to leverage private-sector actors enabling market mechanisms to facilitate the transition to zero-emission technologies as smoothly as possible.

1. Reduce investment uncertainties through regulation, standardized data collection, and long-term planning to shape the market in the mid to long term.
2. Focus public funds in areas with high potential to mobilize private investment, such as mitigating credit and residual value risks, and facilitate aggregated procurement.
3. Where economically feasible, implement a direct cash-purchase subsidy program alongside supply-side regulations for ZE-MHDVs that reduces the point-of-sale price of the vehicle, ensuring it is compatible with leasing and as-a-service business models that split ownership and use. Stand-alone subsidies are not sufficient.
4. Introduce tax-based mechanisms that exempt ZE-MHDVs from certain taxes or levy additional taxes or fees on polluting vehicles; revenues can be used to further finance zero-emission vehicles and supportive, clean infrastructure. Phase out fossil-fuel subsidies (for fully assembled vehicles and vehicle parts) that artificially keep prices of fossil fuels low at the expense of the environment and technology innovation—redirect funds to ZEVs.
5. For emerging economies, prioritize ZE-MHDVs in country strategy negotiations with multi-lateral development banks that have the capacity to leverage concessional funds and reduce costs of deployment through investment de-risking.

CONCLUSION

Today, transportation stands as the world's second largest contributor to global emissions, second only to the power sector. According to this year's 2024 UNEP Gap Report, which takes stock of each country's nationally determined contributions (NDCs), the world is not on track to limit warming to 1.5 degrees Celsius.[81] This crossroad marks a pivotal moment in which the world must choose progress or profits and pollution. With transportation relying on oil products for nearly 91 percent of its final energy consumption, a coordinated, global transformation must take place to decouple harmful externalities from transportation.[82]

The actions of decarbonizing the transport sector are grounded in a pollution-burdened reality that billions of individuals around the world face. Recognizing that demand for transportation, particularly freight, is expected to grow, there is a once-in-a-generation opportunity to double down on efforts to decarbonize this sector and deploy every tool available to reduce harmful emissions to both communities and the planet. It is not just a volume of preventable harms to avoid but an unprecedented opportunity to shape the future new generations deserve.

While it may be challenging, the path ahead must be done to achieve a clean and healthy future for all. Already, countries from across the world are making clear the need for the rapid decarbonization of MHDV transportation through regulations, deployment of infrastructure networks, and supporting fleets in their transitions. Recognizing that none of this can be achieved overnight, collaboration between governments and industry must prevail to co-create solutions that address the impact of this sector. In a way that has not been needed in the past, the energy sector and transportation sector must work in greater harmony to ensure growth in power production is in alignment with the growing energy demand of the transportation sector.

The priority actions outlined in this report provide a clear yet demanding path forward. Through the leadership of the 38 national governments united in their commitment to the Global MOU, and the more than 200 endorsers that have dedicated their actions to achieving Global MOU goals, the systemic decarbonization of the transport sector that is unfolding must grow in action and scale across all actors in the value chain—through innovation, collaboration, and persistence of will.

REFERENCES

1 World Bank Group (n.d.). Work Bank Open Data. Retrieved from: https://www.worldbank.org/ext/en/home

2 European Automobile Manufacturers' Association (2024). New commercial vehicle registrations: vans +15%, trucks +3%, buses +28.6% in H1 2024. Retrieved from: https://www.acea.auto/cv-registrations/new-commercial-vehicle-registrations-vans-15-trucks-3-buses-28-6-in-h1-2024

3 Ibid.

4 California Air Resources Board (2024). 1 in 6 new trucks, buses, and vans in California are zero-emission. Retrieved from: https://ww2.arb.ca.gov/news/1-6-new-trucks-buses-and-vans-california-are-zero-emission

5 Accelerating to Zero Coalition (2024). COP28 Progress Update. Retrieved from: https://acceleratingtozero.org/progress/cop-progress-update

6 United Nations Environment Programme (2024). Emissions Gap Report 2024. Retrieved from: https://www.unep.org/resources/emissions-gap-report-2024

7 International Energy Agency (n.d.) Transport. Retrieved from: https://www.iea.org/energy-system/transport

8 Accelerating to Zero Coalition (2024). COP28 Progress Update. Retrieved from: https://acceleratingtozero.org/progress/cop-progress-update

9 International Energy Agency (2023). Tracking Clean Energy Progress 2023: Tracking Transport. Retrieved from: https://www.iea.org/energy-system/transport#tracking

10 Welch, D. and Facanha, C. (2020). Moving Zero-Emission Freight Toward Commercialization. CALSTART. Retrieve from: https://globaldrivetozero.org/publication/moving-zero-emission-freight-toward-commercialization

11 Anenberg, S., Miller, J., Henze, D., and Minjares, R. (2019). A Global Snapshot of the Air Pollution-Related Health Impacts of Transportation Sector Emissions in 2010 and 2015. ICCT. Retrieved from: https://theicct.org/new-study-quantifies-the-global-health-impacts-of-vehicle-exhaust

12 U.S. Congress Joint Economic Committee (2024). Electrifying Heavy-Duty Vehicles Will Benefit the U.S. Economy, Environment, and Public Health. Retrieved from: https://www.jec.senate.gov/public/index.cfm/democrats/2024/4/electrifying-heavy-duty-vehicles-will-benefit-the-u-s-economy-environment-and-public-health

13 Accelerating to Zero Coalition (2024). COP28 Progress Update. Retrieved from: https://acceleratingtozero.org/progress/cop-progress-update

14 United Nations (n.d.). Key aspects of the Paris Agreement. Retrieved from: https://unfccc.int/most-requested/key-aspects-of-the-paris-agreement#:~:text=The%20Paris%20Agreement's%20central%20aim,further%20to%201.5%20degrees%20Celsius

15 United Nations (n.d.). Nationally Determined Contributions (NDCs). Retrieved from: https://unfccc.int/process-and-meetings/the-paris-agreement/nationally-determined-contributions-ndcs

16 CALSTART (2024). Drive to Zero's Zero-Emission Technology Inventory (ZETI) Tool Version 9.0. Retrieved from: https://globaldrivetozero.org/tools/zeti

17 Facanha, C., Van Amburg, B., Jenkins, P., and MacDonnell, O. (2022). Global Roadmap for Reaching 100% Zero-Emission Medium- and Heavy-Duty Vehicles by 2040. CALSTART. Retrieved from: https://globaldrivetozero.org/publication/global-roadmap-for-reaching-100-zero-emission-medium-and-heavy-duty-vehicles-by-2040

18 European Commission (n.d.). Reducing CO_2 emissions from heavy-duty vehicles. Retrieved from: https://climate.ec.europa.eu/eu-action/transport/road-transport-reducing-co2-emissions-vehicles/reducing-co2-emissions-heavy-duty-vehicles_en

19 European Council (2024). Euro 7: Council adopts new rules on emission limits for cars, vans and trucks. Retrieved from: https://www.consilium.europa.eu/en/press/press-releases/2024/04/12/euro-7-council-adopts-new-rules-on-emission-limits-for-cars-vans-and-trucks

20 Kasdan, J. (2024). EPA Phase 3 Rule Fact Sheet. Retrieved from: https://calstart.org/wp-content/uploads/2024/05/EPA-Phase-3-Rule-Fact-Sheet_Final.pdf

21 Ibid.

22 U.S. Environmental Protection Agency (2024). Final Rule: Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles. Retrieved from: https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-multi-pollutant-emissions-standards-model

23 California Air Resources Board (n.d.). Advanced Clean Trucks. Retrieved from: https://ww2.arb.ca.gov/our-work/programs/advanced-clean-trucks

24 California Air Resources Board (n.d.). Advanced Clean Fleets. Retrieved from: https://ww2.arb.ca.gov/our-work/programs/advanced-clean-fleets

25 Kasdan, J. and Steen, J. (2024). Fact Sheet: States Pave the Way for ZET Adoption: Assessing the Impact of ACT and ACF Through 2030. Retrieved from: https://calstart.org/wp-content/uploads/2024/08/Assessing-the-Impact-of-ACT-ACF-Fact-Sheet_Final-1.pdf

26 California Air Resources Board (2024). 1 in 6 new trucks, buses, and vans in California are zero-emission. Retrieved from: https://ww2.arb.ca.gov/news/1-6-new-trucks-buses-and-vans-california-are-zero-emission

27 International Energy Agency (2024). National Electromobility Strategy. Retrieved from: https://www.iea.org/policies/14381-national-electromobility-strategy

28 Government of Chile (2021). National Electromobility Strategy Launch: Government announces that only electric vehicles will be sold in Chile by 2035. Retrieved from: https://www.gob.cl/en/news/national-electromobility-strategy-launch-government-announces-only-electric-vehicles-will-be-sold-chile-2035/

29 Government of Chile Ministry of Energy (2021). Ministry of Energy celebrates approval of the first Energy Efficiency Law. Retrieved from: https://energia.gob.cl/noticias/nacional/ministerio-de-energia-celebra-aprobacion-de-primera-ley-de-eficiencia-energetica

30 European Commission (n.d.). Road charging (tolls and vignettes). Retrieved from: https://transport.ec.europa.eu/transport-modes/road/road-charging_en

31 Kulikowska, A. (2024). Denmark replaces Eurovignette with mileage-based truck toll from 2025. Trans.info. Retrieved from: https://trans.info/en/denmark-replaces-eurovignette-with-mileage-based-truck-toll-from-2025-395176

32 Koll, S. (2024). Netherlands to increase Eurovignette tariffs from January 2025. Here are the new rates. Trans.info. Retrieved from: https://trans.info/en/netherlands-to-increase-eurovignette-tariffs-396691

33 Republic of Lithuania (2024). Law on the Roads of the Republic on Lithuania: Current consolidated version. Retrieved from: https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/TAIS.17779/asr

34 Federal Office for Customs and Board Security (n.d.). R-15 Road traffic charges. Retrieved from: https://www.bazg.admin.ch/bazg/de/home/dokumentation/richtlinien/r-15-strassenverkehrsabgaben.html

35 Ministry of Infrastructure and Water (n.d.). Heavy goods vehicle charge in the Netherlands. Retrieved from: https://www.vrachtwagenheffing.nl/english

36 U.N. Environment Program (2020). Used vehicles get a second life in Africa – but at what cost? Retrieved from: https://www.unep.org/news-and-stories/story/used-vehicles-get-second-life-africa-what-cost

37 U.S. Department of Commerce (2024). Dominican Republic - Country Commercial Guide. Retrieved from: https://www.trade.gov/country-commercial-guides/dominican-republic-prohibited-restricted-imports

38 Ekhator, O. (2024). Ethiopia to ban importation of fuel-powered cars to focus on green mobility. Techpoint. Retrieved from: https://techpoint.africa/2024/02/08/ethiopia-ban-importation-fuel-powered-cars

39 European Commission (n.d.). ETS2: buildings, road transport and additional sectors. Retrieved from: https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/ets2-buildings-road-transport-and-additional-sectors_en

40 European Commission (n.d.). Alternative Fuels Infrastructure. Retrieved from: https://transport.ec.europa.eu/transport-themes/clean-transport/alternative-fuels-sustainable-mobility-europe/alternative-fuels-infrastructure_en

41 Pressacco, M. (2024). The new European Alternative Fuels Initiative is launched. Euro Funding. Retrieved from: https://euro-funding.com/en/blog/the-new-european-alternative-fuels-initiative-is-launched

42 U.S. Joint Office of Energy and Transportation (2024). National Zero-Emission Freight Corridor Strategy. Retrieved from: https://driveelectric.gov/files/zef-corridor-strategy.pdf

43 Gurman, R. (2021). Taking Commercial Fleet Electrification to Scale: Financing Barriers and Solutions. CALSTART. Retrieved from: https://globaldrivetozero.org/publication/taking-commercial-fleet-electrification-to-scale-financing-barriers-and-solutions

44 Ibid.

45 Gutierrez, L. (n.d.). Snapshot: Chile's EV charging point rules. Center for Energy Transition. Retrieved from: https://centra.uai.cl/las-reglas-para-los-puntos-de-carga-de-vehiculos-electricos-en-chile/?lang=en

46 Superintendencia de Electricidad Y Combustibles (2024). Pliego Técnico Normativo RIC N°15. Ministerio de Energia. Retrieved from: https://www.sec.cl/sitio-web/wp-content/uploads/2024/03/RIC-N15-Version-2024.pdf

47 Mobilidade Electrica (n.d.). The Network That Takes You Everywhere. Retrieved from: https://www.mobie.pt/en/mobienetwork/what-is-it

48 Koehler, L. and MacDougall, P. (2022). Accelerating Electric Vehicle Infrastructure: A How-to Guide for Regulators. Environmental Defense Fund. Retrieved from: https://blogs.edf.org/energyexchange/wp- content/blogs.dir/38/files/2022/02/Accelerating_Electric_Vehicle_Infrastructure.pdf

49 Basma, H., Rodriguez, F., Hildermeier, J., and Jahn, A. (2022). Electrifying Last-Mile Delivery: A total cost of ownership comparison of battery-electric and diesel trucks in Europe. ICCT. Retrieved from: https://theicct.org/wp-content/uploads/2022/06/tco-battery-diesel-delivery-trucks-jun2022.pdf

50 Basma, H. and Rodriguez, F. (2023). A Total Cost of Ownership Comparison of Truck Decarbonization Pathways in Europe. ICCT. Retrieved from: https://theicct.org/publication/total-cost-ownership-trucks-europe-nov23

51 Transport Canada (n.d.). Program overview. Government of Canada. Retrieved from: https://tc.canada.ca/en/road-transportation/innovative-technologies/zero-emission-vehicles/medium-heavy-duty-zero-emission-vehicles/program-overview

52 Ministry of Infrastructure and Water Management (2022). Purchase subsidy for zero-emission trucks (AanZET). Retrieved from: https://www.rvo.nl/subsidies-financiering/aanzet

53 Ministry of Transport and Communications (2023). Procurement and conversion aid to be extended to hydrogen-powered vans and trucks. Retrieved from: https://lvm.fi/-/hankinta-ja-muuntotuki-laajenee-vetykayttoisiin-paketti-ja-kuorma-autoihin

54 Austrian Research promotion Agency (n.d.). ENIN - Zero-emission commercial vehicles and infrastructure. Retrieved from: https://www.ffg.at/ENIN

55 Transport Infrastructure Ireland (n.d.). Zero-Emission Heavy Duty Vehicle Purchase Grant Scheme. Retrieved from: https://www.tii.ie/en/roads-tolling/alt-fuel-projects-unit/zero-emission-heavy-duty

56 California HVIP (n.d.). Funding Updates. Retrieved from: https://californiahvip.org/funding

57 KmToll (n.d.). How much toll do I have to pay? Retrieved from: https://vejafgifter.dk/en/how-much-do-i-have-to-pay

58 Houses of the Oireachtas (2024). Climate | Focus on the carbon tax. Retrieved from: https://www.oireachtas.ie/en/press-centre/news-and-features/20240326-climate-focus-on-the-carbon-tax/#:~:text=The%20Finance%20Act%202020%20has,per%20tonne%20of%20carbon%20dioxide.&text=How%20is%20the%20carbon%20tax%20used%3F

59 Garcia Coyne, R., Jimenez Vera, G., Monterrubio, M., Jimenez, J., Cerezo, A., and Garduno, T. (2023). Expanding Access to Financing for Zero-Emission Trucks in Latin America and the Caribbean. CALSTART. Retrieved from: https://globaldrivetozero.org/site/wp-content/uploads/2023/11/Expanding-Access-to-Financing-for-Zero-Emission-Trucks-in-Latin-America-and-the-Caribbean.pdf

60 Ibid.

61 California Air Resources Board (2024). Zero-Emission Truck Loan Pilot Project. Retrieved from: https://ww2.arb.ca.gov/resources/fact-sheets/zero-emission-truck-loan-pilot-project

62 Ibid.

63 California State Treasurer's Office (2024). CalCAP Zero-Emission Heavy-Duty Programs. Retrieved from: https://www.treasurer.ca.gov/cpcfa/calcap/zero-emission/index.asp

64 California Air Resources Board (n.d.). Truck Loan Assistance Program. Retrieved from: https://ww2.arb.ca.gov/our-work/programs/truck-loan-assistance-program

65 Nadkarni, K. (2024). Financing Fleet Electrification: Battery-Electric Truck Component Resale

Highlights Residual Value Update. CALSTART. Retrieved from: https://calstart.org/bet-component-residual-values

66 Garcia Coyne, R., Jimenez Vera, G., Monterrubio, M., Jimenez, J., Cerezo, A., and Garduno, T. (2023). Expanding Access to Financing for Zero-Emission Trucks in Latin America and the Caribbean. CALSTART. Retrieved from: https://globaldrivetozero.org/site/wp-content/uploads/2023/11/Expanding-Access-to-Financing-for-Zero-Emission-Trucks-in-Latin-America-and-the-Caribbean.pdf

67 Convergence (n.d.). The Grand Challenge for Electric Bus Deployment: Outcomes and Lessons for the Future. Retrieved from: https://www.convergence.co.in/public/images/electric_bus/Grand-Challenge-Case-Study-Final-Web-Version.pdf

68 Sustainable Bus (2023). New huge e-bus tender in India: 4,675 e-buses to be procured. Retrieved from: https://www.sustainable-bus.com/news/tender-india-grand-challenge-4675-cesl/

69 Smart Freight Centre (2023). Leading global companies unite to propel electric truck adoption in the United States and Europe and signal demand for more than 60,000 electric heavy duty trucks by 2030. Retrieved from: https://www.smartfreightcentre.org/en/about-sfc/news/smart-freight-centre-leading-global-companies-unite-to-propel-electric-truck

70 E-Fast India (n.d.) Signals of Demand for E-Freight. Retrieved from: https://efastindia.org/demand-aggregation

71 Partnership on Transparency in the Paris Agreement (2023). Getting the Finance Flowing: Chile. Retrieved from: https://transparency-partnership.net/system/files/migrated_document_files/chileebusesworldbank2023.pdf

72 Zero Emission Bus Rapid-Deployment Accelerator (2020). Case Study: Metbus Pioneering E-Bus Deployments in Santiago. Retrieved from: https://c40.my.salesforce.com/sfc/p/#36000001Enhz/a/1Q000000gQSR/ET0.2kS_O5ps_SIFrmwgPiDb95Z6inMj6uIjaIcF3mg

73 Zero Emission Bus Rapid-Deployment Accelerator (2023). Charging infrastructure for zero-emission buses — Strategies in Bogotá D.C., Colombia. Retrieved from: https://theicct.org/wp-content/uploads/2023/12/ID-53-–-Zero-emission-buses-in-Colombia_final.pdf

74 Batista, M. and Bastos, P. (2023). The Bogotá's business model for deploying electric buses. Transformative Urban Mobility Initiative. Retrieved from: https://transformative-mobility.org/wp-content/uploads/2023/05/Business-model-Bogota_EN.pdf

75 Mayor's Office of Bogotá D.C. (2022). By 2023, Bogotá will have the biggest electric fleet in the world after China. Retrieved from: https://bogota.gov.co/en/international/2023-bogota-will-have-biggest-electric-fleet-after-china

76 Serna, A. and Van Amburg, B. (2024). Global Green Road Corridors: Enabling Factors for Successful Launch, Development, and Scale. CALSTART. Retrieved from: https://globaldrivetozero.org/publication/ggrc-enabling-factors

77 Drive to Zero (n.d.). Global Implementation Hub Network. CALSTART. Retrieved from: https://globaldrivetozero.org/tools/network

78 Drive to Zero (n.d.) Zero-Emission Vehicle Island Task Force (ZEVIT). CALSTART. Retrieved from: https://globaldrivetozero.org/zero-emission-vehicle-island-taskforce-zevit

79 ZEV Transition Council (n.d.). ZEV Rapid Response Facility. Retrieved from: https://zevtc.org/global-commitment/zev-rapid-response-facility/

80 Ibid.

81 United Nations Environment Programme (2024). Emissions Gap Report 2024. Retrieved from: https://www.unep.org/resources/emissions-gap-report-2024

82 International Energy Agency (n.d.). Transport. Retrieved from: https://www.iea.org/energy-system/transport