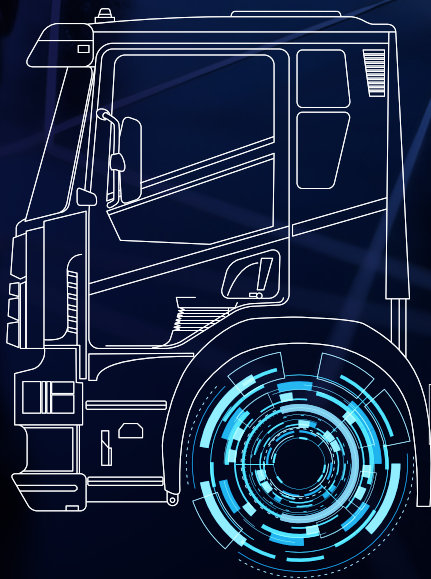


WHITE PAPER



GLOBAL PROGRESS TOWARD DECARBONIZING TRANSPORTATION: MULTI-COUNTRY ACTION PLAN 2023 UPDATE



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LIST OF ACRONYMS

ACT	Advanced Clean Trucks rule
AFIR	Alternative Fuel Infrastructure Regulation
BIL	U.S. Bipartisan Infrastructure Law
CO₂	Carbon dioxide
EPA	U.S. Environmental Protection Agency
FHWA	U.S. Federal Highway Administration
Global MOU	Global Memorandum of Understanding for Zero-Emission Medium- and Heavy-Duty Vehicles
GHG	Greenhouse gas
HDV	Heavy-duty vehicle
ICCT	International Council on Clean Transportation
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
MCAP	Multi-Country Action Plan
MHDV	Medium- and heavy-duty vehicle
NEVI	National Electric Vehicle Infrastructure Formula Program
NO_x	Nitrogen oxides
OEM	Original equipment manufacturer
PM_{2.5}	Particulate matter
TCO	Total cost of ownership
YoY	Year-over-year
ZE-MHDV	Zero-emission medium- and heavy-duty vehicle
ZETI	Zero-Emission Technology Inventory
ZEVI	Zero Emission Vehicle Island Taskforce
ZEV-RRF	Zero Emission Vehicle Rapid Response Facility
ZEV-TC	Zero-Emission Vehicle Transition Council

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EXECUTIVE SUMMARY

Over the past year, tremendous progress and accelerated momentum has occurred in the global, communal work required to rapidly drive commercial vehicles to be 100 percent zero-emission by 2040. Now totaling 27 signatory nations, and with more expected by year's end, the Global Memorandum of Understanding for Zero-Emission Medium- and Heavy-Duty Vehicles (Global MOU) has proven to be a powerful organizing and motivating force to accelerate this change. Recognized by the International Energy Agency in 2023 as one of the most effective programs to engage national action, the Global MOU via its signatory countries and industry and sub-national endorsers have made real, tangible progress against key priorities outlined last year in the first Multi-Country Action Plan (MCAP). The inaugural MCAP established a range of critical actions needed, including enacting strong regulatory requirements, implementing vehicle purchase incentives and infrastructure investments, and establishing other supportive policies.

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

- Eleven additional countries became Global MOU signatories, bringing the total number of signatories to 27.
- These nations represent four major world regions (North America, including the Caribbean; South America; Europe; and Oceania) and, when sub-national endorsers are included, five continents (Asia) that are now connected in joint action.
- These 27 nations contain roughly one in every five, or 20 percent, of all the medium- and heavy-duty vehicles (MHDVs) on the planet, an incredibly powerful market share to influence global production and supply chains.
- Showcasing the critical importance of regulations, nearly half of these nations are enacting or will be bound by new greenhouse gas (GHG) regulations for MHDVs being finalized this year that will require steadily increasing production of zero-emission MHDVs (ZE-MHDVs).
- The global availability of ZE-MHDVs has increased at an astounding pace, with nearly 850 different models of ZE-MHDVs available to purchase across all weight classes and applications, from delivery vans and urban work trucks through heavy regional distribution tractor-trailers—nearly 15 percent of these models are heavy-duty trucks.
- Equally impressive, sales of ZE-MHDVs in Global MOU countries grew approximately 104 percent over the previous year, compared to an average of 70.5 percent over the past five years.

- Multiple nations have enacted strong policies and made significant investments in ZE-MHDV recharging and refueling infrastructure, led by Europe’s Alternative Fuel Infrastructure Regulation.
- Others have implemented transportation infrastructure planning, such as the Transportation Decarbonization Blueprint in the United States, where a second and more detailed plan is under development. These roadmaps will become a priority for Global MOU nations in 2024, supported by additional MCAP tools.

These global actions are meaningful on their own. Taken together, as part of a coordinated, cooperative framework, they represent far greater impact. Leaders in 27 nations directly influencing one-fifth of the planet’s commercial vehicles are now amplifying their influence through these targeted and synchronized steps.

Much more remains to reach 100 percent zero emissions by 2040 and carbon neutrality by 2050, let alone the nearer-term goal of 30 percent new ZE-MHDV sales by 2030. Over this past year, the Intergovernmental Panel on Climate Change (IPCC) issued its most urgent warnings to date that while achieving needed climate reductions are still possible, they cannot be reached without significant GHG reductions within the next five years (IPCC, 2023).

This year’s MCAP details the progress made toward ZE-MHDVs by the 27 Global MOU countries that are leading this coordinated global effort. It also then highlights the priorities for action in the coming year and the next steps that should be applied to advance policy and implementation efforts in each country. The individuals, governments, companies, non-governmental organizations, and other stakeholders that constitute the Global MOU community are all trailblazing leaders in transportation decarbonization and dedicated to eliminating harmful pollutants and planet-warming emissions from the commercial transportation sector. The reality is that both the technology and collective will to implement this transition are here today. This year’s MCAP connects policy, investments, and actions to needed outcomes and stages of change. It provides insight into the leading policy and regulatory frameworks that are working and showcases the actionable “what” and “how” steps where governments can lead most effectively to enable smooth and just transitions in their economies.

Looking ahead, 2024 will be a critical time for all Global MOU nations. The following actions have emerged as top priorities for the coming year to stay on track for 2030, 2040, and 2050 goals:

1. **Strong Requirements:** Nations must adopt or advance a regulatory framework that reduces commercial vehicle GHGs and results in ZE-MHDV production and use. This foundational action is the most important, as it informs and aligns stakeholders, benchmarks, and timelines.
2. **Supporting Policies:** Regulators with the support of industry experts need to create the policies and strategies to de-risk investment in vehicles and infrastructure, reform electric grid operations to enable faster charging, and prioritize areas for early deployments. These actions will in turn create the next generation of best practices, tools, and policy instruments and entrench market certainty.
3. **Private Investment:** Increased capital from private investors is needed to scale the transition, far beyond what public funding can accomplish. Investments in vehicle production alongside zero-emission recharging and refueling infrastructure development must practically align with the

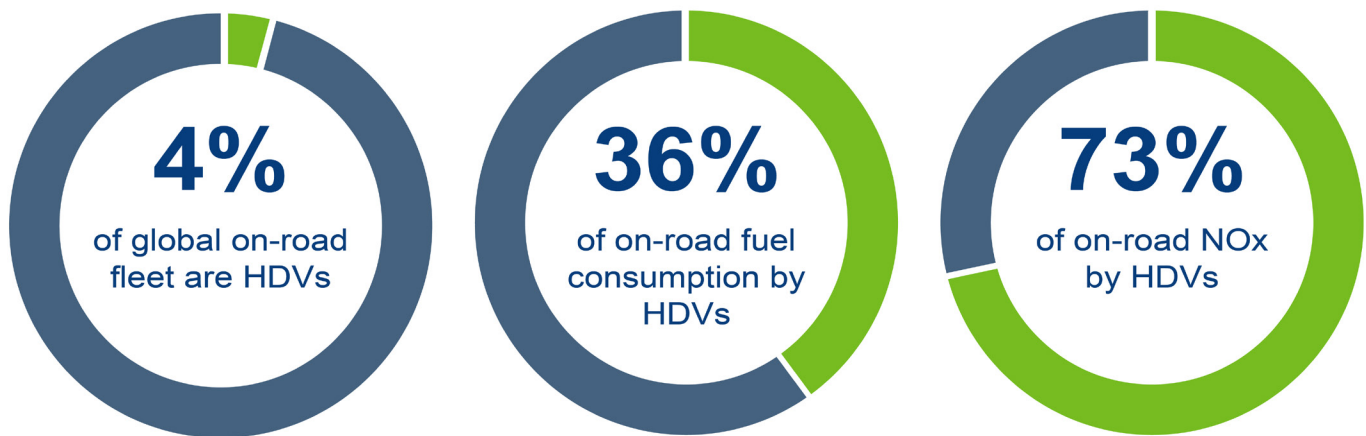
energy and vehicle needs to meet regulatory milestones and timelines.

4. **Infrastructure Roadmaps:** Energy, utility, and transport agencies and related stakeholders need to undertake infrastructure planning, forecast demand, and make targeted co-investments and deployments in highest priority geographies.
5. **Transport/Electric Grid Integration:** Political officials must delegate clear governance structures that turn the urgency for change in the transportation and energy sectors into synchronized actions with harmonized timelines for decarbonization. While energy production is being decarbonized at a faster rate than transportation, these two sectors are often moving separately and independently of one another. The critical integration of transport with energy—specifically with the electricity grid—needs to become a pillar of country infrastructure planning and requirements.

INTRODUCTION TO MCAP AND 2023 UPDATES

Transportation remains the sector showing the least progress in reducing emissions and is instead projected to continue to grow (Welch et al., 2020). The Global Memorandum of Understanding for Zero-Emission Medium- and Heavy-Duty Vehicles (Global MOU), managed jointly by the Government of The Netherlands and CALSTART's Global Commercial Vehicle Drive to Zero program, targets the decarbonization of medium- and heavy-duty vehicles (MHDVs)—the fastest growing transportation segment. Yet, this segment has significant and immediate opportunities to change course. MHDVs are a compelling target for emissions reduction because they are a relatively small share of the vehicle fleet accountable for an outsized impact. While constituting just 4 percent of the global on-road vehicle fleet, MHDVs are responsible for roughly 36 percent of on-road fuel consumption and upwards of 73 percent of nitrogen oxide (NOx) emissions (Welch et al., 2020). From 2020 to 2050, greenhouse gas (GHG) emissions from freight are expected to double, and harmful particulate matter (PM_{2.5}) associated with combusting diesel is predicted to increase by more than 40 percent in this time frame (Welch et al., 2020).

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



These vehicles disproportionately emit GHG and other harmful pollutants, making them a threat to both the climate and air quality. And, because of the concentration of MHDV-related emissions around ports, highways, and many cities, those already vulnerable communities living near these vehicles are further

overburdened by their pollution. Given the steep trends in the future growth of emissions from MHDVs, if meaningful action is to be taken against climate change and air pollution, the coordinated global undertaking to reduce the impact of MHDVs must succeed to ensure that the future of transportation and goods movement does not continue to have an adverse impact on the environment and public health. Facing these combined challenges, zero-emission technologies offer the only complete path forward.

The Global MOU¹ is the leading multi-national effort to rapidly decarbonize trucks, buses, and vans around the world. In 2021, sixteen leading nations (**Austria, Canada, Chile, Denmark, Finland, Luxembourg, The Netherlands, New Zealand, Norway, Portugal, Scotland, Switzerland, Turkey, United Kingdom, Uruguay, and Wales**) became the first wave of countries to sign the Global MOU, agreeing to work together to achieve 100 percent new sales of zero-emission MHDVs (ZE-MHDVs) by 2040, with an interim target of 30 percent new ZE-MHDV sales by 2030 (Drive to Zero, 2023a). These goals are aligned with the critical timelines defined by the Paris Agreement; only by including the decarbonization of the transportation sector will economy-wide, net-zero goals be possible.

To aid in turning the goals of the Global MOU into an actionable reality, the first Multi-Country Action Plan (MCAP), launched in 2022, sought to showcase the alignment of collective efforts of country signatories and partners. By illuminating each country's policy approach and priorities, the MCAP is designed to provide insights as to targeted efforts that other countries can mirror, borrow, or learn from to support and advance key actions across the globe.

Last year's inaugural report looked across five categories of policy targets, regulations, incentives, infrastructure, and innovation. Building on the progress defined last year, this updated report takes a more detailed focus on regulatory action, financing solutions, and infrastructure development—three areas at the forefront of the conversation on decarbonizing MHDVs. This update has been tailored based on input and requests from Global MOU countries and prioritizes specific areas where there are significant growth opportunities. With the collective ambition of the current 27 national government signatories, the MCAP serves as a guidepost for action. Beyond accounting for the year in review, it provides recommendations for action in the year ahead that are designed to be accessible to all countries, regardless of how new or advanced they are in the transition process. Given the urgency of the climate crisis and critical need to accelerate action now, 2024 must be defined by swift and decisive movement to enable the rapid decarbonization of the transportation sector around the world.

¹ For purposes of this MOU, MHDVs are vehicles with gross vehicle weight above 3,500 kilograms used for freight and passenger transport. ZE-MHDVs are MHDVs with zero tailpipe emissions.

CHAPTER II

GLOBAL MOU COUNTRY SIGNATORIES

At COP27, eleven new countries (**Aruba, Belgium, Croatia, Curaçao, Dominican Republic, Liechtenstein, Lithuania, Ireland, Saint Maarten, Ukraine, and United States of America**) announced their signature of the Global MOU, deepening the diverse roster of countries setting their sights on eliminating pollution from MHDVs. Now totaling 27 national government signatories, with more expected at COP28, and over 80 industry, sub-national government, and other stakeholder endorsers, the Global MOU community encompasses 20 percent of new annual MHDV sales globally (Figure 2).

Figure 2. National Government Signatories of the Global MOU



The Global MOU serves as a catalyst and platform for collaborative and action-oriented solutions to accelerate the deployment and uptake of ZE-MHDVs. To support the rapidly advancing nature of policy and action across Global MOU countries, this report serves as a snapshot of the ZE-MHDV policy landscape. However, for a more dynamic and robust representation of each country’s full spectrum of progress, please visit the Policy Suite hosted on the Drive to Zero website, which provides additional detail and granularity to each policy discussed in this report (Drive to Zero, 2023b).

CHAPTER III

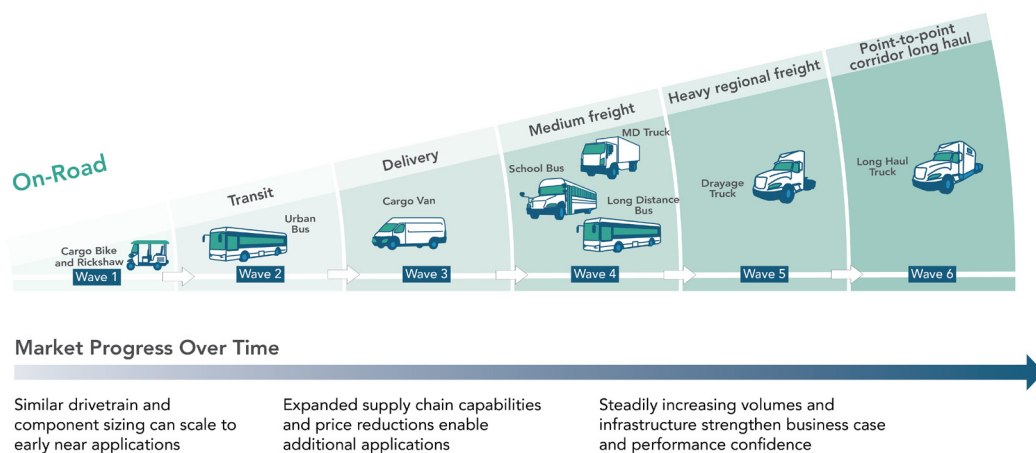
ADVANCEMENTS ON THE ROAD TO 2040

With global trends in logistics, freight, and people movement forecast to increase, transportation emissions will also increase significantly without intervention. Yet, major technological developments in battery-electric vehicle technology over the past few years have positioned zero-emission trucks and buses as the primary pathway to decarbonize the road transportation sector. A growing number of MHDV original equipment manufacturers (OEMs) have demonstrated strong ambitions by producing zero-emission commercial vehicles in increasing volumes and rapidly increasing production, with most OEMs aiming for 2040 to completely decarbonize their commercial vehicle products, coinciding with the goals of the Global MOU and adding to aligned decarbonization efforts (Garcia Coyne, 2021).

SMART MARKET SEGMENTATION

It is important to recognize that zero-emission commercial vehicle adoption has happened—and will continue to happen—in waves. Focusing investments first on segments easiest to electrify (i.e., short- to mid-distance, back-to-base operations, predictable operational patterns, lighter loads) helps advance zero-emission technology into larger markets and other applications (CALSTART and California Air Resources Board, 2022). Knowing which applications will electrify first also allows stakeholders to prioritize locations for charging infrastructure buildout and builds confidence as knowledge and experience grow.

Figure 3. CALSTART's First-Mover Strategy for ZE-MHDV Commercialization

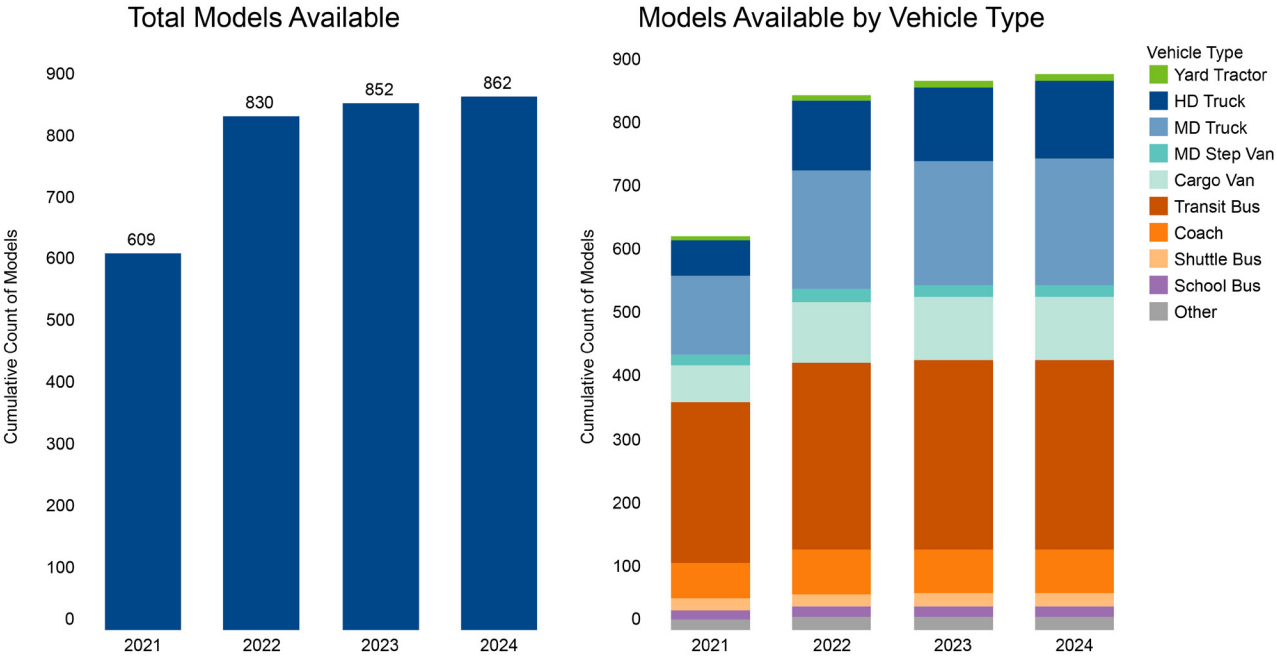


The waves illustrated above are not inherently sequential, and progress can be made across each wave simultaneously. Technology transfer (i.e., the use of similar powertrains and components such as motors and batteries across vehicle segments) has facilitated rapid expansion across these waves in the last decade. This has allowed supply chains to grow and costs to fall, thereby accelerating ZE-MHDV commercialization (see the Adoption Curves section below). However, this approach must also be complimented by a supportive policy environment, robust infrastructure development, and innovative financing models.

MODEL AVAILABILITY

There are currently over 850 ZE-MHDVs available for purchase today worldwide from 146 OEMs, the majority of which are transit buses, commercial vans, and urban trucks. As these initial vehicle waves have developed, the progression in technology and manufacturing has enabled the rollout of heavy-duty tractor-trucks into the market. The Zero-Emission Technology Inventory (ZETI) currently reflects the availability of approximately 116 heavy-duty truck models available for purchase in markets around the world, demonstrating the readiness of the technology to meet demanding but feasible short-haul and regional routes (Drive to Zero, 2023c).

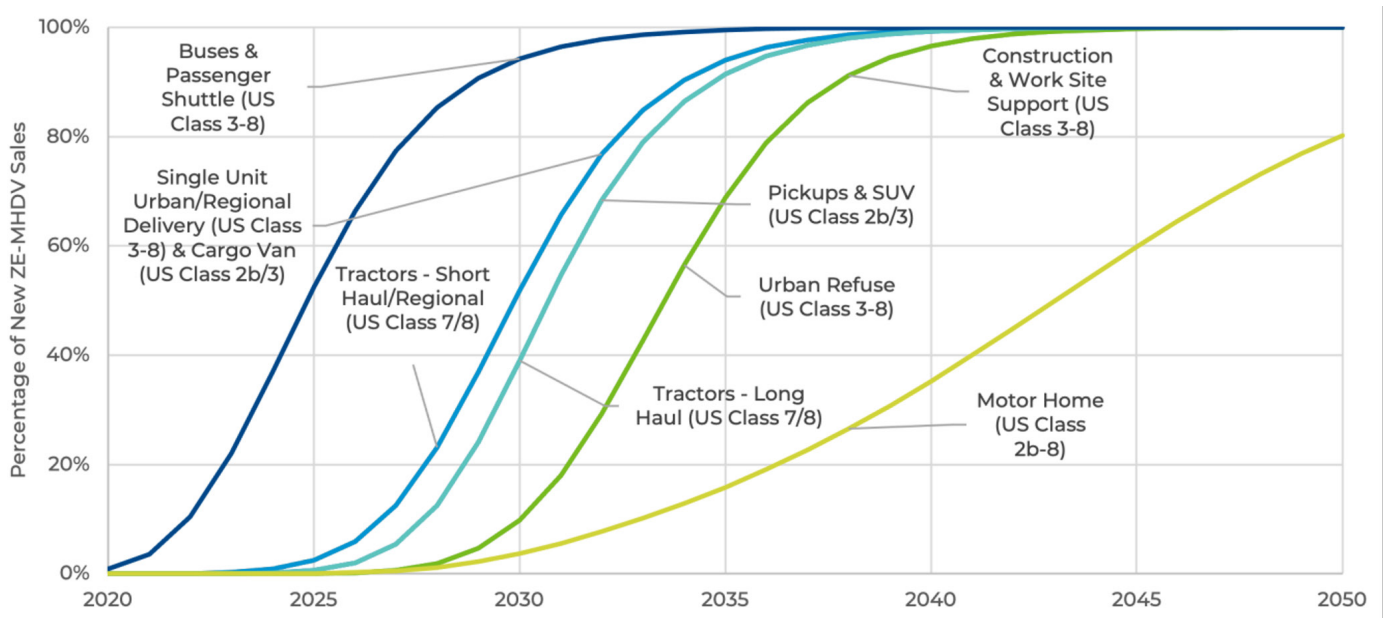
Figure 4. Cumulative Global Count of ZE-MHDVs Available for Purchase by Segment 2021-2024 (Drive to Zero, 2023c)



ADOPTION CURVES

In the pursuit toward a full transition to new ZE-MHDVs by 2040, the question of what vehicles should come first or how the transition prioritizes certain vehicle types arises. Recognizing the great diversity across MHDV segments, CALSTART developed ambitious but feasible adoption curves for eight MHDV segments (Al-Alawi et al., 2022). Figure 5 illustrates such disaggregated adoption curves, which collectively show the path to a full transition toward 100 percent ZE-MHDV sales by 2040 (Al-Alawi et al., 2022).

Figure 5. Global ZE-MHDV Projected Sales Targets in Alignment with the Global MOU



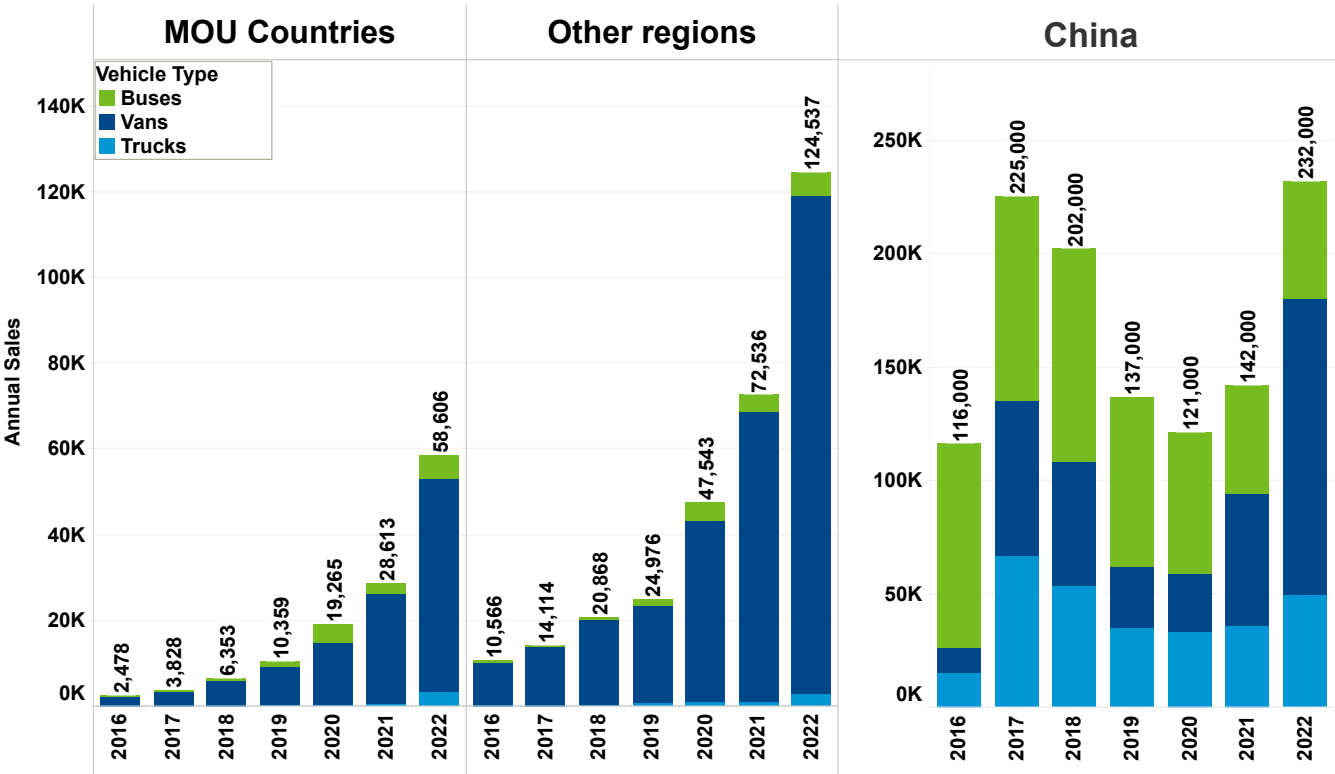
While the modeled projections presented above have not changed since last year’s MCAP, experience in Global MOU countries such as Finland, Denmark, The Netherlands, and Norway demonstrates that early segments are foundational to the transition (Nix, 2022). Over the past years, these countries, among others, have achieved a majority of new bus sales being zero-emission. The modeled projections presented in Figure 5 are supported and reflected in deployment and registration data for new ZE-MHDVs deployed in Global MOU countries (MacDonnell et al., 2022). As momentum continues to build across vehicle segments, zero-emission buses and smaller trucks are resulting in heavier trucks through development and scaling of key vehicle components such as batteries and motors. The sequenced approach in the modeled projections recognizes the timing for technology readiness of different types of ZE-MHDVs, and that zero-emission technologies are transferred across platforms as innovation and economies of scale drive down costs.

SALES AND REGISTRATIONS

In the past year, sales and registrations of new ZE-MHDVs have experienced tremendous growth (approximately 104 percent year-over-year (YoY) compared to an average of 70.5 percent over the past

five years), as shown in Figure 6 below. The trends seen in sales across markets continue to advance favorably for ZE-MHDVs, especially zero-emission trucks, with sales growing approximately 732 percent YoY within the 27 Global MOU countries. While not a signatory of the Global MOU, China’s ZE-MHDV market has moved significantly faster than any other region in the world, with an acute focus on the development of zero-emission buses, urban trucks, and vans.

Figure 6. ZE-MHDV Sales in Global MOU Countries, Other Regions, and China



SHIFTING NARRATIVE

The narrative around technology has shifted beyond doubts on the vehicles and their component parts. The focus now is on political will, acceleration of the transition timeline, and the need for a supportive ecosystem inclusive of infrastructure and financing solutions. While there is still room for growth across vehicle types, zero-emission technology is available, ready, and on the road—it is incumbent on governments around the world to stand up requirements that solidify the ZE-MHDV future. An equitable transition for fleets of all sizes must be embedded in country policy, as well as the development of national charging networks for commercial vehicles. The key to a successful transition, healthy communities, and a sustainable planet will be unprecedented collaboration across borders and industry unlocked by firm country policy.

CHAPTER IV

MCAP PRIORITY UPDATES

A signature or endorsement of the Global MOU is the first step in the transition to widespread adoption of ZE-MHDVs. However, without additional action, the business-as-usual trajectory of the market does not have the conditions needed to achieve the goals of the Paris Agreement within the 2050 timeframe. The following three dimensions of this year's MCAP—Policy, Finance, and Infrastructure—are pivotal areas of action needed in 2024. The following sections offer high-level analyses and examples of progress made to date and provide strategic pathways for countries to make measurable strides in these areas in the coming year.

A. POLICY: SOLIDIFY TARGETS AND REGULATIONS

Establishing clear and ambitious targets for the deployment of ZE-MHDV technologies are foundational to ensure fleet operators, manufacturers, utility providers, local authorities, and other stakeholders plan for the technology transition, make the needed supply chain investments, explore innovative financing mechanisms, and educate the workforce. Regulations that limit harmful emissions like GHGs and NOx, establish fuel economy standards, or create sales mandates for manufacturers solidify the market trajectory to accelerate industry and bring down cost. While regulatory obligations will not succeed in a vacuum and must be joined by investment, collaboration, and implementation, they are the vital precursor, establishing timelines and allocating responsibility for action or inaction. As manufacturers need to produce more ZE-MHDVs to comply with regulatory requirements, economies of scale for key components will be achieved on a more advanced timeline.

The importance of firm regulatory action is imperative, especially for large economies with significant manufacturing capability. Many smaller economies are limited to importing vehicles, and without sufficient supply—driven primarily by regulatory benchmarks—the transition could be stalled. This section provides a high-level overview of the progression of policies driving MHDV electrification in Global MOU countries, focusing on high-impact interventions that will accelerate decarbonization efforts. The following content is not intended to cover every policy and action taking place. Rather, it is meant to highlight the most important, game-changing measures, as well as recommended next steps depending on where a country may be in the regulatory process.

TRACKING POLICY ACTION

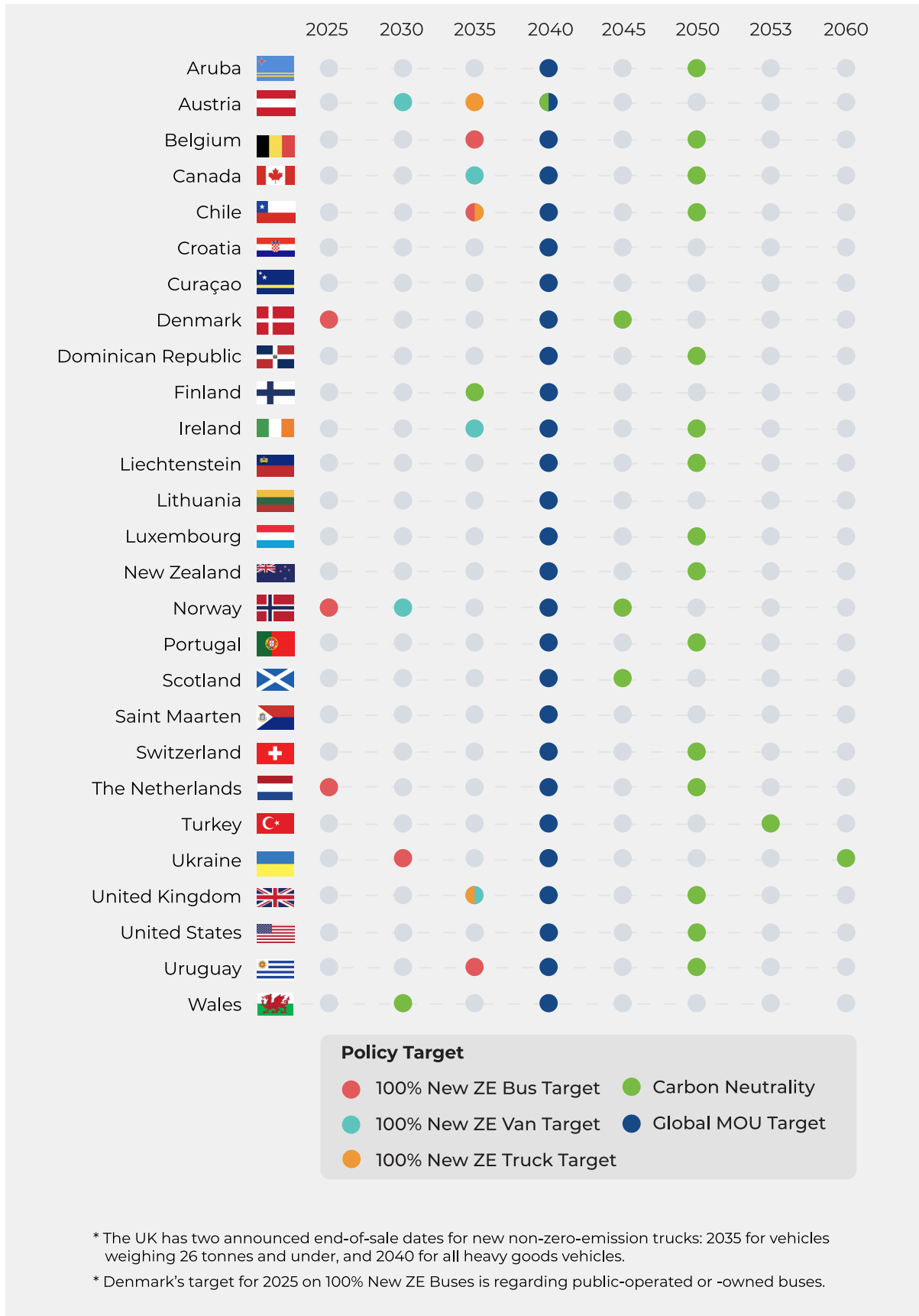
Setting targets is a critical first step for countries to meet their broad, economy-wide climate goals by targeting a sector that is one of the largest and fastest growing global emitters (IEA, 2023a). Countries committing to such targets through the Global MOU set in motion the plans, expectations, and alignment of all implicated stakeholders (Figure 7).

Figure 7. Global MOU Policy Framework



Recognizing the non-linear purchasing schemes many truck and bus fleets operate for their fleet renewals, it is vital that the target to end sales of fossil fuel-powered MHDVs be 2040 at the latest to enable carbon neutrality by 2050. Figure 8 highlights specific policy targets established by the Global MOU countries in a timeline and shows where countries have set more specific targets for certain vehicle types, like buses and vans, where technology and costs are well positioned for commercialization.

Figure 8. Timeline of ZE-MHDV Targets Established by Governments



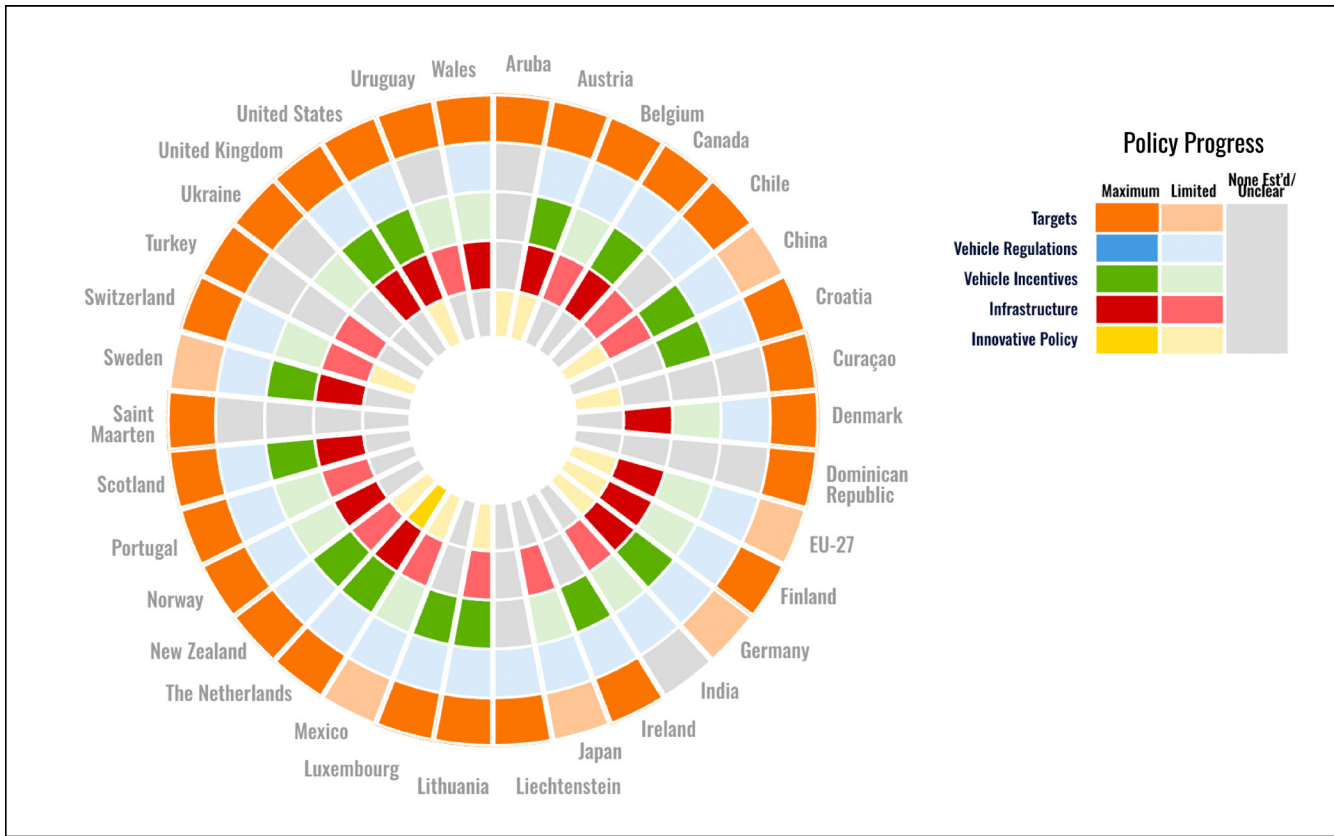
There are several proven ZE-MHDV policy options to meet the distinct purview and size of different economies. Solutions developed in one part of the world may not translate or fit the needs of other countries. However, sharing knowledge, perspective, and experiences across countries enables decision makers to advance policy mechanisms from a place of awareness and as part of a multi-stakeholder collaboration, thus resulting in more dynamic, informed, and expeditious progress. While the necessity of MHDV decarbonization is immediate and action must be global, it is incumbent upon countries of the Global North, responsible for the lion's share of transport-related pollution historically, to be at the forefront of transitioning the sector.

Global MOU Spotlight: ZEVIT

The Zero Emission Vehicle Island Taskforce (ZEVIT) is an action-driven initiative co-led by MOU signatories to identify, develop, and amplify solutions to decarbonize trucks and buses in small island states. The unique characteristics of these small island states—lighter vehicle fleets, more expensive fuel prices, shorter freight route distances, and renewable energy generation potential—make them prime, essential regions for accelerated fleet electrification.

Figure 9 is a visual representation of the policy action toward enabling the goals of the Global MOU. The wheel illustrates the progression of each country across five dimensions of policy and provides an at-a-glance summary (Drive to Zero, 2023d). This visualization is taken from an online tool tracking the policy progress of Global MOU countries, and several additional regions are included due to their industry prevalence, such as China and Germany.

Figure 9. Global MOU Progress Dashboard: Country Policy Status



Many countries have elected to establish more ambitious targets for the phase-in of vehicle technologies that have advantageous operational attributes, such as buses or vans. While targets play an important role in initializing action, to establish greater market certainty and send the right signals to stakeholders, regulations that support these targets must be enacted to achieve maximum impact.

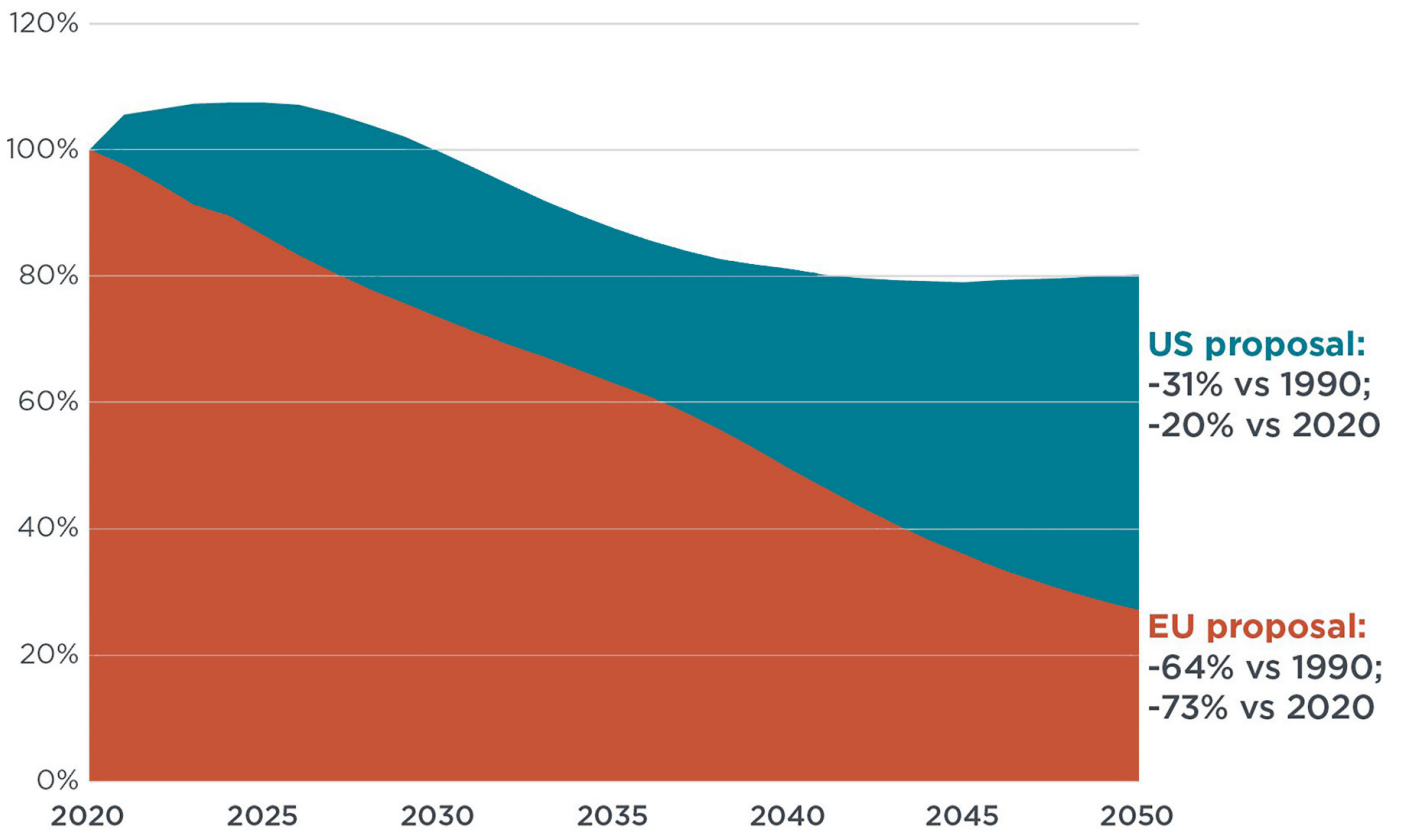
REGULATORY SPOTLIGHT: EUROPEAN UNION AND UNITED STATES OF AMERICA

Over the past year, the European Commission and the U.S. Environmental Protection Agency (EPA) respectively released new proposals to reduce GHG emissions from HDVs to align more closely with the goals of the Paris Agreement and reality of zero-emission vehicle technology. These proposals mean that 11 out of the 27 nations in the Global MOU will likely be covered by binding regulations for GHGs from MHDVs, including the United States and 10 European countries in a historic effort to accelerate the decarbonization of the transportation sector. These GHG standards differ significantly in their ambition and approach, but both take aim at reducing the amount of carbon dioxide (CO₂) emitted by HDVs. Improving the fuel economy of trucks may take several forms, but the requirements are typically technology-neutral, thus allowing manufacturers (the subject of the regulation) some flexibility on how to meet the minimum standards. For the first time in the United States, the proposed EPA Phase 3 standards, while not requiring zero-emission vehicle sales specifically, were built around an assumed sales rate of zero-emission vehicles to meet the reduction goals.

The proposal from the European Commission sets GHG targets for HDVs, aiming for 45 percent reduction by 2030, 65 percent reduction by 2035, and 90 percent reduction by 2040—all compared to the baseline of 2019 (Xie et al., 2023). The U.S. EPA, while also targeting GHG emissions from HDVs, has proposed limits on GHGs based on the projected adoption rate of ZE-MHDVs segmented by vehicle type (U.S. EPA, 2023). Generally, the proposed E.U. policy sends a significantly stronger market signal to manufacturers to ramp up production and extends clear targets through 2040. The U.S. EPA's market-driven proposal only extends through 2032 and effectively creates a floor to ensure a minimum reduction of GHGs from HDVs. The U.S. proposal comes amid efforts by California and nine other U.S. states that have enacted strong sales requirements for ZE-MHDVs through the Advanced Clean Truck (ACT) rule, which will be discussed later in this section.

The following figure, developed by the International Council on Clean Transportation (ICCT), illustrates the projected impact of the two proposed regulations and highlights the significantly higher reduction of CO₂ achieved by 2050 through the current proposed standard put forth by the European Commission (Xie et al., 2023).

Figure 10. Tank-to-wheel HDV CO₂ Emissions Based on Most Recent Proposed E.U., U.S. Standards (Xie et al., 2023)



While both proposals—each still to be finalized—represent significant advancements from former standards, there is still need for improvement. Neither proposal requires 100 percent reduction in CO₂ emissions, leaving the door open to technologies that are not zero-emission and continuing to facilitate the use of fossil fuels. These performance-based standards differ from other supply-side regulations aimed at boosting latent supply of ZE-MHDVs to advance the market. Regulation that requires vehicle manufacturers to reduce GHGs emitted through the operations of their vehicles is just one mechanism that can be deployed.

GHGs aside, there are a significant number of other pollutants that have a direct impact on public health and air quality. Emissions standards refer to regulations that establish limits on the harmful pollutants that trucks emit as a result of the combustion of fossil fuels. Such pollutants like NO_x, PM_{2.5}, and hydrocarbons are common byproducts of combustion and contribute to smog, air pollution, and harmful health impacts. These chemicals are limited by regional policies, such as the Euro VI vehicle emissions standards in Europe and the Clean Trucks Plan in the United States, and establish performance-based limits on specific air pollutants. Emissions standard stringency has gradually increased over the past decade and has resulted in significant reductions in pollutants, resulting in cleaner air in these geographies. Many other countries have chosen to adopt aligned policies to limit the pollutants emitted by trucks, but depending on the stage of development, may lag behind the most ambitious standards. These regulations typically establish a date after which all new vehicles sold or imported must comply with the latest standards, thus ensuring a gradual phase-out of emissions.

One of the strongest regulatory pathways found worldwide, originated in the U.S. state of California, is the Advanced Clean Trucks (ACT) rule. ACT establishes sales requirements for zero-emission vehicles. Sales requirements obligate vehicle manufacturers to sell zero-emission vehicles as an increasing percentage of their total annual sales. This kind of regulation, also referred to as a zero-emission vehicle mandate, creates a minimum market for manufacturers of zero-emission trucks to grow their businesses, develop their supply chains, and innovate to meet new duty cycles. The regulation not only ensures that the transition will happen, but it is also a highly effective intervention in economic terms: regulatory analysis done by the California Air Resources Board showed that the economic benefits of ACT compliance exceed its costs by a factor of 1.5 (Buysse and Sharpe, 2020). In other words, every \$1 in costs would generate \$1.5 in benefits. By 2040, ACT will have generated economic savings of \$5.9 billion and avoided \$8.9 billion in health costs due to air pollution. In addition to California, nine other states have followed suit in enacting ACT regulations, including New Mexico, Colorado, and Vermont in the past year. A parallel regulation, also in California, is the Advanced Clean Fleets rule, which requires fleet operators to purchase progressive percentages of zero-emitting trucks and buses annually until 100 percent of fleets are zero-emitting by 2045.

Sales requirements are one of the most effective ways to compel private-sector actors, specifically manufacturers, to increase supply and scale production. This in turn provides certainty to the ecosystem of other stakeholders, motivating investments in zero-emission fleets and grid upgrades and buildout. It also gives confidence to energy providers to plan and develop infrastructure in order to meet projected need and reduce risk for companies and financiers looking to invest in zero-emitting trucks, buses, and related infrastructure.

POLICY RECOMMENDATIONS

Global MOU countries and other economies that want to make a real impact on transportation emissions and position themselves as global leaders in clean transportation must establish regulations that require a progressively increasing and strong supply of ZE-MHDVs on a timeline that matches the 2030 and 2040 goals of the MOU. The efforts underway in the European Union through the proposed EU HDV CO₂ standards and in the United States through the proposed EPA Phase 3 standards are examples of the kind of ambition and regulatory precedent needed to drive change. While there is no doubt both regulations have room for improvement, each marks a historic milestone in the direction they steer the market and trajectory they set for the decarbonization of trucks and buses.

To drive the supply of technologies and level off the higher upfront costs of ZE-MHDVs, the Global MOU community is committed to supporting each signatory country in achieving MOU goals. As such, regardless of where a country is in the process of regulatory development, this community will work to support progressive and concrete action. The below recommendations are structured so that any country may take action in the next year, regardless of where one may be in the regulatory process:

1. If in-country discussions on impactful regulation for MHDVs have not begun:
 - Start by reviewing the Global MOU Policy Primer² for examples of effective policy enactment.
 - Undertake a power-mapping effort of effected government agencies, industry players, grid operators, and others to identify and assemble those with interest, authority, and capacity to act.
 - Establish a working group with key stakeholders to evaluate and identify the preferred regulatory approach (consider supply-side regulations as the gold standard), conditions for regulation to succeed, and consideration of locale-specific priorities, including sustainable jobs, public health, and economic gain, alongside political windows of opportunity.
 - For emerging markets and developing economies, additional support may be available through the Zero Emission Vehicle Transition Council's (ZEV-TC) Rapid Response Facility³ for targeted, short-term technical assistance.
2. If there has been some indication of forthcoming regulations but lack of momentum or action:
 - Identify the source of delay or obstacles impeding progress.
 - Evaluate interventions, procedural alternatives, and allies to help unstick any pending process.
 - Draw on and promote the use and reliance of accurate information pertaining to ZE-MHDVs, including the availability of models by region⁴ and locale-specific total cost of ownership.
 - Engage with Global MOU signatory countries and/or regions to understand their experience with obstacles and how they tackled similar situations for lessons learned.
 - Explore common interests with aligned stakeholders, including Global MOU endorsers, to build alliances or collaborations that generate support for policy advancement.
3. If regulatory proposal is in motion:
 - Continue building political support through collaboration with national and sub-national governments with aligned interests and goals.
 - Maintain regular touch points with decision makers to keep this issue at the forefront, including sharing updates regarding other country policies to decarbonize MHDVs globally and zero-emission market updates.
 - Identify common questions or concerns regarding rule proposal and invite academic institutions, non-profit organizations, or other allies to generate research and analyses to address questions or concerns with regulatory approach.
 - Monitor and seek to correct false information or details surrounding proposed regulations, including with and through allies.

2 The Global MOU Policy Primer is accessible at <https://globaldrivetozero.org/policy-primer>.

3 Read more about the Rapid Response Facility at <https://zevtc.org/global-commitment/zev-rapid-response-facility>.

4 The Zero-Emission Technology Inventory is available at <https://globaldrivetozero.org/tools/zeti>.

- Stay focused and committed, knowing the Global MOU community supports these efforts to solidify rulemaking processes and ensure sufficient stringency will be achieved.

4. If regulations have been finalized:

- Continue building political support through collaboration with national and sub-national governments with aligned interests and goals.
- Maintain regular touch points with decision makers to keep this issue at the forefront, including sharing updates regarding other country policies to decarbonize MHDVs globally and zero-emission market updates.
- Identify common questions or concerns regarding rule proposal and invite academic institutions, non-profit organizations, or other allies to generate research and analyses to address questions or concerns with regulatory approach.
- Monitor and seek to correct false information or details surrounding proposed regulations, including with and through allies.
- Stay focused and committed, knowing the Global MOU community supports these efforts to solidify rulemaking processes and ensure sufficient stringency will be achieved.

B. FINANCE: UNLOCK MASS MARKET ADOPTION

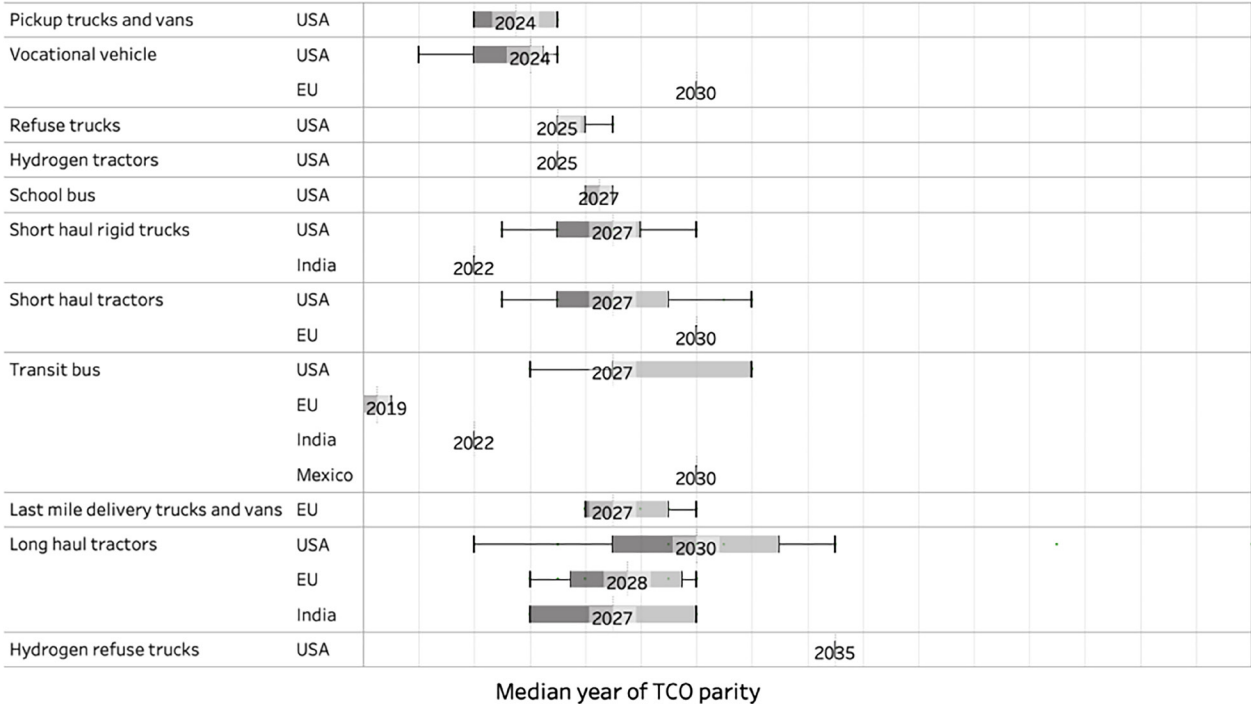
The higher upfront cost of ZE-MHDVs poses a significant barrier to the mass adoption of zero-emission trucks and buses. While costs for components and vehicles have been gradually declining, there is an urgent need for innovative solutions to accelerate the timeline to price parity. Additionally, even when total cost of ownership (TCO) parity is achieved, the upfront costs of ZE-MHDVs will continue to be higher than diesel. Access to financial products will therefore be critical, particularly for small fleets with limited access to capital. 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.

This section focuses on the financing of ZE-MHDVs and explores pathways to reduce costs in the coming year to facilitate access to clean technologies. This section primarily centers financing solutions and overall cost reductions for vehicles and highlights key strategies and approaches that must begin in 2024 to achieve success in accelerating adoption. Pathways such as investment de-risking, direct incentives for vehicles, tax subsidies and exemptions, and strengthened collaboration with development finance institutions should all be considered in a combined approach to facilitate an equitable transition for all regions of the world. The following section (C. Infrastructure) adds detail on the funding and financial support for infrastructure and charging development in each country, an equally important aspect of an accelerated, just transition.

TRACKING ACTION ON TCO PARITY

Regulations will spur the supply of zero-emission vehicles and reduce costs in the medium term through economies of scale and competition. In the near term, however, there is an acute need for incentives, tax exemptions, and de-risking interventions that can accelerate TCO parity between zero-emission and combustion engine technologies. The vast majority of TCO analyses show that TCO parity between zero-emission and combustion engine technologies is expected within this decade for most markets and applications. Figure 11 below from ZEV-TC highlights the expected timeframe for cost parity by vehicle type through a comprehensive literature review. The encouraging result shows that many of the vehicle types achieve cost parity before 2030, which could be further accelerated through the right combination of regulations and financing (ZEV-TC, 2023).

Figure 11. Median Year of TCO Parity Between Zero-Emission and Internal Combustion Engine HDVs in Current Literature by Market and Vehicle Segment (ZEV-TC, 2023)



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. Figure 12 summarizes the funding that has been allocated to subsidies and specific vehicle types by Global MOU countries. This type of subsidy can be cost-prohibitive for some countries, which are relying on alternative incentive structures (as shown later on). In countries where direct subsidies are possible, these are being deployed to reduce the costs of procurement for any fleet and accelerate electrification by specific users, such as small fleets, that typically face tougher challenges to transition. For example, in California, the Innovative Small E-Fleet program sets aside a share of subsidy funding for small fleets (California Air Resources Board, 2023a). In fiscal year 2022–23, these funds totaled \$85 million. Similar set-aside structures have been developed in funding programs in The Netherlands to enable small fleet acquisition of ZE-MHDVs.

Figure 12. Opportunities for ZE-MHDV Subsidies/Funding in Global MOU Countries

Country	Total funding (as of 2023)	(Funding amount per vehicle)		
		Truck	Bus	Van
 Austria	Emission Free Utility Vehicles and Infrastructure (ENIN): €85 million	Unspecified	€20,000 for EV minibus €130,000 for EV bus	€10,000 for N1 EV
 Belgium	Emissionsfreie Nutzfahrzeuge und Infrastruktur: €3 million	Up to 80% of price differences between ZE and diesel equivalent	Unspecified	Unspecified
 Canada	The Zero-Emission Trucking Program (ZETP) was allocated \$75.8 million over five years, starting in 2022-23; iMHZEV Program has \$547.5 million available; Green Freight Program (GFP) has a total funding of \$200 million (over 5 years); Zero Emission Transit Fund has \$2.75 billion to support public transit and school bus (2021-2026)	ZETP: Up to 75% of eligible expenditures incurred towards the project; iMHZEV: \$40,000 - \$200,000 GFP: Up to 50% of the cost per device	iMHZEV: Up to 50% of purchase cost through grants and up to 100% of purchase cost through financing	iMHZEV: Up to \$10,000
 Croatia	Public Call for co-financing of energy-efficient vehicles program provides a total budget of HRK 108.3 million (€14.6 million)	HRK 700,000 (€94,654)	Unspecified	Unspecified
 Denmark	Ministry of Transport: DKK 250 million (€33.5 million) 2021-2026; DKK 50 million (€6.7 million) per year Agreement for Green Transport: 50 million DKK (\$7 million)	Covering additional costs for heavy-duty ZEV	Unspecified	Unspecified
 Finland	Purchase subsidies for electric and gas-fuelled vehicles: €6 million for trucks (2022-2023) €6 million for vans (2022-2023)	Up to €50,000	Unspecified	Up to €6,000
 Ireland	Alternatively-Fuelled Heavy Duty Vehicle Purchase Grant: €5 million	Up to 60% of price differences	Up to 60% of price differences	Up to 60% of price differences
 Lithuania	Lithuania's National Recovery and Resilience Facility (RRF) Fund: €347 million (2021-2026)	€20.6 million share with ZEB	€72.4 million for electric buses only; €20.6 million share with ZET	Unspecified
 Luxembourg	Financial aid for the purchase of zero-emission vehicles	Up to 60% of eligible cost, and not to exceed €300,000 per group in total	Unspecified	Unspecified
 The Netherlands	AanZET program: €30 million for trucks; SpUK-ZEBus program: €40 million for buses; SEBA program: €33 million for vans	Up to €131,900	€25,000 - €75,000 per vehicle	Up to €5,000
 United Kingdom	Over £1.8 billion ultra-low and zero emission vehicle grant funding	Small truck (4.5t-12t): Up to £16,000 Large truck (above 12t): Up to £25,000	Unspecified	Small van (less 2,500 kg): Up to £2,500 Large van (2,500 kg-4,250 kg): Up to £5,000
 United States	HMP (California): \$265 million	Straight trucks: Up to \$120,000 Tractors: Up to \$120,000	Shuttle bus: Up to \$85,000 School bus: Up to \$198,000	Van: Up to \$45,000

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. Other countries like Uruguay and Ukraine have reduced or eliminated value-added taxes on ZE-MHDVs, and Switzerland has 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 United States 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 electric vehicles. 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. As technology costs decline, tax incentives can be rolled back, allowing governments to recover their tax revenues.

Taxation is effective as a “carrot” to reduce zero-emission technology costs, but it can also be used as a “stick” to ensure that pollution costs are internalized by those responsible, rather than being passed on to governments and communities. While not yet a Global MOU signatory, Germany has implemented an innovative kilometer-based road fee for MHDVs that produce emissions that will charge operators for each ton of CO₂, while reducing this fee for zero-emitting vehicles (Federal Ministry for Digital and Transport, 2023). Lithuania has adopted a “polluter pays” principle that ensures a kilometer-based fee is charged to combustion engine truck operators. Similar policies can also be found in development in Denmark, Norway, The Netherlands, and other EU countries (Drive to Zero, 2023e).

The timelines of funding disbursement are an important consideration, given that fleets operating with small margins and limited cashflows may not be able to wait until the end of the fiscal year to receive a tax rebate. Upfront subsidies, such as direct cash purchase incentive programs, and tax exemptions are effective ways to ensure financial support is available at the time of purchase.

INCREASING ACCESS TO FINANCE

Global MOU Spotlight: Implementation Hubs

Implementations hubs will accelerate the global shift to ZE-MHDVs by overcoming knowledge hurdles currently delaying local implementation. These hubs serve as vital local support centers, using locally adopted tools and guidance to offer tailored technical planning assistance for fleet electrification projects. The hubs are being established in countries across the world, led by local implementation partners helping fleets to understand costs, identify vehicles, plan out charging infrastructure, and find partners. The first hub is currently in development in The Netherlands, in collaboration with FIER Automotive.

Once TCO parity is achieved (with or without subsidies and tax exemptions), access to finance and innovative business models will ensure that the higher upfront costs of ZE-MHDVs are no longer an obstacle for mass market adoption.

For fleets that want to own and operate their vehicles, accessible loans with preferential terms such as longer repayment periods and lower interest rates are an effective alternative. Accessibility is key given that smaller fleets may face additional obstacles in accessing loans due to lower credit scores and limited

collateral. Programs like California's Truck Loan Assistance Program (which has now ended and will be replaced by the Zero-Emission Truck Loan Pilot Project, currently under development) have successfully increased access to loans for smaller fleets by providing guarantees against loan defaults (California Air Resources Board, 2023b). This approach maximizes the impact of government funding by focusing it on de-risking commercial lending, which allows the private sector to make resources available at a higher order or magnitude than government programs can usually offer.

Global MOU Spotlight: ZEV Rapid Response Facility

Launched at COP27, the Zero Emission Vehicle Rapid Response Facility (ZEV-RRF) is an initiative of ZEV-TC aimed at providing targeted, short-term technical assistance to emerging markets and developing economy countries that are decarbonizing their road transportation sectors and transitioning to zero-emission vehicles. 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. ICCT, Secretariat of ZEV-TC, serves as the Hub; the Spokes are partner organizations with technical expertise in topics related to the transition. The Hub collects requests from eligible countries and connects these countries' governments to the appropriate Spoke(s) able and willing to assist. **Global MOU countries are eligible for support through ZEV-RRF and encouraged to reach out for more information.**

For fleets that want to operate but not necessarily own the vehicles, leasing and "as-a-service" offerings are growing in popularity since they allow fleets to access vehicles and charging infrastructure without the high upfront investment and learning curve. Governments can create a favorable ecosystem for these business models by ensuring that subsidies and tax exemptions are compatible with split ownership and operation.

For emerging markets and developing economies, development finance institutions can play a big role in facilitating access to finance by blending concessional resources with public- and private-sector funds. In Chile, IDB Invest and International Finance Corporation issued loans totaling \$304 million USD for the purchase, operation, and maintenance of 992 electric buses (Garcia Coyne et al., 2023). In Uruguay, the MOVÉS project implemented by the government with support from Global Environmental Facility and United Nations Development Programme leveraged \$21 million USD in grants and government co-funding to deploy 32 electric buses while strengthening institutional capacity, regulation, monitoring, and communication (Garcia Coyne et al., 2023).

Development finance institutions are successfully kick-starting the electric bus market in many countries. Electric trucks, however, have yet to receive the same type of support. A recent study looking at leading countries in Latin America and the Caribbean found that only 0.08 percent of investments in zero-emission vehicles by development finance institutions have been allocated to trucks (Garcia Coyne et al., 2023). Governments have a large degree of influence in determining the areas of focus for development finance institution intervention. Ensuring both trucks and buses are included in country programs will help accelerate adoption domestically, while allowing private companies and communities to reap the economic and job-creation benefits of the transition.

FINANCE RECOMMENDATIONS

With long-term forecasts and projections on TCO showing significant reductions in upfront vehicle costs, in 2024, countries must focus on actions regarding financing and vehicle funding. As the ongoing increase in supply driven by firm regulation will continue to bring down costs in the medium term, the proposed actions below should be prioritized in the coming year to enable the uptake of technology in the immediate future. While each Global MOU country may be in a different economic position, there are a variety of interventions needed to facilitate the transition and reduce financial frictions, especially for small fleets and operators with less capital to invest in ZE-MHDVs. The following government actions will bring down vehicle costs and enable access to financing for fleets:

Global MOU Spotlight: ZEVWISE Coalition

The ZEVWISE coalition aims to tackle the barriers hindering the rapid adoption of ZE-MHDVs by addressing the two key obstacles to this transformation: infrastructure and financing. Through digital and in-person events and working sessions, ZEVWISE brings together thought leaders from across stakeholders to accelerate solutions to infrastructure and financing barriers. The ZEVWISE coalition includes The Netherlands, CALSTART's Drive to Zero program, ICCT, Smart Freight Centre, U.S. Department of Energy, United Kingdom, the Clean Energy Ministerial's Electric Vehicles Initiative, The World Bank, World Business Council for Sustainable Development, International Transport Forum, and the United National Environment Programme.

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 facilitating demand aggregation and mitigating loan loss and residual value risks.
3. Where economically feasible, implement a direct cash purchase subsidy program 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.
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 that artificially keep prices of fossil fuels low at the expense of the environment and technology innovation.
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.

C. INFRASTRUCTURE: ALIGN TARGETED INVESTMENT WITH STRATEGIC NETWORK PLANNING

Infrastructure development for electric vehicles is often posed as a chicken-or-egg dilemma: without vehicles to utilize the network, there will be a weak business case for charging stations, and without a robust charging network to support the rollout of vehicles, uptake and deployment of ZE-MHDVs will

lag. However, in reality, there is not a one-to-one relationship between trucks and chargers—a single high-powered charger can support multiple trucks if planned well. Investing in and expanding national networks of fast chargers will enable significant advancements in vehicle operational range and utilization potential to meet demands of heavier loads and longer distances.











This section will focus on the evolving development of supportive infrastructure for ZE-MHDVs. Given the complexity of this part of the transition, and the multitude of stakeholders involved in the successful rollout of grid upgrades, site planning, and installation, this topic must be addressed well ahead of the mass adoption of vehicles. Without the right collaboration across industry and government, progress will not move as quickly as needed. Significant progress has been made thus far to begin the planning and funding of major charging networks across the United States and the European Union, but more work is required to meet the needs of ZE-MHDVs hitting the road today, especially in the Global South.

TRACKING INFRASTRUCTURE ACTION

To date, approximately 323,064 zero-emission trucks and 649,780 zero-emission buses have been sold and deployed worldwide (the majority being in China), most of which are refueled and supplied at centralized depot or hub locations (IEA, 2023b). The Fleet Electrification Coalition, a joint partnership between CALSTART and Smart Freight Center, has identified an additional demand of 60,000 zero-emission trucks from the world's largest fleets across Europe and North America over the next several years (Smart Freight Centre, 2023). While India is not a Global MOU signatory, Electric Freight Accelerator for Sustainable Transport-India (E-FAST), led by the Government of India and supported by World Resources Institute in collaboration with CALSTART/Drive to Zero, Climate Group, Shakti Sustainable Energy Foundation, Smart Freight Center, UC Davis-India ZEV Research Center, World Business Counsel for Sustainable Development, and World Economic Forum, has identified an additional demand of 7,750 zero-emission trucks to add to the Indian government's aggregated demand of 50,000 zero-emission buses across 170 cities in the country. Taken together, these developments send a clear demand signal to vehicle manufacturers that infrastructure and energy providers must also heed.

Figure 13 highlights the dedicated funding that countries have allocated to the development of infrastructure to support zero-emission vehicles.

Figure 13. Current Funding Opportunities for ZE-MHDV Acquisition

Country	Program	Total Funding	Funding per Project
 Austria	Emission Free Utility Vehicles and Infrastructure (ENIN)	€85 million in 2023 €445 million in total through 2026	Up to €30,000
 Belgium	LEZ bonus	-	35% deduction of investment charging and fuelling infrastructure for new BEVs and FCEVs (N1-N3).
 Canada	Zero-Emission Vehicle Program (ZEVIP) Electric Vehicle and Alternative Fuel Infrastructure Deployment Initiative (EVAFIDI): April 2019- March 2024 Emissions Reduction Fund: \$500 million	ZEVIP: \$680 million through 2027 EVAFIDI: \$260 million ERF: \$675 million	ZEVIP: Maximum of \$10 million per project EVAFIDI: Maximum of \$5 million per project ERF: \$100,000 - \$50 million per project
 Denmark	Agreement on redemption of pool for green transport Agreement for Green Transport Accommodate and implement AFIR (Infrastructure Plan 2035)	Invest 749.8 million DKK (€100.5 million) in charging infrastructure Agreement for Green Transport: 72 million DKK (\$10 million) Accommodate and implement AFIR: 700 million DKK (\$102 million)	-
 EU	The Alternative Fuels Infrastructure Facility (AFIF)	€1.5 billion	-
 Finland	Public infrastructure support for charging and hydrogen refueling stations, private charging infrastructure support	Distribution infrastructure support for public charging and hydrogen refueling stations is altogether €35 million + charging infrastructure support for housing companies and workplaces is altogether €32.5 million	General level of support up to 35% of project cost
 The Netherlands	Environmental Investment Allowance (MIA) Random Depreciation of Environmental Investments (VAMIL)	MIA: €192 million VAMIL: €25 million	MIA: Up to 36% of the amount invested into a charging point VAMIL: Depreciate 75% of the investment costs of a charging point
 Turkey	Electric Vehicles Fast Charging Stations Support Program	Providing approximately \$7.5 million for the investment of \$54 million to 20 investor companies to install fast chargers	Up to €60,000 for truck projects Up to €120,000 for ZEB projects
 United Kingdom	EV Infrastructure Strategy (March 2022) Rapid Charging Fund (RCF) Local EV Infrastructure (LEVI) Fund On-Street Residential Chargepoint Scheme (ORCS) ZE HGV and coach infrastructure strategy (due for publication in 2024) ZE HGV and Infrastructure Demonstrator Programme ZE Bus Regional Areas (ZEBRA) scheme All Electric Bus City (AEBIC)	Up to £2 billion	RCF – up to £950 million LEVI – £381 million (£343 million capital and £37.8 million resource) available over next two financial years up to 2025 ORCS – £15 million in FY23/24 ZEHID – £200 million (vehicles and infrastructure) by summer 2025 ZEBRA – £410 million (vehicles and infrastructure) by March 2025 AEBIC – £50 million (vehicles and infrastructure) by 2021
 United States	National Electric Vehicle Infrastructure (NEVI) Formula Program	\$5 billion	Up to 80% project cost

While many countries are dedicating funds to accelerate this shift, there is also an overwhelming need to begin the planning and phasing of infrastructure, acknowledging several factors to address so as not to prolong deployment, namely:

1. Most countries are working with grid capacities that will require upgrading to enable additional demand.
2. Lengthy permitting and planning timelines, supply of key components, installations, and the need for grid operators to coordinate and align may cause delays.
3. Cost of electricity in many regions does not accommodate vehicle charging use cases and will need to be amended to ensure costs are appropriately leveled to encourage utilization.

The European Union has established its path to achieve a widespread, multi-national electric vehicle charging network for trucks through a combination of policies aimed at setting specific parameters for what the network will need. The European Commission adopted what may serve as a global framework for supporting ZE-MHDV infrastructure deployment with its Alternative Fuels Infrastructure Regulation (AFIR) requirements in 2023 (Mammonas, 2023). The new law sets minimum requirements for distance between charging locations (every 120 kilometers for MHDVs) that can accommodate ZE-MHDVs along the European Union's primary road system (TEN-T), and that these stations must provide sufficient energy (1.4–2.8 megawatts) to recharge or refuel a vehicle at speeds that can be achieved during a driver's mandated rest period. It also sets provisions for supporting urban and regional ZE-MHDV fast-charging and reliability metrics. 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. AFIR is driven by the European Union's Fit for 55 package that aims to reduce net GHG emissions by 55 percent by 2030 compared to 1990 levels and to achieve climate neutrality by 2050. European Green Deal investments will help support some of the deployments. Complementing the AFIR regulation is the Alternative Fuel Infrastructure Facility that will provide funding to the buildout of projects, supplying a critical €1.5 billion to enable the rapid transition (European Climate, Infrastructure and Environment Executive Agency, 2021).

In the United States, the National Electric Vehicle Infrastructure (NEVI) Formula Program was established by the U.S. Bipartisan Infrastructure Law (BIL) to provide funding for states to deploy electric vehicle charging infrastructure and establish a national network for access and reliability, with a vision of establishing roughly 500,000 charge points by 2030 (FHWA, 2023). States submit annual plans to access NEVI funding for their projects, supplying up to 80 percent of a project's costs (U.S. Department of Transportation, 2021). While initially established in late 2021 following BIL passage, and though first funds were deployed in 2022, 2023 saw a major and significant set of new regulations and guidance issued for NEVI. This new guidance sets national standards and requirements for chargers, connectors, power levels, ports, reliability, and interoperability. The updated regulations were primarily aimed at passenger car electric vehicles. However, the Federal Highway Administration (FHWA), which administers the funding, noted that ZE-MHDV infrastructure was not precluded from funding and was encouraged. However, specific guidance for MHDV requirements was not set, except for encouraging "pull-through" charging lane designs to better accommodate large commercial vehicles. Future additions to NEVI may include ZE-MHDV guidelines.

Uruguay, the United Kingdom, Chile, Canada, Portugal, Switzerland, and other countries also have plans to significantly boost the publicly available network of chargers for ZE-MHDVs to further advance the uptake of vehicles (Drive to Zero, 2023e). Corridor planning is essential to boost the operational range of ZE-MHDVs and enable long-haul trucking routes. While not yet a signatory of the Global MOU, Germany's Charging Infrastructure Masterplan II, the second version of the German Charging Infrastructure Masterplan, provides a strong template for how nations can plan for and establish the roadmap for anticipating charging needs and building out infrastructure in advance of vehicle demand, including specifically ZE-MHDVs. A core tenant of the Charging Infrastructure Masterplan is that "the rollout must precede the ramp-up (of vehicles) and must be supported and backed by state activities" (Federal Ministry for Digital and Transport, 2022). Germany's inter-governmental plan, which anticipated and preceded the final AFIR requirements, also importantly focuses on "the optimum integration of charging infrastructure and electricity system (electricity market and electricity network)" (Federal Ministry for Digital and Transport, 2022). While the plan update technically was revealed at the end of 2022, it outlined 68 measures for action. Several of those launched in 2023, including developing ZE-MHDV demand and a development plan through 2035, as well as outlining an initial charging network and site design requirements for heavy goods vehicles.

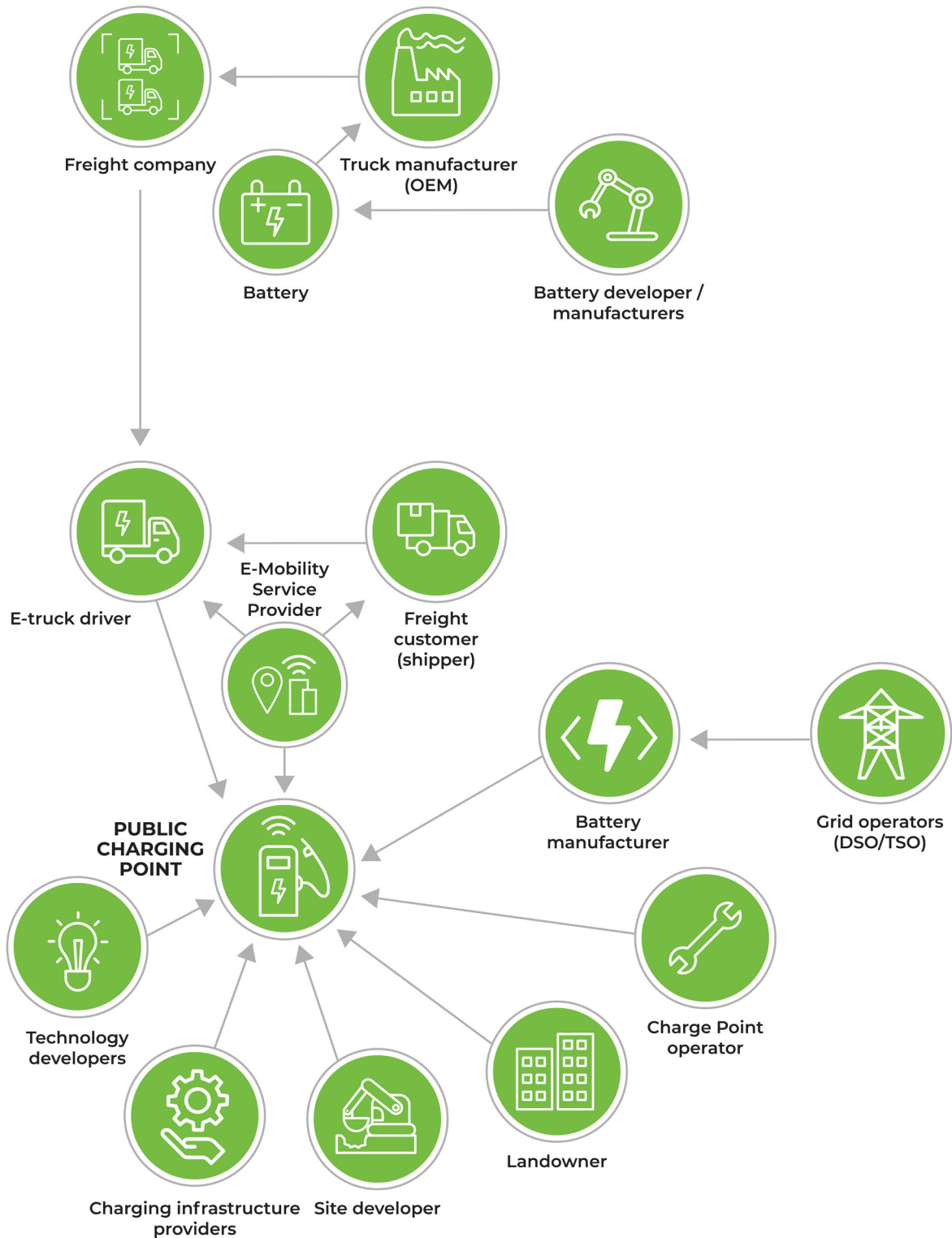
In 2023, the United States issued its first national transportation decarbonization roadmap, a milestone document that outlines the nation's strategy for cutting emissions from the transportation sector to zero by 2050 (U.S. Department of Energy, 2023). A joint strategy developed across and by multiple federal agencies (including the Department of Energy, Department of Transportation, EPA, and the Department of Housing and Urban Development), the blueprint outlines three immediate strategies: increasing convenience by supporting community design and land use planning that reduces travel; improving efficiency by expanding access to and use of public transportation and increased vehicle efficiency; and transitioning to clean options by deploying zero-emission vehicles and fuels. The blueprint specifically cites the U.S. signing of the Global MOU and the need to meet it via policy and regulation; investments and financing (such as using funding from BIL and the Inflation Reduction Act); and research and innovation. In late 2023, the joint agencies were developing the next phase of the blueprint: specific action plans by transportation mode.

Immediate action and significant investment, planning, and development of national networks for zero-emission vehicles is therefore needed today to drive rapid growth in vehicle deployments and increase consumer confidence. Urgent action is needed to prioritize strategic planning for grid infrastructure development.

PLANNING FOR INFRASTRUCTURE PHASE-IN

Collaboration between stakeholders is vital for the market to move rapidly and within the sphere of ZE-MHDV charging infrastructure. This collaboration involves many parties, each with a unique and impactful role to play. Figure 14 maps out the breadth of stakeholders with significant roles in the infrastructure development process.

Figure 14. Stakeholders of Charging Sites (Punte, 2023)

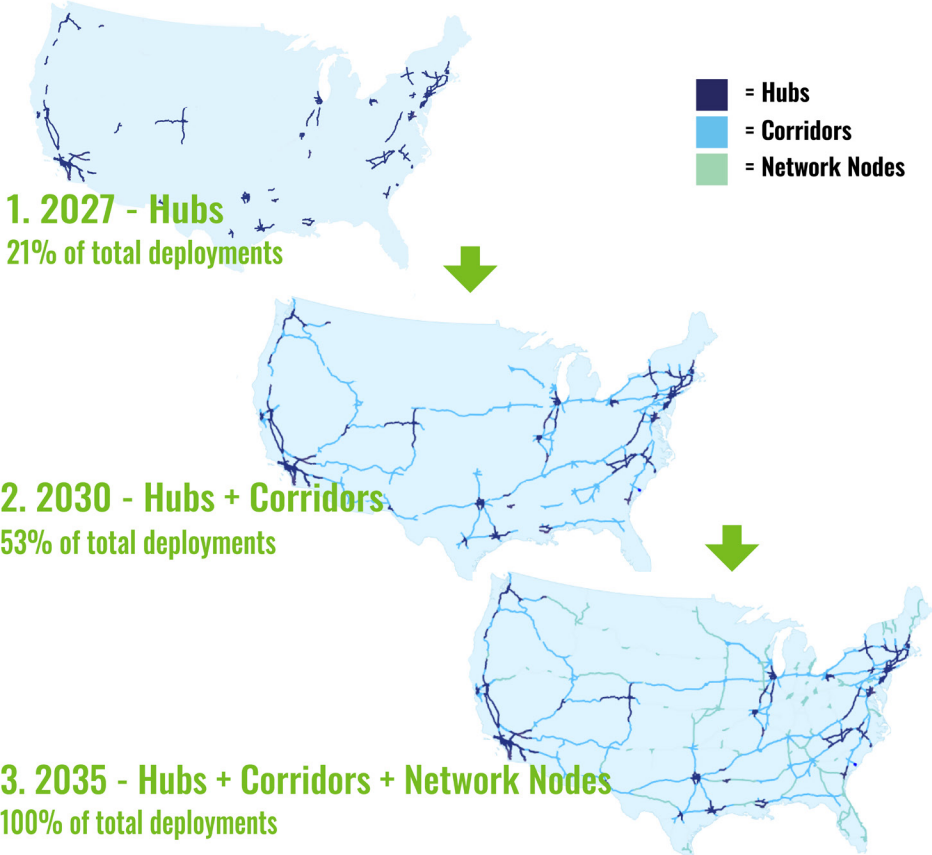


Translated from Nationale Agenda Laadinfrastructuur

Collaboration and coordination across energy and transportation stakeholders are critical for a long-term successful buildout of infrastructure, and planning and action must begin now. Gradual, definite “phase-in” of infrastructure to support transitions is urgent, and infrastructure planning must pinpoint specific areas for early launch and further buildout. Priority has been on the deployment of infrastructure in “hubs” like ports, depots, or warehouses where vehicles return to base after their daily operations, suiting the needs for first-mover vehicle segments like transit buses, regional haul, and urban delivery trucks. At the same time, extensive national networks have been announced in many countries and must be linked to the hubs that are developed. While much of the needed ZE-MHDV charging infrastructure will focus on depot charging over the next years, to achieve longer routes and greater fleet confidence, corridor routes must be planned for in the near term between cities and hubs—from there, national networks will need to be filled in. This planned buildout must also synchronize with the energy sector and the rapid advancement of additional clean electrical capacity. There must be intentional coordination and collaboration across the two sectors that enable decision-making and project development to happen quickly.

The following figure is derived from a modeled analysis of phases of infrastructure development in the United States and illustrates the phases of deployment required for a national network to be in place (Joseph et al., 2023). By focusing on hubs that have a high clustering of industry and transportation activities and are located in an area with supportive policy for both ZE-MHDVs and infrastructure, more rapid development can occur.

Figure 15. Phase-in of ZE-MHDV Charging Infrastructure: U.S. Example



Looking ahead over the next year, countries must begin buildout with hubs to allow for the deployment of private infrastructure at depots and warehouse locations in and around cities. This stage is important, as first-success segments can then launch without the need for much public infrastructure. Hub growth and development will occur in parallel across geographies and should be the focus of collaborative action. At the same time, the second phase of the strategy involves the connecting of hubs to build a more comprehensive network that enables greater distances and long-haul travel between hubs.

Corridor connectors may be a mix of 1) depots or shared and multi-use sites with clear connections to corridors, or alternatively, 2) pull-through charging sites along these key routes. As transportation volumes grow, targeted private and public investment in these configurations will enable point-to-point operations that continue to catalyze hub development. Sites can store energy in onsite battery storage systems, especially in areas where it is cheap and can be supplemented.

Countries must also consider the additional energy capacity that will be required by the grid from the added demand of ZE-MHDV charging. A recent report by the International Energy Agency (IEA) regarding the energy transition indicates that grids around the world are not keeping pace with the accelerating growth of clean energy technologies like electric vehicles, heat pumps, and renewables. The modeled scenario by IEA suggests that if grid investment is not scaled up quickly enough, the resulting global temperature rise would be well over 1.5 degrees Celsius. The report doubles down on the call for decisive action and investment into grid expansion and modernization, citing that new grid infrastructure often takes 5–15 years to plan, permit, and complete, while new charging infrastructure for vehicles takes less than two years (IEA, 2023c). Further, a case study conducted by National Grid in their U.S. service territory assessing the demand and system impact of truck electrification on their transmission lines concluded that significant upgrades will be needed across the network to ensure new demand can be met by utilities (National Grid and Hitachi Energy, 2023).

INFRASTRUCTURE RECOMMENDATIONS

To develop infrastructure to support a decarbonized economy inclusive of MHDVs, each country will need to tailor strategies to tackle the challenges of grid capacity, planning, and funding infrastructure development. With the vast majority of the transportation network reliant on fossil fuels, close collaboration between the energy and transportation sectors now is critical. In many countries, there are dozens, or even hundreds, of grid operators, charging providers, and other entities that require alignment and standardization. The creation of new joint departments or oversight agencies, such as the recently formed U.S. Joint Office of Energy and Transportation or the United Kingdom's proposed climate-oriented Future System Operator, focus not just on delivery of energy for present needs but also around proactive planning (U.S. Joint Office of Energy and Transportation, 2023; U.K. Department for Business, Energy & Industrial Strategy and Department for Energy Security & Net Zero, 2023). Producing governance structures and coordinative instruments that call for interagency coordination and tie existing government initiatives together help identify interagency regulatory pathways. Together, these bodies develop shared regulatory analysis around the integration of transportation electrification, establish what is feasible within these frameworks, and recommend legislation to better integrate each agency's infrastructure domain.

With the challenges of near-term permitting and site-specific upgrades, along with the more long-term prospect of full grid modernization, countries must take specific actions to reduce frictions and expedite the processes surrounding infrastructure development for ZE-MHDVs.⁵ Each of these actions can be within reach for respective countries to undertake in 2024:

1. Identify national and local stakeholders. The first step is to firmly identify and understand the role of government agencies, the private sector, non-governmental organizations, 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 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.

⁵ For additional examples on how to lock in commercial vehicle charging infrastructure, review the Actionable Framework for E-trucks and Charging at <https://globaldrivetozero.org/site/wp-content/uploads/2023/11/Actionable-Framework-for-E-trucks-and-Charging.pdf>.

CONCLUSION

The countries that have signed the Global MOU represent a vanguard of innovators leading the way to a more sustainable transportation future. By working together toward the goal of 100 percent ZE-MHDV sales by 2040, these nations are stepping forward to ensure that the way goods and people are moved does not continue to have detrimental effects on air quality and devastating impacts on the planet. This MCAP paves the way for accelerated action and highlights the framework for the implementation of aligned policy measures to enable achievement of the Global MOU ambition. As global climate discussions advance, the top priority of the Global MOU forum is to continue progressing MOU ambition into tangible action.

While meaningful action and strong momentum were built and displayed in 2023, looking ahead to 2024, the coming year will be a critical period for all Global MOU nations and partners to stay on track to 2030, 2040, and 2050 goals. Based on the research that has been conducted over the past year into the collective progress of the Global MOU, several factors emerge as top priorities to both complete and launch during 2024:

1. **Lock in Strong Requirements:** It is imperative that all signatories engage in the process to enact and implement a regulatory framework that reduces commercial vehicle GHGs and requires ZE-MHDV production and use.
2. **Build Supporting Policies:** Policies and strategies create regulatory and market certainty for vehicles and infrastructure. Priorities include:
 - a. De-risking investment in vehicles and infrastructure via clear and strong regulations, co-investments, and incentive structures.
 - b. Reforming electric grid operations to encourage faster connection of charging to the grid, accelerated investment in infrastructure readiness, and competitive and consistent fuel pricing.
 - c. Providing geographical focus for first deployments to drive an effective initial phase-in of infrastructure. By ensuring that first-moving applications and high-priority regions are targeted initially, public resources and private capital can be most effectively leveraged.

- d. Developing a next generation of best practices, tools, and policy instruments—some derived from the renewable energy arena—that can be directed to vehicle and infrastructure applications.
3. **Engage Public Finance Tools and Unleash Private Investment:** To achieve the scale and the timing required, public funds are necessary and must be complimented by private capital investment. In the coming year, public funding mechanisms such as direct subsidies or tax exemptions for zero-emission trucks, as well as the phase-out of subsidies for fossil fuels, must be used to unlock private investment alongside collaboration with multi-lateral development banks to prioritize MHDV decarbonization. To further facilitate private investment in all regions, novel approaches to cost and risk reduction like subsidized loans, guarantees, and blended finance products can all be employed with limited upfront capital investment.
4. **Develop Infrastructure Roadmaps:** Infrastructure planning and ZE-MHDV demand forecasting, as well as launching public co-investments and first deployments in high-priority regions and corridors, will establish a blueprint for coordinated action. The roadmap must prioritize building out urban and city charging hubs and related infrastructure, as well as the specific planning and funding for the first long-haul zero-emission freight corridors and dates by which they will commence.
5. **Integrate Transportation with the Electrical Grid:** Finally, the urgency for change in the transportation sector must be synchronized with a similar timeline and urgency in the energy sector. While electrical energy production is being decarbonized at a faster rate than transportation, each is too often moving separately and independently of the other. The critical integration of transport with energy—specifically with the electricity grid—needs to become a global priority.

These are the priorities that will inform and motivate Global MOU actions in 2024. As with 2023, the Global MOU community is firmly committed to modeling best practices and serving as a learning laboratory for advancing the solutions needed to decarbonize the transportation sector.

For those readers that are not yet part of the Global MOU community, we encourage you to join us by signing if you are a country and endorsing if you are a non-country stakeholder. Together, we will achieve a fully decarbonized MHDV sector by 2040!

REFERENCES

- Al-Alawi, B., MacDonnell, O., and Façanha, C. (2022). CASTART. Global Sales Targets for Zero-Emission Medium- and Heavy-Duty Vehicles – Methods and Application. Retrieved from: <https://globaldrivetozero.org/publication/global-sales-targets-zemhdvs>
- Buyse, Claire and Sharpe, Ben (2020). ICCT. California's Advanced Clean Trucks regulation: Sales requirements for zero-emission heavy-duty trucks. Retrieved from: <https://theicct.org/wp-content/uploads/2021/06/CA-HDV-EV-policy-update-jul212020.pdf>
- California Air Resources Board (2023a). Innovative Small e-Fleet Pilot Program. Retrieved from: <https://ww2.arb.ca.gov/resources/fact-sheets/innovative-small-e-fleet-pilot-program>
- California Air Resources Board (2023b). Zero-Emission Truck Loan Pilot Project. Retrieved from: <https://ww2.arb.ca.gov/our-work/programs/zero-emission-truck-loan-pilot>
- CALSTART and California Air Resources Board (2022). The Beachhead Strategy: A Theory of Change for Medium- and Heavy-Duty Clean Commercial Transportation. Retrieved from: https://calstart.org/wp-content/uploads/2022/04/The-Beachhead-Strategy_Final.pdf
- Drive to Zero (2023a). CALSTART. Global Memorandum of Understanding on Zero-Emission Medium-and Heavy-Duty Vehicles. Retrieved from: <https://globaldrivetozero.org/mou-nations>
- Drive to Zero (2023b). CALSTART. Policy Suite. Retrieved from: <https://globaldrivetozero.org/policy-suite>
- Drive to Zero (2023c). CALSTART. ZETI (Zero-Emission Technology Inventory). Retrieved from: <https://globaldrivetozero.org/tools/zeti>
- Drive to Zero (2023d). CALSTART. Global MOU Policy Tracker Dashboard. Retrieved from: <https://globaldrivetozero.org/progress-dashboard>
- Drive to Zero (2023e). CALSTART. Global MOU Policy Tracker Matrix. Retrieved from: <https://globaldrivetozero.org/global-mou-policy-tracker-matrix>
- European Climate, Infrastructure and Environment Executive Agency (2021). CEF Transport Alternative fuels Infrastructure Facility Call for Proposal. Retrieved from: https://cinea.ec.europa.eu/funding-opportunities/calls-proposals/cef-transport-alternative-fuels-infrastructure-facility-call-proposal_en
- Federal Ministry for Digital and Transport (2023). Changes to the Federal Highway Toll Act Were Approved by the Cabinet. Retrieved from: <https://bmdv.bund.de/SharedDocs/DE/Pressemitteilungen/2023/054-wissing-aenderung-bundesfernstrassenmautgesetz.html?nn=13326>
- FHWA (2023). National Electric Vehicle Infrastructure Formula Program Guidance (Update) Memorandum. Retrieved from: https://www.fhwa.dot.gov/environment/nevi/formula_prog_guid/90d_nevi_formula_program_guidance.pdf

- Garcia Coyne, R., MacDonnell, O., and Facanha, C. (2021). CALSTART. Analysis of Public Sales Commitments of Medium- and heavy-Duty vehicle Manufacturers and Expected Volumes. Retrieved from: <https://globaldrivetozero.org/publication/analysis-of-public-sales-commitments-of-medium-and-heavy-duty-vehicle-manufacturers-and-expected-volumes>
- Garcia Coyne, R., Jimenez, G., Miriam Monterrubio, V., Jimenez, J., Cerezo, A., and Garduno, T. (2023). CALSTART. Expanding Access to Financing for Zero-Emission Trucks in Latin America and the Caribbean. Retrieved from: <https://globaldrivetozero.org/publication/expanding-access-to-financing-for-zets-latin-america-caribbean-eng>
- IEA (2023a). Transport. Retrieved from: <https://www.iea.org/energy-system/transport>
- IEA (2023b). Global EV Data Explorer. Retrieved from: <https://www.iea.org/data-and-statistics/data-tools/global-ev-data-explorer>
- IEA (2023c). Lack of Ambition and Attention Risks Making Electricity Grids the Weak Link in Clean Energy Transitions. Retrieved from: <https://www.iea.org/news/lack-of-ambition-and-attention-risks-making-electricity-grids-the-weak-link-in-clean-energy-transitions>
- IPCC (2023). Climate Change 2023 Synthesis Report – Summary for Policymakers. Retrieved from: https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_SPM.pdf
- Joint Office of Energy and Transportation (2023). Electrifying the U.S. Transportation System with the Joint Office. Retrieved from: <https://driveelectric.gov/files/electrifying-transportation-system.pdf>
- Joseph, M., Amburg, B., Hill, M., and Sathiamoorthy, B. (2023). CALSTART. Phasing in U.S. Charging Infrastructure. Retrieved from: <https://calstart.org/ZEV-infrastructure-phase-in>
- MacDonnell, Owen and Façanha, Cristiano (2022). CALSTART. Multi-Country Action Plan for the Global Memorandum of Understanding on Zero-Emission Medium-and Heavy-Duty Vehicles. Retrieved from: <https://globaldrivetozero.org/publication/multi-country-action-plan-for-the-global-memorandum-of-understanding-on-zero-emission-medium-and-heavy-duty-vehicles>
- Mammonas, Dimosthenis (2023). European Council of the European Union. Alternative Fuels Infrastructure: Council Adopts new Law for More Recharging and Refueling Stations Across Europe. Retrieved from: <https://www.consilium.europa.eu/en/press/press-releases/2023/07/25/alternative-fuels-infrastructure-council-adopts-new-law-for-more-recharging-and-refuelling-stations-across-europe/#:~:text=The%20alternative%20fuels%20infrastructure%20regulation,achieve%20climate%20neutrality%20in%202050>
- National Grid and Hitachi Energy (2023). The Road to Transportation Decarbonization: Readyng the Grid for Electric Fleets. Retrieved from: <https://www.nationalgrid.com/document/150356/download>
- Nix, James (2022). Transport & Environment. Cities are buying more electric buses, but an EU deadline is needed. Retrieved from: <https://www.transportenvironment.org/discover/cities-are-buying-more-electric-buses-but-an-eu-deadline-is-needed/#:~:text=Which%20countries%20lead%20on%20zero,more%20than%2070%25%20last%20year>
- Punte, Sophie (2023). Actionable Framework for E-trucks and Charging – a reference paper to organize climate action. Retrieved from: <https://globaldrivetozero.org/site/wp-content/uploads/2023/11/Actionable-Framework-for-E-trucks-and-Charging.pdf>
- 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>

- U.K. Department for Business, Energy & Industrial Strategy and Department for Energy Security & Net Zero (2023). Energy Security Bill Factsheet: Future System Operator. Retrieved from: <https://www.gov.uk/government/publications/energy-security-bill-factsheets/energy-security-bill-factsheet-future-system-operator>
- U.S. Department of Energy (2023). The U.S. National Blueprint for Transportation Decarbonization. Retrieved from: <https://www.energy.gov/sites/default/files/2023-01/the-us-national-blueprint-for-transportation-decarbonization.pdf>
- U.S. Department of Transportation (2021). Alternative Fuels Data Center. National Electric Vehicle Infrastructure (NEVI) Formula Program. Retrieved from: <https://afdc.energy.gov/laws/12744>
- U.S. EPA (2023). Office of Transportation and Air Quality, Greenhouse Gas Emissions Standards for Heavy-Duty Vehicles – Phase 3: Overview Briefing of the Proposal for EVE IWG. Retrieved from: <https://wiki.unece.org/download/attachments/192840855/EVE-61-17e%20-%20US%20EPA%20HDV%20phase%203%20NPRM%20overview%20.pdf?api=v2>
- Welch, D., Façanha, C., Kroon, R., Weken, H., Bruil, D., and Jousma, F. (2020). CALSTART. Moving Zero-Emission Freight Toward Commercialization. Retrieved from: <https://globaldrivetozero.org/publication/moving-zero-emission-freight-toward-commercialization>
- Xie, Yihao and Minjares, Ray (2023). How U.S. and EU Proposals Could Steer the Transition to Zero-Emission Truck and Bus Fleets. Retrieved from: <https://theicct.org/us-and-eu-proposals-zev-truck-and-bus-fleets-sept23>
- ZEV-TC (n.d.). Rapid Response Facility. Retrieved from: <https://zevtc.org/global-commitment/zev-rapid-response-facility>
- ZEV-TC (2023). ZEV Cost: Total Cost of Ownership. Retrieved from: <https://zevtc.org/tracking-progress/zev-cost-total-cost-of-ownership>