

WHITE PAPER



GLOBAL GREEN ROAD CORRIDORS: ENABLING FACTORS FOR SUCCESSFUL LAUNCH, DEVELOPMENT, AND SCALE

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LIST OF ACRONYMS

ACF	Advanced Clean Fleets regulation
ACT	Advanced Clean Trucks regulation
CPO	Charging point operator
DFIs	Development financial institutions
EMDE	Emerging markets and developing economies
ESG	Environmental, Social, and Governance
EVI	Electric Vehicles Initiative
EV	Electric vehicle
EVSE	Electric vehicle supply equipment
ESG	Environmental, Social, and Governance
GGRC	Global Green Road Corridors Initiative
GHG	Greenhouse gas
ICCT	International Council on Clean Transportation
ITF	International Transport Forum
KF	Kühne Foundation
LCFS	Low Carbon Fuel Standard
MCS	Megawatt Charging Systems
NCTTA	Northern Corridor Transit and Transport Agreement
NCTTCA	Northern Corridor Transit and Transport Coordination Authority
NGO	Non-governmental organization
OEM	Original equipment manufacturer
PPA	Power purchase agreements
SFC	Smart Freight Centre
SME	Small and medium-sized enterprises
TCO	Total cost of ownership
UNEP	United Nations Environment Programme

LIST OF ACRONYMS

WBCSD	World Business Council for Sustainable Development
ZE-MHDV	Zero-emission medium- and heavy-duty vehicle
ZET	Zero-emission truck

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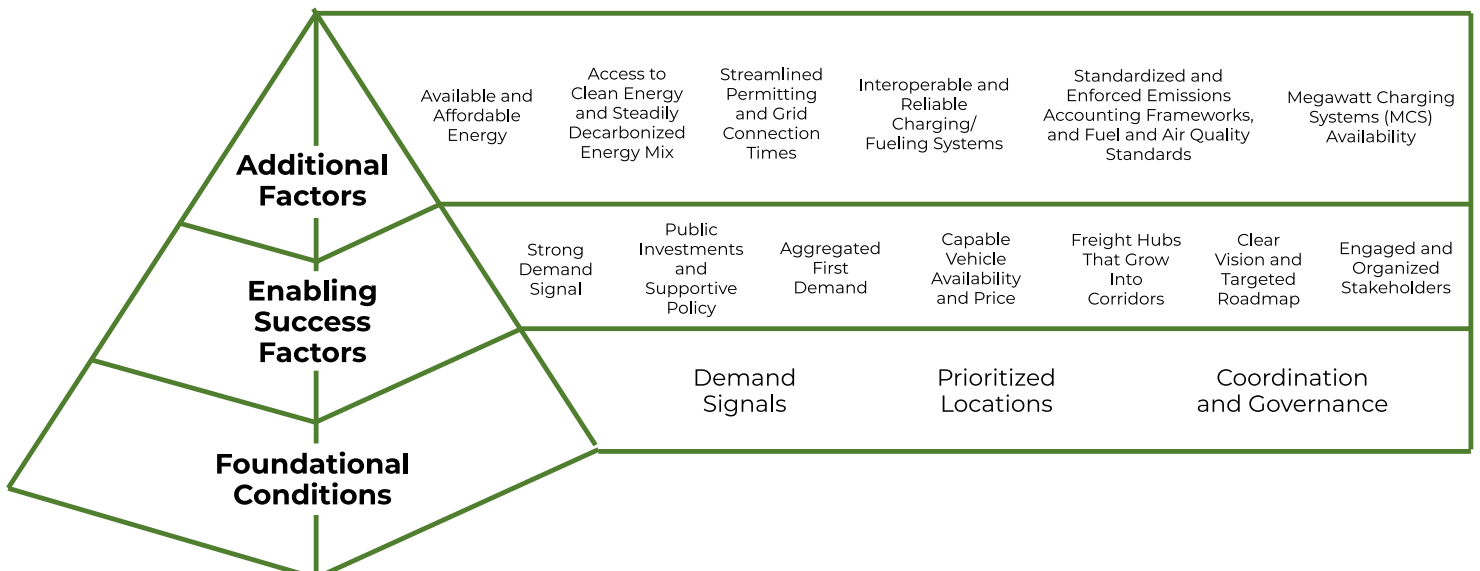
EXECUTIVE SUMMARY

Green road corridors utilizing zero-emission medium- and heavy-duty vehicles (ZE-MHDVs) play a crucial role in achieving net-zero emissions by 2050. The transportation sector, particularly MHDVs, remains a significant contributor to greenhouse gas (GHG) emissions and public health risks.

This report, based on insights from multiple stakeholder interviews, outlines the key parties who must be involved in the development of green road corridors and establishes the essential base conditions: demand signals, prioritized locations, and coordination and governance. These foundational conditions are critical for scaling up the implementation of ZE-MHDVs, especially in the long-haul and regional freight segments, which face cost and operational challenges at this stage of the market.

In addition to these base conditions, the report provides a comprehensive list of factors that contribute to their success, offering a roadmap for the practical implementation of green road corridors. These factors, which include regulatory requirements and support, funding, accessible infrastructure, and technology readiness, serve as key drivers for a successful transition to ZE transport (Figure ES-1). The report also highlights best practices and showcases real examples of corridors under development globally. These examples demonstrate ongoing efforts to support green corridors but underscore that their success depends on establishing a robust foundation of collaboration, policy, finance, technology, and stakeholder alignment.

Figure ES-1. Key Elements of a Successful Global Green Road Corridor Ecosystem



The findings of this report establish a model for action on green road corridors and call for a comprehensive, proactive, and collaborative approach to firmly establish these foundational conditions, setting the groundwork for a sustainable and widespread adoption of ZE-MHDVs and fostering a resilient and climate-aligned transportation sector.

SECTION 1

WHY GREEN ROAD CORRIDORS?

A transportation corridor refers to a strategically planned network of infrastructure designed to optimize the traffic flow between key sites, such as hubs, ports, industrial centers, or cities, along vital routes. Corridors are fundamental to economies, providing the essential infrastructure that enables trade and supports the movement of goods, services, and people. By integrating supply chains and creating financial and logistical links between regions, corridors stimulate economic growth, promote regional development, and deliver a range of benefits to the communities they connect.

While corridors can incorporate various and more efficient modes of transport, road corridors have the flexibility and ability to provide both inter-hub connections and last-mile transportation where other modes are not feasible. Road corridors act as critical connectors that make the entire transportation system function efficiently, ensuring goods and people can flow effectively across industries and regions.

However, road corridors also present significant challenges, particularly as transport remains the only major sector where emissions continue to rise [1]. Within this sector, the fastest growth in emissions comes from medium- and heavy-duty commercial vehicles (MHDVs), representing a disproportionate impact on climate and public health [1]. For example, regional and long-haul segments, which utilize the largest trucks driving longer distances, make up less than 15 percent of the U.S. fleet but are responsible for approximately 60 percent of greenhouse gas (GHG) emissions, urban nitrogen oxides, and particulate matter due to their higher mileage and more intensive use [2]. As the demand for freight transport continues to grow globally, these numbers are expected to increase.

To reverse this trend and improve air quality in communities heavily burdened by diesel pollution, a rapid transition to zero-emission (ZE) MHDVs is crucial. While the first big growth of ZE-MHDVs is taking place in return-to-base applications, such as urban transit and local goods movement giving rise to hubs, technology is now able to serve the regional and long-haul segments and turn the world's road corridors green.

Green road corridors build upon the existing framework of traditional road corridors but place a specific emphasis on sustainability and resilience. By prioritizing the reduction of environmental and health impacts—specifically through the use of ZE-MHDVs—while maintaining operational efficiency, green road corridors will transform how transport infrastructure is approached. Environmentally, they cut air pollutants and GHG emissions, contributing to better public health and helping meet global climate targets. Economically, they reduce fuel costs and stimulate future-proof job creation in ZE transport,

infrastructure, and renewable energy sectors. Moreover, developing green road corridors to establish public and semi-public infrastructure promotes a just transition by ensuring that small and medium enterprises (SMEs) without their own facilities have access to charging and refueling facilities.

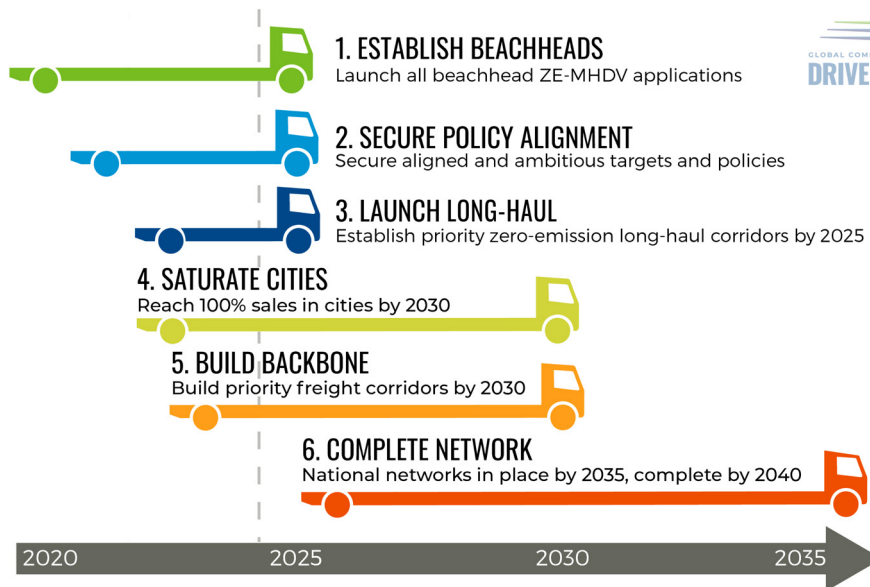
SECTION 2

WHY ACT NOW?

To avoid the worst impacts of climate change, the world must achieve a net-zero economy by 2050. For trucks and buses, this means 30 percent of new sales must be ZE by 2030 and 100 percent by 2040, as is being carried forward by 38 nations through the Global Memorandum of Understanding (Global MOU) on ZE-MHDVs [3]. To achieve these targets, efforts to organize and develop green road corridors must advance.

It is imperative to begin the buildout of these first corridors by 2025 to stay on track to 2040 outcomes (Figure 1) [4]. Acting now provides valuable lead time to address the unique requirements of ZE regional and long-haul vehicles, including capital costs, operational demands on longer routes, and high-power infrastructure. Building the first key corridors proactively positions the world to stay on pace to reach climate neutrality and sends a powerful message of certainty to the entire market.

Figure 1. 6-Stage Strategy to Enable 100% ZE-MHDVs by 2040 (and 30% by 2030)



Note: Original first published in Drive to Zero's "Global Roadmap for Reaching 100% ZE-MHDVs by 2040" [4]. Modifications made to show present day (dashed line).

GLOBAL GREEN ROAD CORRIDORS INITIATIVE

CALSTART’s Global Commercial Vehicle Drive to Zero program, alongside partners and allies in the ZEVWISE coalition, have launched an ambitious effort to advance a diverse set of the world’s road corridors to transition to a ZE-MHDV ecosystem (Figure 2). These autonomous Global Green Road Corridors (GGRC), each led and/or supported by an array of partners worldwide, will establish the basis for replicable, adaptable models that will serve as a real-time resource and framework for growth and success. The initiative intends to catalyze the development of additional corridors worldwide to support the widespread adoption of ZE-MHDVs. Beyond the scope of the initiative, Drive to Zero has identified nearly 30 green road corridors in development worldwide, showing the momentum, scale, and benefit of this effort.

Figure 2. Set of Corridors Supported by Global Green Road Corridors Initiative



- 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*)

The GGRC coordinated effort includes the collaboration of 11 leading organizations, including governments, nonprofits, financing institutions, and international development organizations. These partners bring a diverse array of expertise and experience to support the development of ZE-MHDVs and infrastructure: Drive to Zero, Electric Vehicles Initiative (EVI), International Council on Clean Transportation (ICCT), International Transport Forum (ITF), the Government of the Netherlands, Smart Freight Centre (SFC), United Nations Environment Programme (UNEP), United Kingdom, United States, The World Bank, and The World Business Council for Sustainable Development (WBCSD).

SECTION 3

WHO NEEDS TO BE INVOLVED?

Corridors are complex, dynamic transportation systems that require involvement and coordination of multiple stakeholders to be successful, including government, independent authorities, industry, nonprofit organizations, and communities.

Due to this complexity, developing global green road corridors requires collaboration and governance that balances top-down approaches (i.e., decisions made and managed centrally, either from a national government or a corridor authority) with bottom-up approaches (i.e., initiatives from local governments and other actors), along with a clear vision. Stakeholders involved in the development and operation of corridors can be categorized into two main groups.

STAKEHOLDER ROLES AND INTERCONNECTIONS

Implementing stakeholders are directly engaged in the construction, deployment, use, management, and maintenance of the corridor network and associated publicly available infrastructure. They include charge/refuel point operators (CPOs, also known as infrastructure service providers), shippers/freight owners, transport companies, and site developers. These entities can be partners, especially in the early stages, but at minimum are bound together by providing demand for and utilization of corridor facilities. They ensure that the logistical and physical components of the corridors function effectively and their business case depends on this success.

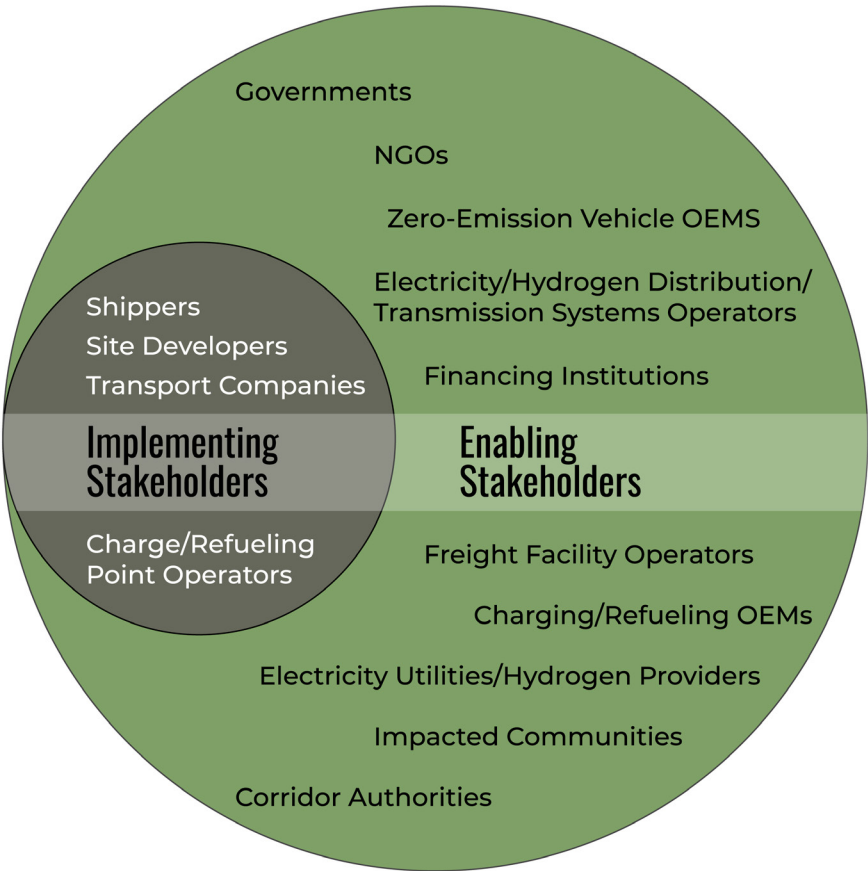
Enabling stakeholders focus on creating the conditions necessary for the successful development and operation of corridors. They can support a corridor system by providing the regulations that can drive demand, supplying funding for assets that will operate in the corridor, coordinating efforts among different organizations, supplying the necessary equipment, and providing access to fuels, electricity, or hydrogen.

Governments are perhaps the most important enabling stakeholder with significant abilities to set conditions for success. Local governments also control critical functions such as permitting and zoning, which can hinder or help site deployment. Financing institutions also play a key role. Other enabling stakeholders include electricity and hydrogen providers (e.g., utility distribution and transmission companies), original equipment manufacturers (OEMs) for vehicles and charging/fueling equipment,

freight facility operators (e.g., ports, multi-modal freight locations, distribution centers), corridor authorities, and/or NGOs that can provide demand aggregation, stakeholder coordination, and best practices and knowledge sharing. Impacted communities also form an important stakeholder set for emphasizing location, need, and urgency of timing.

Figure 3 illustrates the interconnected nature of the corridor stakeholder ecosystem, and the following sections describe each of these stakeholders, their primary roles, and how they interconnect in detail.

Figure 3. Stakeholders Involved in Road Corridors Development



IMPLEMENTING STAKEHOLDERS

Shippers and Cargo Owners

Shippers and cargo owners represent an important and core stakeholder set that can drive the success of early corridors. Their demand for ZE shipping modes is driven by a combination of voluntary commitments to carbon reduction, ESG (Environmental, Social, and Governance) goals, and compliance with regulations.

Transport Companies

Transport companies are the cargo carriers for the corridor, ranging from multi-national logistics providers to regional, local, and small fleet operators. Their primary customers are the shippers and cargo owners. While many transport companies are making investments in ZE-MHDVs either in response to regulations or proactively, they move fastest when motivated by their shipper customers. Their business is highly dependent on vehicle and fuel prices and availability.

Charge/Refueling Point Operators (CPOs)

CPOs provide the ZE fueling services—electricity or hydrogen—at strategically placed locations in regional hubs and along corridors. To succeed, they must integrate their sites with the freight movement needs of the corridors and address the specific needs of the early adopters, who are critical during the initial years of the transition. Their business is highly dependent on utilization of their infrastructure—customers must regularly and consistently use their sites at minimum threshold levels to justify the investment.

Site Developers

Site developers can take on the role of building and sometimes operating a charging/refueling site, either as a stand-alone facility or integrated within freight facility locations. Site developers would need to bring a deep understanding of freight flows and customer demand on their own or serve at the behest of specific customers.

ENABLING STAKEHOLDERS

Governments

Governments at all levels (i.e., national, sub-national, and local) are critical enabling stakeholders.

National and sub-national:

- First and foremost, governments can set regulations with requirements for vehicle emissions that can drive the need and demand for ZE-MHDVs. They can also set requirements for infrastructure installation and standards.
- Equally important, governments can be co- and seed funders for the transition in the form of purchase incentives for vehicles, project co-funding for infrastructure, policies to support the use of ZE-MHDVs, and encouragement to use carbon-free fuels and install infrastructure.
- Governments can prioritize corridor locations and coordinate stakeholders around corridor projects.
- Government agencies often oversee electric utilities and energy providers and can set requirements for investment, service, price, and connection timing. This is sometimes done at the local level.

Local:

Local governments generally have the primary oversight of permitting and zoning, which can slow deployment of infrastructure if local laws are not streamlined and modernized.

Corridor Authorities

Corridor authorities are especially essential in the development of multi-country corridors. They coordinate efforts among national governments, as well as with private entities and local communities. Additionally, they can homogenize regulations and standards, including those for emissions, technology, and safety.

Electricity/Hydrogen Distribution/Transmission Systems and Utilities

While generally not considered implementing stakeholders, there are cases where utilities, distribution, or even transmission operators may play that role. However, they are usually the critical providers of access to the fuel and “interconnection” to the electrical grid. It is imperative that these stakeholders are brought in early to charging infrastructure projects, since they, along with utilities, are responsible for providing connections to the grid and any necessary additional capacity, which often involves lengthy processes. Potential time delays from these processes and localized capacity gaps are critical issues for infrastructure site developers.

Financial Institutions

As with all large system changes, the transition at scale to ZE-MHDVs will require significant investment. Some initial funding from the public sector will help the launch, but private capital will be the real driver of large deployments for the longer term. Financial institutions, including banks, development institutions, and an array of private investors are poised for this transition and already have experience in renewable energy. But they are highly sensitive to risks, project bankability, asset owner/operator profiles, and return on investment, requiring tangible evidence of deployment volumes and infrastructure site utilization underway before committing to large-scale investments. First corridors offer the chance to organize demand, build shared understanding on bankability through market analysis and project financial modeling, and test revenue or risk mitigation models that investors need to see.

Non-Governmental Organizations (NGOs)

NGOs can play a variety of highly valuable roles, particularly in the early market stages of ZE-MHDVs and the first corridors that support them. NGOs can serve as third-party trusted conveners and coordinators of stakeholders around first corridors. They can help identify and solve initial partner challenges as well as recruit and aggregate additional demand for identified corridors to reach minimum thresholds for success. They can also help to capture, share, and elevate best practices and success factors for use in other regions.

Freight Facility Operators

Freight movement is defined by a variety of key facilities where freight assembles, ships, and is transported on. These include air and sea ports, rail yards, multi-modal freight facilities, transshipment, and distribution centers. Each of these sites can play host to thousands of cargo visits per day, and as such, are prime locations for locating and operating regional hub and corridor infrastructure. These operators must be encouraged to add infrastructure capabilities at or near their sites to support the growing customer set that will make the transition to ZE.

ZE Vehicle and Equipment OEMs

Vehicle OEMs are vital stakeholders as they provide the core capability to perform the corridor role with their vehicles, significantly influencing the business case of the transport companies and the cargo carriers using their trucks. While vehicle range has reached a stage to perform corridor operations, it does

not yet support the high-speed charging desired, and vehicle pricing remains one of the key barriers to the success of these corridors. Incentives and supportive policies are the current strategies to mitigate this cost while the vehicles' cost drops due to economies of scale. Charging equipment OEMs are vital for providing reliable charging/fueling equipment that can work with all truck types at low to zero failure rates. They also need to provide the next generation of high-power Megawatt Charging Systems (MCS) needed for effective corridor operations.

Impacted Communities

While most regulations focus on the carbon-reducing benefits of ZE-MHDVs, these vehicles also provide substantial and immediate elimination of combustion emissions that are harmful to human health. These criteria emissions from diesel trucks are of prime impact to communities closest to freight routes and facilities—often the least advantaged communities in urban and other regions. Engaged communities can identify and help solve primary concerns, provide insights into optimal locations for charging and fueling facilities, and support local job markets. With their insight, corridor development can include the appropriate type of training initiatives and skill building required for maintaining and installing new equipment, benefitting communities historically marginalized.

SECTION 4

FOUNDATIONAL CONDITIONS FOR GREEN CORRIDORS AND STAKEHOLDER INVOLVEMENT

The core stakeholders listed above, and their interactions, form the framework of a successful green road corridor. Yet just as a corridor is much more than a line on a map, developing one requires more than simply assembling key entities. In evaluating the initial global corridors emerging worldwide, some foundational base conditions and steps are becoming clear. Demand signals, prioritized locations, and coordination and governance all outline the initial needs to spur green corridors and define the first stages of a green corridor's launch.

DEMAND SIGNALS

Demand is the overriding prime condition. For a green corridor to be developed, there must be conditions, requirements, or other factors that create near-term demand for ZE transport. There must be a willingness to procure, charge/refuel, and operate ZE-MHDVs for a customer. While ZE-MHDV technology is now in production and available worldwide, it is still in relatively low volumes and more expensive than its diesel counterpart in most parts of the world. Even with much lower operating costs—including considerably lower fuel and maintenance costs—the business case for ZE-MHDVs is still emerging in most regions.

This means that market forces alone will not drive ZE-MHDV adoption fast enough to meet climate reductions needed nor drive most corridors. Regulation still drives this early market. While it is true that many large shippers have strong carbon reduction and ESG goals that cause them to explore electrification, these drivers alone do not create sufficient ZE-MHDV demand today to support a corridor. Therefore, there is a need for strong policy and regulatory signals of the requirement for transitioning to ZE transportation, combined with supportive policy and public investments and incentives to assist the early market.

“We need confidence to keep investing. We need strong signals and data that our corridors and site locations make sense for fleet customers. At this early stage in the market, we also need incentives and regulations that help ease the path to EV adoption.”

– Emilia Sibley, Head of Solutions, Terawatt

Importantly, this demand signal is most powerful when it can combine several critical elements:

- Strong regulatory requirements, such as supply-side requirements for sales of ZE-MHDVs and/or stringent carbon and air pollution emissions regulations.
- Effective supporting public investments, such as infrastructure grant funding, vehicle purchase incentives, and loan guarantees.
- Effective supporting policies, such as utility grid interconnection requirements and truck weight waivers to accommodate batteries or fuel tanks.
- Strong shipper and industry carbon-reduction commitments and ESG goals.

PRIORITIZED LOCATIONS

To succeed, green road corridors must first be located where there is sufficient high-volume freight flow, early demand for ZE-MDHDVs, supportive policy and funding, availability of power/fuels, and willing early adopters. In other words, the focus should be on connecting hubs or corridors that are transitioning to or showing interest in adopting ZE-MDHDVs and/or where there is a robust set of enabling factors supporting this development (see the following section). Having power providers who are engaged and electricity rate structures that are competitive (e.g., volume vs. peak-load based) is highly valuable. So too are locations, such as communities surrounding major freight hubs, that would see air quality benefits from ZE-MDHDVs. While many locations can provide one or two, corridors need a strong combination of these elements to justify launch.

“We believe electrification is not if but when, but [we] need the right industry data to identify which corridors are the best places to start. Our partners have provided access to data on routes and freight lanes to make thoughtful decisions.”

– Patrick Macdonald-King, CEO, Greenlane

Therefore, in addition to creating a strong demand signal, it is imperative that either in parallel or as a second stage of action the key freight routes that can support ZE-MDHDVs be identified and prioritized by these elements and other key factors. Such prioritization creates a staged or phased roadmap for growth and provides clear guidance to investors and stakeholders on where to begin. Coupled with this approach, a commitment to focus government funding on these priority locations will further reduce risk to stakeholders and can speed implementation.

COORDINATION AND GOVERNANCE

These two conditions ideally work together for the success of implementing a green road corridor. Most stakeholders agree that coordination is a critical element. The needs and integration of the core implementing and enabling stakeholders must be brought together and aligned with the timing and requirements of the corridor. A valuable role to play includes shining a spotlight on a priority corridor

location, convening the key stakeholders who should be involved, and encouraging cooperation and joint action. Governments and corridor authorities are well suited to play this role as are NGOs, but industry stakeholders can also step in, including shippers or partnerships of infrastructure providers, investors, and other stakeholders.

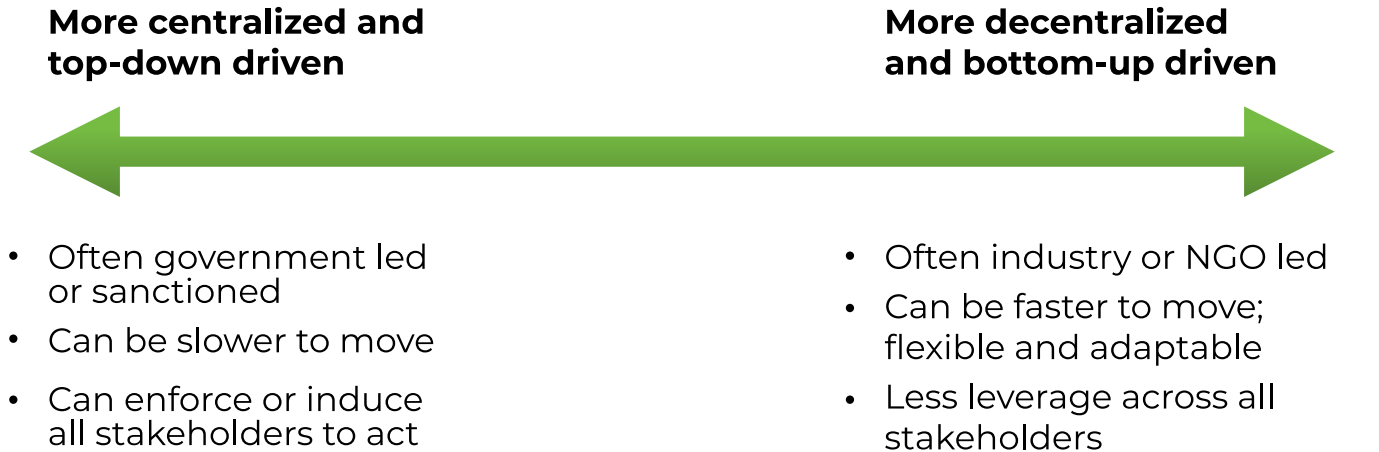
Effective coordination cannot exist without governance, and governance must go beyond merely coordination. In this case, governance means a set of rules, responsibilities, and objectives agreed to by a core set of stakeholders for how they will work together to fund, operate, and use a green road corridor. In essence, this governance defines the basic “rules of the road” for launching the corridor. Several early corridor efforts report that developing an effective way to coordinate stakeholders through some form of governance was a key to progress.

Governance approaches and structures can take many forms and be driven by different stakeholders. Generally, they fall along a spectrum of structure, from centralized top-down designs on one end of the spectrum to decentralized, bottom-up structures managed by self-organized stakeholders on the other (Figure 4). As described earlier, a top-down form could be driven by a government or governments and/or corridor authorities setting the rules and even designating an oversight or guidance entity to manage corridor stakeholders and sites. At the other end of the spectrum, a group of stakeholders, such as shippers, can identify a corridor of mutual benefit and priority and agree to work with a minimum set of other stakeholders to implement this route. Most corridors will likely fall somewhere between these points.

“By extending a hand and working together as partners, we can cultivate ideas and solutions to advance clean and sustainable freight. It is important that we are on this mission together - industry, government, labor, environmental groups, and communities.”

– Alycia Gilde, Senior Transportation Advisor, White House Office of Climate Policy

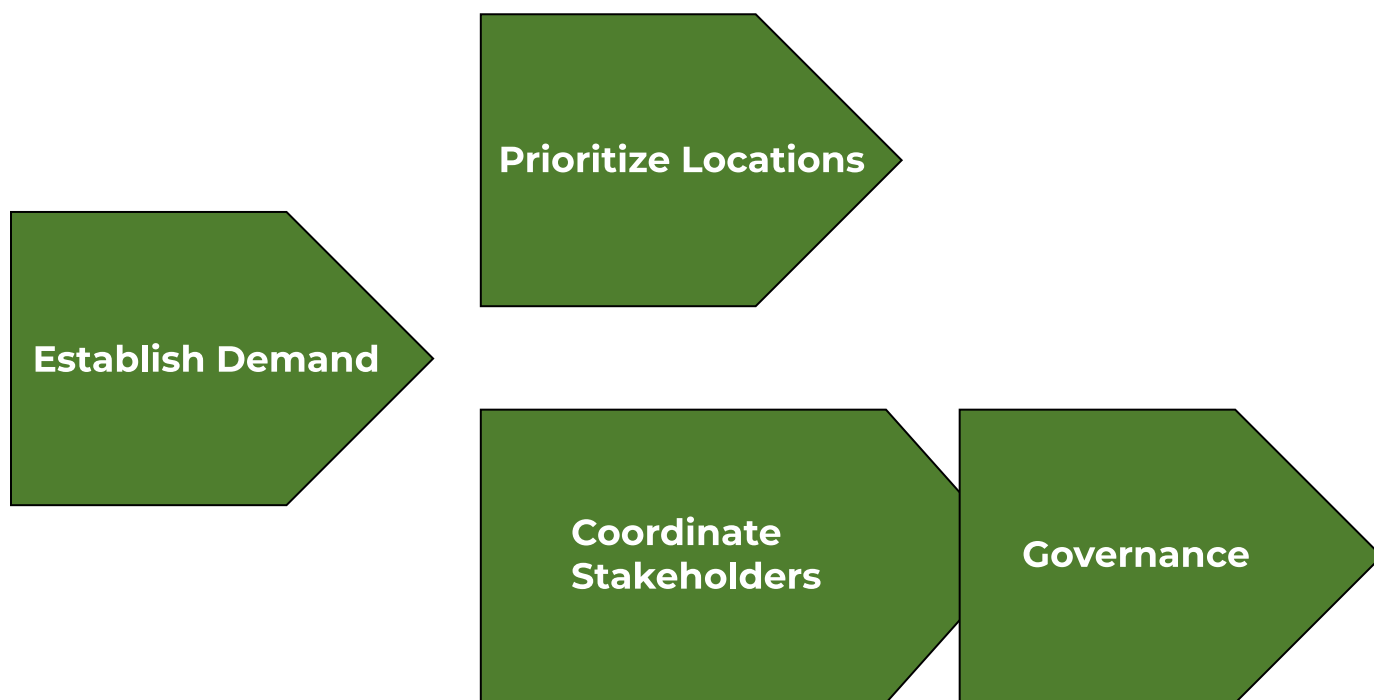
Figure 4. Corridor Governance Spectrum



These foundational conditions do not have a strict, linear relationship. They will likely proceed almost concurrently, but looking at how these conditions roughly sequence in time highlights the need for

establishing strong demand signals as the primary step (Figure 5). Identifying and prioritizing corridor locations is valuable but has less impact without established demand. Similarly, while coordination and governance working in advance of demand can help identify issues, there is little urgency to address them without demand.

Figure 5. Corridor Foundational Conditions

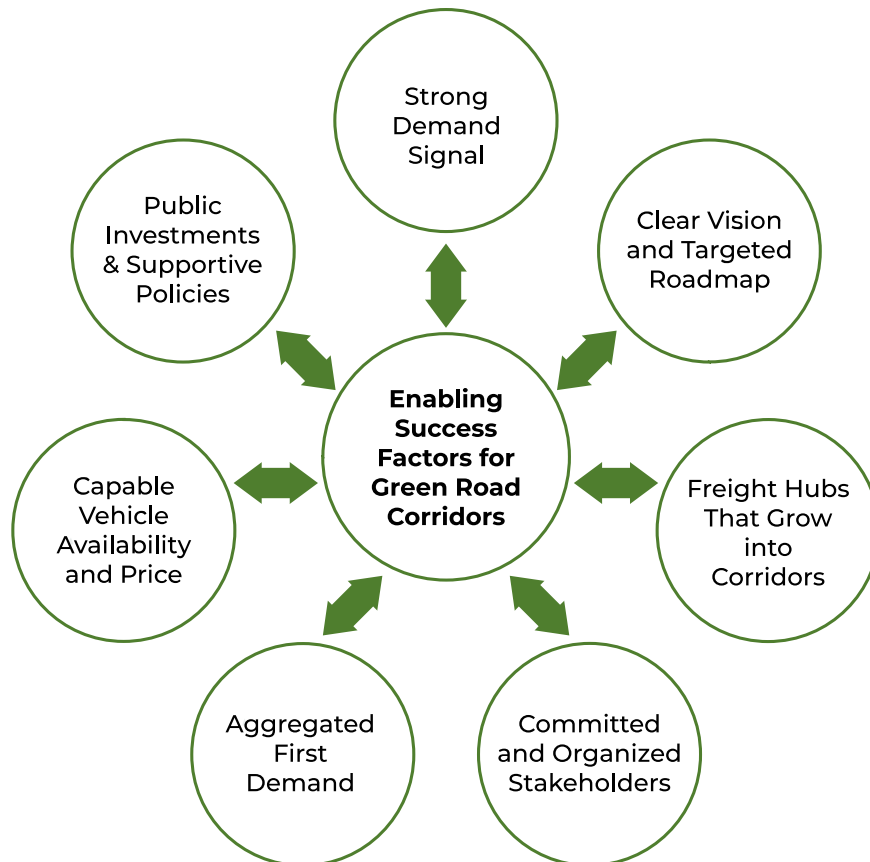


SECTION 5

ENABLING SUCCESS FACTORS

The foundational conditions described above frame the necessary starting point for green road corridors but are insufficient alone. The more complete framework for developing green road corridors requires understanding the core factors that drive their establishment and effectiveness, and which build from the foundational conditions (Figure 6). Governments and corridor governance leaders have a significant role to play. By engaging and coordinating stakeholders on all of these factors early on, leaders can speed up action and increase the likelihood of launch and longer-term success. Importantly, these factors form an interconnected ecosystem of support, all of which should be implemented in tandem with one another.

Figure 6. Key Enabling Success Factors for Developing Green Road Corridors



Building ZE corridors is a work in progress and actively taking place in real time around the world. Therefore, the following preliminary success factors are the beginning of an active learning process. They distill the current and best learnings from leading site developers, CPOs, shipper and transport companies, and governments interviewed by Drive to Zero (see the appendix for full list of interviewees) actively engaged in several corridors, together with the experience and knowledge of CALSTART and partners.

STRONG DEMAND SIGNAL

Driving and supporting vehicle and infrastructure demand is both the main foundational condition and the primary enabling success factor to establish green road corridors on the timeline needed. The reason is clear: While poised for breakout, the market for ZE-MHDVs is still early and emerging. There has been remarkable progress in deploying ZE-MHDVs, and they are showing advantageous total cost of ownership (TCO) in several truck applications today. However, relying only on market forces alone is insufficient to meet climate timelines.

To compensate for the early-stage market conditions, early demand can and must be driven by several elements. Based on extensive stakeholder discussions, the most effective form comes from strong and clear government regulations that require an increasing number of ZE-MHDVs to be bought and sold each year. Examples of these requirements include supply-side regulations (SSR) such as Advanced Clean Trucks (ACT) [5] in California and other U.S. states and the heavy-duty CO₂ emission standards in Europe [6]. Demand-side regulations, such as California’s Advanced Clean Fleets (ACF) [7], which requires fleet purchase of ZE-MHDVs, can complement SSR.

Setting a clear goal and vision, such as nations do in signing on to the Global MOU, is a good step that should be strengthened by making these goals mandatory requirements. These regulations establish a clear transition timeline, encourage production at scale and associated price reductions, and bring certainty to companies—and investors—to plan for the future.

PUBLIC INVESTMENTS AND SUPPORTIVE POLICY

Coupled with a strong signal based on requirements, demand must also be backed by strong initial funding and supportive policy. While private capital is anticipated to provide the backbone for the long-term buildout of green road corridor infrastructure, initial public co-funding of infrastructure deployments, for purchasing ZE-MHDVs and even underwriting the charging business case, is a critical enabling condition. This can take the form of grants, incentives, loan funding utilization guarantees, or other innovative

“In this stage of the market, public funding is the single most important factor to securing private investment. Public funding helps to offset early utilization risk while driving the confidence required for private sector investment by building out the necessary infrastructure today to catalyze future fleet electrification.”

– Zeina El-Aziz, Co-Founder and CEO, Gage Zero

financial mechanisms that reduce the risk of investing in and using ZE-MHDVs and infrastructure. Development financial institutions (DFIs) play a critical role in enabling this supportive environment in emerging markets and developing economies (EMDEs) that lack access to public funding. The public has an immense stake in ensuring corridor success to reap the economic and health benefits from these vehicles.

In addition to a commitment to co-fund, there are other supportive policies that play an important role in corridor success. Generally, these policies fall into three categories:

- Requiring the energy sector—and the electric power industry—to invest in and support rapid infrastructure deployments.
- Providing greater flexibility in vehicle operations to encourage ZE-MHDV use.
- Streamlining and aligning local regulations to speed permitting and siting of infrastructure.

Energy Sector Integration

The energy and electric power industries are not adequately aligned with the transportation sector on such basics as the timing for electrified vehicles and the urgency for infrastructure planning, capacity development, and fast interconnection to the grid. Oversight of the electric power industry is often performed at the sub-national level and by agencies or regulators not directly connected with transportation or transportation emissions regulations. There are a variety of examples of utilities and energy agencies actions that are useful. Several sub-national governments were lauded for their leadership (see the Emerging Best Practices section for additional detail).

Greater Vehicle Flexibility

This can take many forms but most generally involves rules governing vehicle use and operation. Among those is allowing weight waivers for ZE-MHDVs because of the greater weight from batteries or hydrogen storage tanks. Many governments allow up to 2,000 pounds/900 kilograms of excess weight, but it does not apply to all highways; interviewees from the industry believe that a higher weight allowance is needed. Another example is involving driver hours of service limitations and allowing more flexibility on measuring these to accommodate vehicle charging time at stops.

Streamlined Local Regulations

For infrastructure service providers, this issue was one of the most common causes of delays separate from utility capacity and interconnection delays. Local governments generally oversee and manage zoning of land use and permitting of business sites. However, most local governments have not updated their zoning and permitting rules to accommodate large charging sites for vehicles and often do not know how to categorize them. Stakeholders call for better alignment across all levels of government to support the deployment speed and scale needed. In response, national infrastructure strategies have included educational initiatives to help local governments understand the unique complexities of charging sites.

CLEAR VISION AND TARGETED ROADMAP

Alongside regulatory certainty and financing, identifying and prioritizing the locations where corridors can succeed first is vital. It is one of the foundational conditions for corridors and a success factor. Infrastructure site operators, investors, and fleets cannot afford to launch their efforts everywhere all at once. They all require targeted locations chosen for success metrics. These success metrics can include:

- Routes with the highest-volume freight traffic
- Regions with supportive policy and financing mechanisms
- Available energy, supportive utilities, and conducive energy rates
- Proximity to high-volume freight hubs, such as ports, railyards, warehousing centers, and multi-modal shipping sites
- Locations where emissions reduction of local and non-local air pollutants would produce the greatest benefits to air quality and GHG reduction

Such prioritization can also help the energy industry by focusing capacity optimization, expansion, and interconnection resources in key areas to start.

Several stakeholders can realistically establish a prioritized vision, and many initial corridors have grown from motivated industry stakeholders in areas of strong demand signals identifying opportunistic first locations. However, this prioritization is ideally a role for national and sub-national governments to take, building off the inputs from industry and other stakeholders. Governments can look beyond regional boundaries and assess national freight and goods movement trends. They have the ability to engage all stakeholder sets and the power to focus their funding assets and incentives on the prioritized regions to drive alignment and co-investment.

By developing a national prioritized and phased infrastructure plan, a country can set the timing of each phase of infrastructure growth and align them with national carbon goals. At the subnational level, more detailed local strategies can then build off the national vision and provide a finer level of detail for investments (see the Emerging Best Practices section for additional detail).

ENGAGED AND ORGANIZED STAKEHOLDERS

Effective stakeholder coordination and governance are foundational conditions and essential success factors for developing green road corridors. Achieving a successful corridor requires early and ongoing collaboration and some level of organization. Trusted and well-resourced governments, independent authorities, and/or NGOs can serve this role.

As noted, governance can take many forms but generally falls on a continuum between top-down centralized approaches on one hand to bottom-up decentralized approaches on the other. Most governance structures will be somewhere between these points, and many will use approaches from both.

Top-down engagement from central authorities, like national governments or corridor management bodies, provides policies, resources, and guidance. Bottom-up involvement from industry (e.g., shippers and carriers), infrastructure services providers, and other stakeholders can move quickly. Including local governments and community groups, for instance, also ensures sensitivity to local contexts and support for development efforts.

AGGREGATED FIRST DEMAND

While regulations will provide broad demand certainty, aggregating initial specific demand from shippers and transport companies in targeted regions can greatly help accelerate early corridor deployment, mitigate risks, reduce costs, and unlock finance.

Shippers and the carriers they contract with are key stakeholders when aggregating demand. Many global shippers have strong carbon reduction and ESG goals while also directly influencing the vehicle purchasing decisions of multiple carriers. These carriers will generally—depending on conditions—adopt technology requested or required by their shipper customers. By identifying the shared freight routes of a handful of key shippers, it is possible to influence multiple carriers to adopt ZE-MHDVs and thereby aggregate initial vehicles into a threshold level of demand. Fleets in the same location can also coordinate timing on truck orders and infrastructure installation to promote asset sharing and help utilities coordinate.

This activity is critically important because CPOs require a minimum level of utilization (i.e., vehicles charging each day at their sites) to justify investment and make their business case work. Realistically, most early users will not represent sufficient utilization of first sites on their own for third-party site developers to attract capital—unless the demand from additional users can be combined. Several NGOs are providing such valuable coordinative services to bring fleets and developers in business parks or hubs together, and more of this creative coordination around shared asset-use is needed.

CAPABLE VEHICLE AVAILABILITY AND PRICE

ZE-MHDVs are currently available in nearly 1,000 models and most applications from the world’s major manufacturers [8]. They are also rapidly increasing in volume each year. As of 2023, ZE trucks capable of pulling the heaviest loads have become available with ranges between charging or refueling (more than 240 miles or 400 kilometers) that make the operation of corridors practical [8]. This has enabled the first green corridors to develop and the first longer segments to operate.

Three key factors currently limit even faster expansion: vehicle price, availability, and charging rate. During interviews for this

“We are treating this as a rapid learning exercise. We plan to get started - iterate as we go - learn - then rebuild. What we are really investing in is next-generation thinking.”

– Nico De Golia, Director of Cloud Logistics Sustainability, Microsoft

report, corridor implementing stakeholders consistently cited the need for greater availability of vehicles, noting that infrastructure was not always their limiting factor. They also said they wanted access to vehicles that could charge at megawatt levels to limit dwell times (i.e., the time a truck spends waiting while charging). Truck manufacturers have been testing MCS, but most do not expect to field such trucks before 2026 or 2027, likely to happen first in Europe. Finally, truck prices remain prohibitively high (i.e., up to almost three times the cost of a diesel truck [9]), even as volumes increase and battery prices drop.

To support the needs of freight hubs and early corridors, faster-charging, long-range vehicles are needed sooner than some manufacturers are currently planning. Their price must also be low enough to ensure affordability (especially for SMEs with limited access to financing), support a viable life-cycle business case, and provide a competitive choice versus a diesel vehicle. In the near term, strong regulations combined with public incentives can help bridge the gap as vehicle volumes rise and supply chains grow.

However, an additional forcing mechanism may be required. This could take the form of a partnership with manufacturers, or a competitive challenge to them, to offer reduced pricing in exchange for high-volume commitments. Manufacturers seeking to differentiate themselves could also offer more competitive “forward pricing” (i.e., pricing vehicles to match expected future costs) to stimulate early market growth. Such strategies are often used with other technologies and would provide significant support to corridor and hub growth.

FREIGHT HUBS THAT GROW INTO CORRIDORS

At their core, corridors are high-volume freight routes that connect important freight hubs, such as ports and major centers of distribution. Most stakeholders believe the first focus of any corridor must be to build out an effective regional charging capability at hubs and consequently grow the planned corridor from these success points.

This expansion from hubs to corridors is not strictly linear and will vary based on market maturity in different regions of the world. However, generally the first wave of market penetration for ZE-MHDVs will be in regional applications and then expand as capabilities grow. This sequencing concept is based on two proven models of change for the ZE-MHDV transition: the beachhead strategy [10], the foundational paradigm for Drive to Zero, and the infrastructure phasing-in [11] strategy, which was developed to inform national infrastructure prioritization efforts in the United States. Taken together, these models emphasize building out ZE-MHDVs from a base of steady market success.

Nonetheless, in many regions the growth of ZE freight hubs and the expansion to corridors can and is happening concurrently, and their strategies are cross supporting. As hub charging expands outward from a region to support full regional freight operations, it also forms the basis of the next charging points for the corridors that radiate out from these hubs. Thus, hub charging must be an integral part of planning corridors.

ADDITIONAL ENABLING FACTORS

Available and Affordable Energy

Most infrastructure service providers noted that in the early years demand was their first concern, and that they could work around issues such as limited distribution grid capacity via careful site selection, phasing in infrastructure over time, and implementing smart, managed charging strategies. However, going forward, the energy sector and electric power providers specifically need to plan for providing adequate and affordable power that meets the locations and load demands of ZE transportation.

Coupled with this, electric energy pricing structures must be adapted to meet the unique needs of the transportation segment. Most power providers are adept at—and designed for—servicing the stationary market (i.e., homes, buildings, and industries) but not for mobile customers represented by transportation. As ZE-MHDVs start at low volumes and grow, with relatively low initial utilization of charging or refueling sites, they can face high rates caused by factors such as “demand charges” that can far exceed the base energy cost. Regions expanding their ZE-MHDV utilization should ensure that the regulatory oversight of electric power providers includes deep integration and accommodation of vehicle electrification.

Access to Clean Energy and Steadily Decarbonized Energy Mix

While not a direct limiter of ZE-MHDV introductions and growth, it is vital that the electric power generation mix and hydrogen feedstock sourcing decarbonize on the same or greater pace as vehicles are growing in the market to achieve greater environmental benefits. Additionally, a renewable energy mix is generally and in principle more cost-effective than fossil-fuel alternatives, which positively impacts the operational costs of ZE-MHDVs.

Although the electric generation mix has been decarbonizing on a much faster pace than the transportation segment, particularly in regions where ZE-MHDVs are being introduced, there can be a premium associated with purchasing renewable electricity at wholesale markets [12]. More competitive pricing can be achieved through power purchase agreements (PPAs), which are typically long-term contracts between renewable electricity generators and off-takers, such as fleets or CPOs. These contracts secure stable electricity prices over the long term, but there can be a mismatch between the typical electricity volumes covered by PPAs and the actual needs of fleets. This often necessitates the pooling of multiple customers to achieve the scale generators require.

Alternatively, while implementing onsite renewable generation adds complexity, longer implementation times, and increased initial investment costs for charging infrastructure projects, renewable energy can deliver long-term economic benefits, even when combined with battery storage. Additionally, decentralized or off-grid systems can help reduce the required grid connection capacity and associated lead times, especially beneficial in areas with congested grids. These systems can create extra revenue streams by enabling participation in ancillary services, balancing markets, demand response programs, and capacity procurement markets.

Even in energy mixes dominated by fossil fuels, ZE-MHDVs can provide benefits because of their significantly higher efficiency in using energy [13]. But ideally, as ZE-MHDV volumes grow, they will be

powered by steadily decarbonized energy sources. As global nations commit to and implement the transition to ZE transportation, it is imperative they have strong goals, regulations, and inducements for decarbonizing their energy sectors as well.

Streamlined Permitting and Grid Connection Times

Carbon reduction strategies and regulations are usually set at the national or sub-national level. However, actually implementing these strategies on the ground is a localized action. Since building permits and land-use zoning that allow charging or refueling sites is usually determined at the local and municipal level, it is critical that all levels of government know and serve their role in supporting this transition.

Providing local governments with recommended practices and templates for accommodating charging and refueling sites can be a useful step to address this issue. Providing guidance to local agencies on the urgency of the transition, its benefits, and information on the critical nature of timing to hold back projects can assist.

Similarly, oversight bodies for electric power providers need to set clear guidance and rules governing grid connection times that prioritize transportation charging projects. Several jurisdictions have developed useful processes to manage this (see the Emerging Best Practices section for additional detail).

Interoperable and Reliable Charging/Fueling Systems

Even more so than for passenger cars, commercial vehicles require highly reliable charging and refueling sites. Commercial vehicles are performing work tasks, from carrying freight to providing services. Delays or an inability to charge or fuel means lost revenue and disappointed customers. While still in the early stages, infrastructure equipment is proving to be less reliable than required and does not always provide error-free connections to all vehicles.

Infrastructure service providers emphasize that standards for connectors, testing to ensure reliability, and even setting reliability metrics to receive government co-funding could all be useful to guarantee the level of service commercial vehicles need. In the interim, some site operators are using work-around strategies to address these issues, such as installing more equipment than needed to ensure a back-up capability is available. However, this adds costs to installations that do not help the business case.

Standardized and Enforced Emissions Accounting Frameworks, and Fuel and Air Quality Standards

To build a successful business case, it is important to develop and make use of as many revenue streams as possible. This can include providing services for passenger car charging at a HD charging site to increase utilization of the asset, as both segments have complementary usage patterns—MDHVs typically operate more during the weekdays, while passenger cars are used more during the weekends.

Another intriguing source is via environmental and emissions reduction credits. Where operating ZE-MHDVs can be shown to provide net-emissions reductions beyond requirements, there can be an opportunity to generate and sell credits. Similarly, some existing regulatory programs such as California's Low Carbon Fuel Program (LCFS) support generating sellable credits for using low carbon fuels, including electricity.

To enable this capability, however, standardized and common accounting frameworks for such emissions must be in place and enforced to ensure real reductions are made, tracked, and not double counted.

Global protocols have been established that could serve as a standardized framework for emissions credits, but they would need to be adopted and enforced by the appropriate jurisdictions. Attention to both enabling and enforcing such structures would provide real additional value to grow the ZE-MHDV market.

Megawatt Charging Systems (MCS) Availability

As has been previously noted, having MCS-capable ZE-MHDVs is an important success factor for corridors. The corollary is equally true: MCS equipment must be available, reliable, and installed to support this capability. As of this writing, MCS charging equipment remains in the pilot phase. The capability is being proven in real-world use, but the equipment is not yet in serial production. Most observers have indicated the first production equipment will likely emerge in Europe by late 2025 and later in other regions of the world.

SECTION 6

INTERCONNECTING SUCCESS FACTORS: AN INTERACTIVE ECOSYSTEM

When considering both the foundational conditions and the enabling success factors, it is vital to realize that they represent interconnected elements of a complete system. Each factor influences and is influenced by the others, and if one is missing, it can reduce overall effectiveness. That said, these factors do not always move forward at the same pace; sometimes progress or setbacks in one area will ripple out to others, but the impact varies. While not all factors must be implemented absolutely, it is helpful to visualize what outcomes the factors help drive.

“At the site level, success is all based on utilization/throughput. That is the key factor. If vehicles are not charging, the operator is losing money.”

– Jason Gies, Vice President, Global OEMs and North American Fleet Solutions, ABB

Figure 7. Key Elements of a Successful Global Green Road Corridor Ecosystem

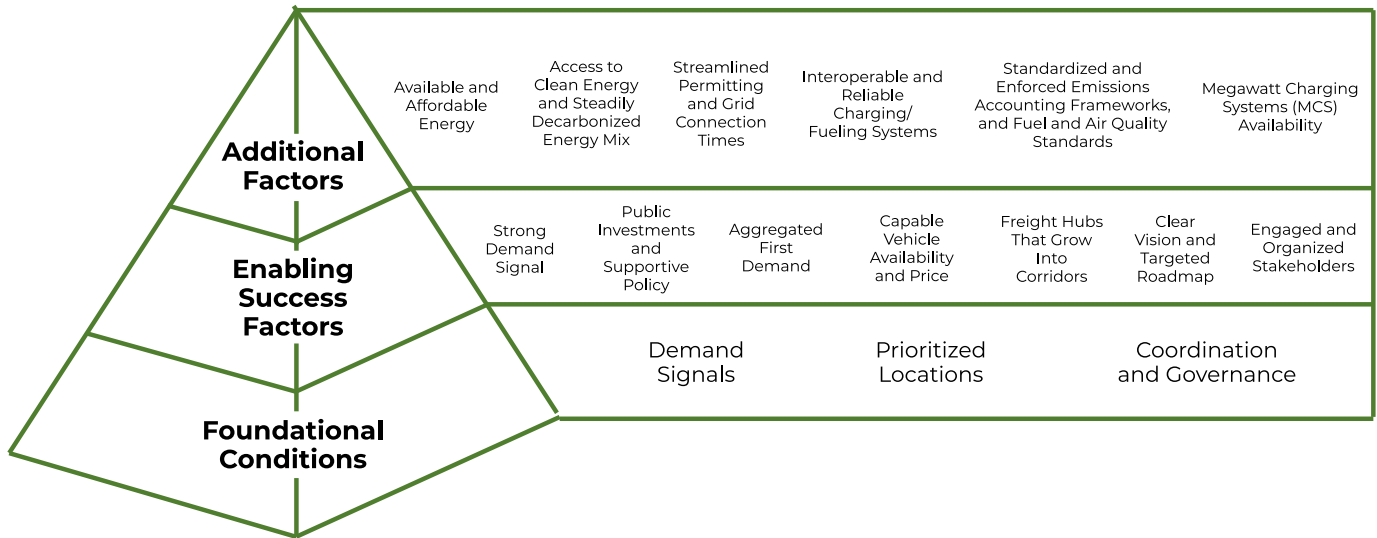
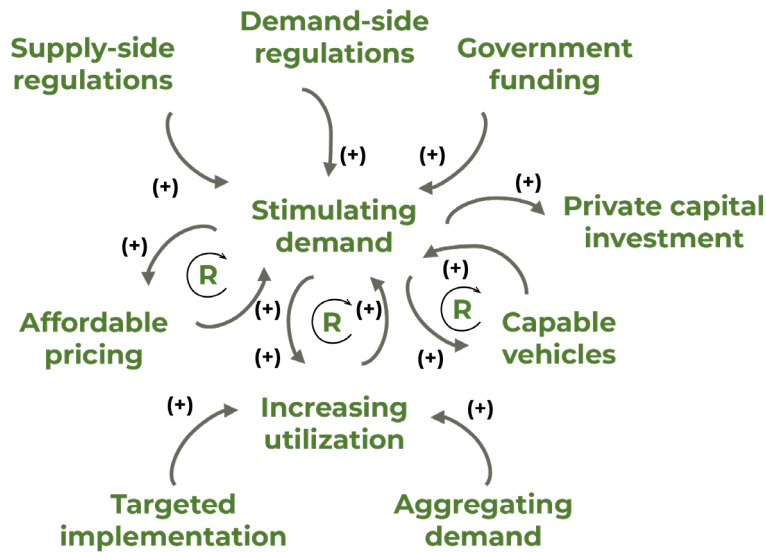


Figure 8 provides a simplified model that illustrates the interactions among the enabling factors and the intermediate actions they initiate. These actions create reinforcing loops that propel the system toward achieving larger outcomes. Ultimately, the key measure of success for the corridor at large and

the individual business cases within it (i.e., CPOs, carriers, shippers, fuel providers) is utilization—that the charging/refueling assets are being sufficiently used, carriers are moving goods within time and cost constraints, and shippers are using and demanding ZE service because it meets their economic and carbon commitment needs.

Figure 8. Causal Loop Map for Utilization



To reach utilization targets according to this general model, the starting point involves actions to **stimulate demand**. Given the early stage of market maturity, government **regulations** are the primary tools for this, but more is required: **Public investments and incentives** to match with **private capital** along with supportive policies must be integrated with requirements. Regions that have set in place strong regulations, investments, and economic support are showing the fastest progress on ZE-MHDV implementation.

Targeting where first corridor implementations take place is another critical factor shown in the model. It helps to focus often limited public and private resources on locations most likely to succeed first. Amplifying this signal are efforts to **aggregate demand** to drive the highest utilization of assets on a given route. Coordinating stakeholders within this corridor and providing governance (i.e., defined responsibilities, timing, and role for the first implementers) further speeds implementation and can guarantee minimum utilization levels.

In the near term, incentives can defray some of the higher costs of ZE-MHDVs, but vehicle makers need to **reduce prices** and consider forward pricing to support initial utilization. Similarly, speeding the availability of vehicles **capable of faster charge** rates can also support carrier and shipper adoption.

Implementing the additional success factors help support the key areas outlined in the model, speed near-term success, and create the conditions for long-term sustainability. Together, these factors help green road corridors play their vital role in enabling the complete transformation of freight movement and commercial vehicles to ZE.

SECTION 7

WHICH EMERGING BEST PRACTICES CONTRIBUTE TO FOUNDATIONAL CONDITIONS AND SUCCESS FACTORS?

Corridor stakeholders are not sitting still. Despite the early stage of the market and the range of acknowledged challenges, they are turning lessons learned into next-step actions. Most stakeholders realize they cannot wait: They need to create the structures that work as part of an iterative learning, refining, and improvement process.

That template is starting to take shape. While not yet complete nor final, key implementing stakeholders have identified the main lessons developed from addressing challenges in the field combined with their emerging knowledge of what enabling factors truly drive successful implementation. Based on interviews with key stakeholders, an emerging set of best practices and examples can be framed to guide global partners evaluating their own corridor implementation (Table 1).

Table 1. Emerging Best Practices and Examples for Enabling Success Factors

FACTOR	BEST PRACTICES	EXAMPLES/REFERENCES
<p>Strong Demand Signal</p>	<p>1. Implement strong regulation, both at the supply and demand side.</p> <ul style="list-style-type: none"> • <i>Most stakeholders acknowledge that demand is not yet market driven and needs to be accelerated by government requirements. There are multiple examples of such regulations from around the globe at both the national and sub-national levels. Most are supply-side regulations (SSR), but there are also examples of demand-side regulations (DSR).</i> 	<p>1a. Tailpipe carbon emissions limits – the more stringent the standards, the faster electrification is driven:</p> <ul style="list-style-type: none"> • European Commission CO₂-Standards for HDVs – 45% carbon reduction by 2030, 90% by 2040. Already driving ZET penetration. • U.S. EPA Heavy-Duty CO₂-Regulations – From 25% to 60% CO₂ reduction, depending on the segment, by 2030. Will likely drive small to moderate ZET penetration. <p>1b. ZE sales requirements:</p> <ul style="list-style-type: none"> • California Advanced Clean Trucks (ACT) regulation – requires steadily increasing ZET sales percentages (varied by weight and use profile) starting in 2024. It is already driving ZET penetration. Ten other U.S. states have adopted. <p>1c. ZE purchase requirements:</p> <ul style="list-style-type: none"> • California Advanced Clean Fleets (ACF) regulation – requires steadily increasing purchase of and fleet percentages of ZETs. Implementation delayed. If implemented, likely will drive strong ZET penetration by 2030. • Zero-emission zones – although typically applied in urban centers, they could be explored for implementations along corridors.

FACTOR	BEST PRACTICES	EXAMPLES/REFERENCES
	<p>2. Work with industry partners who have made real carbon reduction commitments.</p> <ul style="list-style-type: none"> • <i>Corporate, science-based carbon target commitments are useful and often powerful tools for action. They are insufficient alone, but when combined with regions implementing requirements and investments, they can drive action.</i> <p>3. Aggregate demand.</p> <ul style="list-style-type: none"> • <i>Aggregating the demand of multiple parties does not itself create demand, but it is a strong tool for focusing and multiplying its force at specific locations. Combined with stringent regulations and industry commitments, it can justify faster investment and deployments in specific locations or applications</i> 	<p>3a. Interstate 10 (I-10) corridor in the United States is a shipper-driven corridor where they have aggregated demand among several global shippers to launch (see Examples of Foundational Conditions and Enabling Factors in Action section below).</p> <p>3b. India's e-FAST platform to facilitate collaboration between government stakeholders and private-sector partners to shape strategies and actions that support freight electrification at scale. They have signaled aggregated demand for more than 5,000 electric trucks by 2027 and around 7,700 by 2030.</p>
<p>Public Investments and Supportive Policy</p>	<p>1. Vehicle and infrastructure purchase and installation incentives:</p> <ul style="list-style-type: none"> • Direct incentives/rebates • Public project co-funding • Support “shared charging” models • Tax credits 	<p>1a. Polish National Fund for Environmental Protection and Water Management support programs for the electric heavy-duty vehicle sector, including EUR 1.4 billion subsidies for the purchase of vehicles, charging stations and electricity infrastructure for high-power public charging stations.</p> <p>1b. "Colombia's Fund for the Promotion of Technological Advancement", which will offer soft loans and co-funding for the purchase of clean vehicles. The program will be funded through multiple income streams, including federal funding, and more interestingly an increased tax on vehicle purchases.</p>

FACTOR	BEST PRACTICES	EXAMPLES/REFERENCES
	<p>2. Innovative finance</p>	<p>1c. California HVIP: incentives for clean trucks and buses; New York Truck VIP: voucher incentive program for trucks; California EnergIZE: funding of ZE-MDHV charging and refueling deployment for fleets.</p> <p>1d. U.S. Bipartisan Infrastructure Law (BIL)</p> <p>1e. Infrastructure service providers in North America urge funders to allow early charging stations to be shared use or subscription services instead or being purely public until utilization rates rise.</p> <p>1f. U.S. Inflation Reduction Act (IRA)</p> <p>1g. AFIR's AFIF €1 billion subsidies including the support to megawatt recharging stations for HDVs.</p> <p>1h. Dutch subsidy for public charging stations (SPULA) for the costs to install or expand charging infrastructure for heavy electric vehicles.</p> <p>2a. Wider suite of financing programs/projects from Multilateral Development Banks, governments, and private sector in Latin America.</p> <p>2/b. BancoEstado, Chile's public bank, offers concessional loans for the purchase of ZEVs, including lower interest rates, longer repayment periods, and grace periods.</p> <p>2c. A partnership between Lombard and Natwest in the U.K. offers a Residual Value Lease for commercial ZETs.</p> <p>2d. California Pollution Control Financing Authority provides financing support for small fleets to purchase ZE-MHDVs via a loan-loss reserve system to cover lender risks.</p>

FACTOR	BEST PRACTICES	EXAMPLES/REFERENCES
	<p>3. Vehicle rule flexibility to accommodate ZE-MHDVs</p> <p>4. Aligning energy sector/utility engagement:</p> <ul style="list-style-type: none"> • Require utility investments in infrastructure capacity and installation support • Allow utilities and grid operators improved access to financing to invest in advance of demand • Set enforceable timelines for energization 	<p>3. E.U.'s proposal to revise the Weights and Dimensions Directive to allow higher weight limits for battery and fuel cell electric HDVs.</p> <p>4a. Utility and grid operators "Make-ready" investments such as those in New York and California, such as Southern California Edison's Charge Ready Transport Program.</p> <p>4b. New York Public Service Commission pending Case 23-E-0070 would allow "no-regrets" investment in ZE-MHDV infrastructure in high priority locations.</p> <p>4c. E.U.'s Action Plan for grids to promote among other, long-term planning and access to finance for grids.</p> <p>4d. California Senate Bill (SB) 410 requires the California Public Utilities Commission to establish average and maximum energization times for EV infrastructure.</p> <p>4e. California Public Utilities Commission Rulemaking 24-01-018 sets goals and maximum timelines for utilities to connect to and energize EV charging sites.</p>
<p>Clear Vision and Targeted Roadmap</p>	<p>1. Develop an infrastructure vision.</p> <p>2. Focus on prioritization/roadmapping.</p>	<p>1. California Executive Order (EO) N-8-23 establishes an Infrastructure Strike Team to identify priority projects, coordinate government support, streamline approvals, and focus funding.</p> <p>2a. E.U. Alternative Fuel Infrastructure Regulation (AFIR) – requires specific infrastructure installations for ZE-MHDVs along major E.U. freight routes by 2030.</p>

FACTOR	BEST PRACTICES	EXAMPLES/REFERENCES
		<p>2b. U.S. National ZE Freight Corridor Strategy – establishes a four-phase priority implementation framework and timeline for freight infrastructure at hubs and corridors.</p> <p>2c. Colorado State Infrastructure Phasing Plan to inform the development of the state’s forthcoming charging incentive program for MHDVs.</p> <p>2d. German tendering process for the construction of a fast-charging network for trucks along federal motorways.</p>
Engaged and Organized Stakeholders	<p>1. Stakeholder ecosystem coordination:</p> <ul style="list-style-type: none"> • Promote collaborative partnerships that align and leverage different stakeholders’ interests and expertise. • Establish clear governance structures that outline responsibilities and decision-making processes, balancing top-down and bottom-up approaches. 	<p>1a. U.S. Interstate 10 partnership of shippers, carriers, and infrastructure provider (see Examples of Foundational Conditions and Enabling Factors in Action section below).</p> <p>1b. The Northern Corridor Transport Network, led by the Northern Corridor Transit and Transport Coordination Authority (NCTTCA) (see Examples of Foundational Conditions and Enabling Factors in Action section below).</p>
Capable Vehicle Availability and Price	See Regulations and Supportive Policy above.	
Freight Hubs That Grow into Corridors	See Prioritization/Roadmapping above under Clear Vision and Targeted Roadmap.	
Available and Affordable Energy	1. Collaborative and integral long-term planning with the energy sector.	<p>1a. Austria’s Integrated Network Infrastructure Plan, including renewables, different energy vectors, and economic sectors.</p> <p>1b. Austria’s STELE - exchange platform to integrate electromobility into power grids, focusing on match-making events to bring relevant stakeholders, including electricity DSOs and CPOs.</p>

FACTOR	BEST PRACTICES	EXAMPLES/REFERENCES
	<p>2. Implementation of tailored pricing structures that cater to the needs of ZE-MDHVs.</p>	<p>2. Introduction of alternative electricity contract types in the Netherlands that incentivize consumption during off-peak hours, thereby increasing available capacity for customers and reducing overall costs.</p>
<p>Access to Clean Energy and Steadily Decarbonized Energy Mix</p>	<p>1. Implementation of strong goals, regulations, and inducements for decarbonizing energy sector.</p> <p>2. Promoting the use of decentralized or off-grid energy systems.</p> <p>3. Use of PPAs to source renewable energy at charging sites.</p>	<p>1a. E.U.'s Renewable Energy Directive – E.U.'s legal framework for the development of clean energy across all sectors of the E.U. economy.</p> <p>1b. Dutch Sustainable Energy Production and Climate Transition Incentive Scheme (SDE++) - subsidies to companies and nonprofit organisations that generate renewable energy or reduce CO₂ emissions on a large scale.</p> <p>2. Charging Energy Hubs project funded by the Dutch Government.</p> <p>3. CPO Fastned signs its first multi-year Power Purchase Agreement (PPA) in the Netherlands.</p>
<p>Streamlined Permitting and Grid Connection Times</p>	<p>1. Work with local authorities and utilities to provide guidance and establishing fast-track permitting for ZE-MDHSV infrastructure projects, prioritizing projects according to their impact:</p> <ul style="list-style-type: none"> Involve local communities and environmental groups in the planning process from the project outset to gather input and address concerns. 	<p>1a. California Assembly Bill AB 1236 requires counties and cities to create an expedited permitting process for EV charging stations.</p> <p>1b. California Assembly Bill AB 970 establishes specific time frames for local agencies to approve EV charging permits (additional info on 1236 and 970).</p> <p>1c. Clean Ports Plan, Ports of Los Angeles and Long Beach.</p> <p>1d. Dutch National Charging Infrastructure Agenda – “Flying Brigade” Taskforce - training municipal officials on policy regarding charging infrastructure.</p> <p>1e. E.U.'s best practices guide for permitting and grid connection procedures for recharging infrastructure.</p>

FACTOR	BEST PRACTICES	EXAMPLES/REFERENCES
<p>Standardized and Enforced Emissions Accounting Frameworks, and Fuel and Air Quality Standards</p>	<p>1. Promote and leverage emissions reduction credit and programs as additional revenue source.</p> <p>2. Enforce and utilize internationally recognized emissions protocols to track and validate reductions.</p>	<p>1a. California's Low Carbon Fuel Standard (LCFS) credit generation opportunities.</p> <p>1b. Smart Freight Centre's Book and Claim Community - connects, supports, and catalyzes efforts across stakeholders working to develop a coordinated book and claim approach for heavy transport decarbonization.</p> <p>1c. European Union Emission Trading System 2, including the road transport sector from 2027.</p>
<p>Interoperable and Reliable Charging/Fueling Systems</p>	<p>1. Support and adopt standards based on national and global standards organizations.</p> <p>2. Establish reliability and operational standards for charging systems.</p>	<p>1a. ISO 15118, UL, and IEC 61851 standards.</p> <p>1b. CharIN (Charging Interface Initiative) helps create alignment for standardization and interoperability within the EV industry.</p> <p>2a. Chile's regulation of interoperability of electric vehicle charging systems, including differentiation of publicly accessible systems.</p> <p>2b. E.U.'s AFIR – mandates standardization and interoperability requirements of charging and payment interfaces.</p> <p>2c. California Energy Commission reliability reporting and performance standards.</p>
<p>Megawatt Charging Systems (MCS) Availability</p>	<p>See Interoperable and Reliable Charging/Fueling Systems above.</p>	

SECTION 8

EXAMPLES OF FOUNDATIONAL CONDITIONS AND ENABLING FACTORS IN ACTION

AFRICA'S NORTHERN CORRIDOR

Africa's Northern Corridor, led by the Northern Corridor Transit and Transport Coordination Authority (NCTTCA), stands as a model of a corridor built on a robust institutional foundation. This is especially important in multi-country corridors, where policies, regulations, and procedures are often heterogeneous

"In multi-country corridors, establishing a coordinating authority is essential to create an integrated framework that aligns diverse policies, standards, and regulations. Such coordination ensures a seamless and efficient transit, transport, and trade, stimulates economic development, and fosters mutual growth, making the corridor a true engine of regional integration and prosperity."

– Dr. Eng. John Deng Diing,
NCTTCA Executive Secretary

and a wide range of organizations and economic spheres intersect and engage.

Established through a Treaty known as Northern Corridor Transit and Transport Agreement (NCTTA), initially signed in 1985 and revised in 2007, the Northern Corridor is a multi-modal surface transport system encompassing road, rail, pipeline, and inland waterways transport. The NCTTCA was established to oversee the implementation of the NCTTA, whose primary objective is to guarantee free passage of transit traffic through the respective territories of the member states while ensuring environmental sustainability across Burundi, the Democratic Republic of Congo, Kenya, Rwanda, Uganda, and South Sudan. The Northern Corridor also serves Northern Tanzania, Somalia, and Ethiopia.

Through a collaborative approach, the NCTTCA has facilitated numerous partnerships. A notable example is their Green Freight Strategy 2030, developed in collaboration with UNEP (CCAC), the Smart Freight Centre (SFC), and the Kühne Foundation (KF), which aims to promote sustainable, climate-resilient solutions along this key East African trade route, including plans to be electric vehicle-ready by 2030 for its road segments and achieve net ZE by 2050.

This strategy is rooted in stakeholders' consultations and considers regular exchange forums to provide a platform for knowledge exchange, collaborative problem solving, and joint approaches to develop

green freight initiatives among the private-sector stakeholders. This approach is further strengthened by the corridor's participation in and support from the Green Global Road Corridors (GGRC) initiative, which elevates corridors to a global platform, enabling collaboration opportunities and the transfer of knowledge.

The Northern Corridor exemplifies a balance of effective top-down coordination from central authorities and bottom-up engagement from local and private actors, ensuring robust high-level guidance while remaining sensitive to local needs and a broad range of capacities.

U.S. INTERSTATE 10 CORRIDOR

Driven by shippers and coordinated by an NGO, the emerging Interstate 10 (I-10) ZE corridor in the United States illustrates the interaction of several of the identified success factors as well as a potential organizing principle: building corridors around demand from motivated shippers.

The key players launching the corridor speak to this model. Coordinated by Smart Freight Centre (SFC), a global transportation NGO and GGRC partner, the corridor partnership includes global-scale shippers, their prime carriers, and an infrastructure service provider: AIT Worldwide Logistics, DB Schenker, Maersk, Microsoft, and PepsiCo, with infrastructure provider Terawatt. Driven by shipper commitment and initial demand, the partnership identified locations where they each had interest and initial volume and capability. This initial corridor segment will connect Los Angeles, California, and its ports with El Paso, Texas, and its cross-border manufacturing.

"[Stakeholders] realized none of them represented sufficient demand to make the corridor work alone. They needed to share risks and costs to overcome the early barriers."

– Cristiano Façanha, Director of Road Freight Electrification, Smart Freight Centre

Stakeholders realized this first corridor could only succeed by joining together to provide enough demand to justify investments by the charging provider and carriers. Big as they were, they could not make it happen alone.

Working together under a partnership model SFC coordinates, the parties began digging into the details of the operational model they needed. In parallel, corridor charging partner Terawatt secured U.S. federal co-funding for two of the key corridor sites, as the I-10 corridor is one of the priority corridors recognized by the U.S. government's National Zero Emission Freight Corridor Strategy, which helped raise its profile for funding.

"The solution MUST be developed in tandem with willing customers. This is a new ecosystem and operational solution - this is not just a "drop in" fuel. It requires a full supply chain transformation that must include the cargo owner - the carriers - the infrastructure provider - and government."

– Nico De Golia, Director of Cloud Logistics Sustainability, Microsoft

First ZE trucks should start rolling on the more than 800-mile corridor in 2027, with shippers each running a limited number of trips per week to start. An initial six charging plazas will be positioned roughly 150 miles apart on the corridor. The plazas will be designed to accommodate tens of chargers. Additional shipper and carrier partners are expected to join before launch and additional infrastructure providers may be added later. Yet

promising as this first step is, partners also acknowledge the business models for carriers, infrastructure providers, and shippers are in flux in this new endeavor. Their strength is that they have pledged to work together to learn, refine, and adapt as they proceed.

In addition to the shipper focus, this corridor illustrates the interaction of several of the identified success factors: aggregating user demand, focusing on shared high-volume routes, leveraging public funding for infrastructure and vehicles, and building a process to reduce risk and cost for all partners.

RECOMMENDATIONS

WHAT CAN MOTIVATED GOVERNMENTS DO?

- Establish clear goals, strong regulations, and supportive, equitable policies for ZE-MHDVs and their infrastructure.
- Develop a national/sub-national prioritized and phased ZE freight infrastructure plan to identify and target first hub and corridor locations.
- Provide government co-funding and incentives to launch hub and corridor infrastructure and reduce vehicle cost.
- Coordinate, assist, or actively take part in stakeholder collaboration around priority corridors to support faster development and launch.
- Enable and require utilities and energy providers to accelerate and prioritize investments in and support for ZE-MHDV interconnection, renewable energy, and competitive rates.
- Support innovative financial mechanisms—and inclusive access to them—that reduce the risk of investment and operation of ZE-MHDVs and infrastructure.
- Engage with the partners and allies in the GGRC initiative to advance ZE transportation together.

WHAT CAN MOTIVATED TRANSPORT INDUSTRIES DO?

- Prioritize decarbonized transportation, speed evaluation of integrating ZE-MHDVs into operations, and engage sooner to launch pilot projects to demonstrate the benefits and feasibility of ZE-MDVs along corridors, collecting data to inform future decisions.
- Collaborate and create partnerships with shippers, carriers, infrastructure providers, government, utilities, and other stakeholders to develop comprehensive and timely solutions that benefit all parties (e.g., by aggregating demand, utilization agreements, alternative energy contracts, etc.).
- Adopt sustainable practices that provide both economic and operational benefits. Acting early allows organizations to capitalize ahead of regulatory requirements, positioning them as leaders in sustainability and gaining a competitive advantage in the market.

- Engage with policymakers to advocate for supportive regulations and policies that facilitate the development of public and semi-public infrastructure.
- Make use of public funding and utilize innovative financing models that lower the barriers and risks to deploy vehicles and infrastructure.

WHAT CAN MOTIVATED ENERGY SECTORS DO?

- Prioritize powering decarbonized transportation projects and consider their needs into all grid modernization and integration planning.
- Collaborate with government oversight agencies to prioritize electric and hydrogen transportation investments to enhance grid infrastructure in hub and corridor areas to accommodate increased electricity demand from charging stations.
- Develop long-term charging infrastructure programs in collaboration with governments and industry to invest in and/or incentivize the installation of charging stations at strategic locations.
- Offer competitive pricing to transportation customers, find creative new business models to mitigate high utility demand charges in the early ZE-MHDV market, and make investments in distribution grid capacity and faster connections for charging infrastructure.
- Invest in renewable energy sources, including decentralized and off-grid systems, to ensure that ZE-MDHVs operate with minimal environmental impact.
- Utilize PPAs to secure long-term contracts between energy producers and transport/charger operators, ensuring stable pricing and supply for charging operations.

CONCLUSION

Implementing green road corridors is a vital yet challenging stage in the rapid transition to a fully decarbonized transport sector by 2050 in line with net-zero outcomes. While traditionally corridors drive economic growth, they also disproportionately impact the climate and public health. Organizing the transition of the regional and long-haul road segments must begin moving with greater speed today to meet medium- and long-term climate goals. However, success depends on overcoming multiple political, technical, financial, and social barriers.

Based on discussions with numerous stakeholders and tapping industry experience from first corridors, there are solutions to overcome these barriers. ZE-MHDV capabilities have now reached the threshold levels—including minimum range and charging times—to satisfy the initial performance required in first corridors. Green road corridors represent a compelling opportunity to redefine transport, requiring not only ambition but effective coordination and execution at all levels. Therefore, implementation requires a clear understanding of the key stakeholders who must be involved, either to enable or directly implement these corridors. It requires establishing the foundational conditions to make first corridors possible and setting in motion a suite of enabling factors for success in the early years.

First, generating sufficient demand for ZE-MDHVs and infrastructure to support them—the primary foundational condition—requires regulatory certainty and substantial public investment. Policies must be enforceable with priority on supply but also demand levels to create a clear pathway for adoption. Yet, policies alone are not sufficient, especially in the early stages when utilization levels of infrastructure do not yet justify investments along corridors. To overcome this gap, the public and private sectors must organize and collaborate, a vision and prioritization framework must be developed to target those first segments best able to succeed, and those first corridors must be prioritized to link high-volume hubs where motivated organizations and demand can be established.

Significant coordination among a diverse range of stakeholders is needed to achieve corridor success, from international to local levels. It is particularly important to connect goals, timing, and requirements between the electricity/energy and transport sectors, which have not been strongly involved with each other until now. Each stakeholder brings unique interests, agendas, and perspectives to the table. To ensure the implementation of effective and affordable solutions, it is crucial to foster understanding and meaningful collaboration among all parties.

Fortunately, both the public and private sector have demonstrated ability and agility in forming partnerships, enhancing the potential for successful outcomes. Based on these first endeavors, a rich matrix of best practices is now available to inform and assist regions worldwide that are exploring green road corridors. The GGRC initiative will regularly monitor, distill, update, and share these best

practices that support the enabling success factors, providing valuable insights for future corridors. Beyond this, the GGRC initiative will serve as connective tissue between the autonomous initial corridors projects, ensuring that these early learnings reach the global community and progress made visible for policymakers, investors, and industry stakeholders to see, believe, and act to accelerate ecosystem transformation.

While nascent green road corridors may not have all the enabling factors in place initially, this will not deter progress. Instead, it highlights the need for increased support, organization, and coordination, not only among different stakeholders but across different countries on different stages of development to facilitate the exchange of experiences and solutions. Although there is no one-size-fits-all solution, the interconnected foundational conditions and enabling success factors outlined in this report offer a scalable model that can be adapted to diverse contexts.

FURTHER RESEARCH

While the templates illustrated stem mostly from examples in developed economies, they provide a highly valuable starting point for modifying and adapting them to a more localized approach. This can be particularly salient in EMDEs, where specific social, economic, and infrastructural needs must be addressed to ultimately ensure a more equitable distribution of resources, knowledge, and benefits across regions. Outlining a model more directly suited for EMDEs is a potential next-step project for the initiative.

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APPENDIX

LIST OF STAKEHOLDER INTERVIEWEES

Alycia Gilde, Senior Director for Transportation, Climate Policy Office, The White House, U.S. Government

Aravind Kailas, Advanced Technology Policy Director, Volvo Group North America

Cristiano Façanha, Director of Road Freight Electrification, Smart Freight Centre

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Eleanor Bastian, Principal Program Manager, Worldwide Operations Sustainability, Amazon

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