Powering Forward: Insights for Scaling Electric Truck Projects

China's Shenzhen-Dongguan-Huizhou Pilot Project

December 2024

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Disclaimer

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About Smart Freight Centre

Smart Freight Centre is an international non-profit organization focused on reducing greenhouse gas emissions from freight transportation. Smart Freight Centre's vision is an efficient and zero-emission global logistics sector. Smart Freight Centre's mission is to collaborate with the organization's global partners to quantify impacts, identify solutions, and propagate logistics decarbonization strategies. Smart Freight Centre's goal is to guide the global logistics industry in tracking and reducing the industry's greenhouse gas emissions by one billion tonnes by 2030 and to reach zero emissions by 2050 or earlier, consistent with a 1.5°C future.

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Glossary

- **Battery electric vehicle (BEV)**: is a vehicle that relies exclusively on an electric battery for propulsion. BEVs do not have an internal combustion engine or any other backup fuel source.
- **NEICV**: Shenzhen Xieli Innovation Center of New Energy and Intelligent Connected Vehicle
- **Rigid trucks**: are a type of truck with a fixed chassis where the cab and cargo area are permanently attached to the same frame.
- **Tractor trucks**: are a type of truck with a separate tractor unit and trailer connected by a joint.
- **Zero-emission vehicle (ZEV)**: is a vehicle that produces zero-emission at its tailpipe. This includes BEV, fuel cell electric vehicles (FCEV) and plug-in hybrid vehicles (PHEV).

Executive Summary

Freight trucks continue to be a major source of transportation CO_2 emissions, and there is increasing pressure to decarbonize its operations to achieve global climate goals. The need for deploying sustainable solutions at scale could never be more urgent. Electrification of heavy-duty trucks offers a promising pathway towards decarbonization, and the rapidly expanding electric vehicle market provides a unique opportunity for large-scale action.

With an increase in electric truck model availability and applications, more options are available when looking to electrify. This is in part due to government regulations and incentives and improving production economics due to market certainty. Still, several challenges remain in the path towards the mass deployment of electric trucks. One key challenge, as with any new technology, is a high learning curve for users to understand and adjust to the capabilities and economics of electric trucks. While this may be viewed purely as a technical problem, the challenge derives from determining new operational profiles that are needed to maximize the benefits from electric trucks. The only way to meaningfully rectify this is through on-the-ground testing, building collaborative models across different actors and having carriers and industry partners deploy electric trucks within their existing operational models and evaluate the need for new ones.

The Shenzhen-Dongguan-Huizhou (SDH) deployment project, initiated and coordinated by SFC China, addresses this challenge. This report presents the motivation, challenges and actions carried out to develop and initiate the project, as well as an overview of the stages required to plan, execute and evaluate the project. In addition, a summary recap of the lessons learned throughout the process will enable others to view recommendations to replicate similar projects and expand to other regions of China.

The SDH pilot project underscored the importance of collaborative efforts among government bodies, private enterprises, and infrastructure providers in overcoming the operational, financial, and environmental challenges of transitioning to zero-emission freight solutions.

- **Operationally**, the pilot highlighted the suitability of electric trucks for sub-300 km daily logistics operations and showcased how strategic placement of charging and battery-swapping infrastructure can ensure operational continuity. However, gaps in infrastructure density and design—such as the need for truck-specific charging stations—indicate areas requiring immediate attention for future projects.
- **Financially**, the total cost of ownership (TCO) analysis revealed varying outcomes, with high-mileage operations achieving economic competitiveness while low-mileage operations facing barriers to cost parity. These findings emphasize the importance of optimizing vehicle deployment on routes that maximize operational mileage and leveraging economies of scale to drive down costs.
- **Environmentally**, the pilot project achieved significant greenhouse gas emissions reductions. As China's energy grid continues to decarbonize, the environmental benefits of electric trucks will become even more pronounced, making them a cornerstone of sustainable freight systems.

Looking ahead, the success of the SDH pilot sets the stage for expanding zero-emission freight corridors across China. Strategic regions, including the Pearl River Delta, the Yangtze River Delta, and the Beijing-Tianjin-Hebei area, have been identified as prime candidates for electrification due to their dense logistics networks and significant freight volumes. Building upon the lessons from SDH, these corridors can integrate scalable charging infrastructure, battery-swapping networks, and policy incentives to facilitate widespread adoption.

For instance, the proposed Shenzhen-Hong Kong Cross-Border Fresh Produce Corridor and the East Port Zero-Emission Corridor exemplify targeted initiatives aimed at optimizing freight efficiency and promoting sustainability. Future expansions should prioritize high-density logistics hubs and intercity freight corridors, leveraging data-driven planning to align infrastructure development with transport demands. Collaborative policy frameworks, such as relaxing road restrictions for electric trucks and providing financial incentives, will be critical in scaling these efforts.

Moreover, regional integration will play a key role in achieving nationwide impacts. For example, connecting electrified corridors across provinces and linking them with major ports, airports, and railway hubs can establish a comprehensive zero-emission logistics network. By fostering partnerships between stakeholders at all levels—government, private sector, and academia—China can create a robust ecosystem that accelerates the transition to zero-emission freight solutions.

The outcomes of the SDH pilot not only pave the way for electrification within China but also offer a replicable model for other countries and regions. With continued innovation, investment, and stakeholder engagement, zero-emission freight systems can be scaled globally, contributing significantly to achieving net-zero logistics and aligning with international climate goals.

Smart Freight Centre China

The Smart Freight Centre (SFC) is an international non-profit organization focused on reducing greenhouse gas emissions from freight transportation. Its mission is to accelerate the reduction of logistics emissions by fostering collaboration within the global logistics ecosystem. SFC mobilizes global shippers to track and reduce emissions towards net-zero carbon by 2050. This is done through three selected core strategies.

1. By setting global standards for emission accounting in logistics and maintaining recognition as a global authority to enable validation and impacting/tracking;
2. By creating and scaling capacity building programs within the logistics ecosystem in partnerships, with a focus to spread implementation of standards, foster collaboration, and support impact; and,
3. By shaping collaborative initiative's for action, focusing on high impact scalable decarbonization levers, that require joint action across the logistics ecosystem.

This project has been led by SFC China and focuses on SFC's third core strategy – collaborating initiatives for action. China is at the forefront of global truck electrification efforts, demonstrating significant progress in vehicle and battery technology, market development, and research into innovative solutions like battery swapping. Despite these advancements, the actual uptake of electric trucks in China's road freight sector remains below 1% of the total vehicle stock, highlighting the need for continued efforts to accelerate the transition to electric trucks and overcome existing barriers to their implementation.

Zero Emission Freight Initiative

The Zero Emission Freight Initiative (ZEFI) is a non-profit, collaborative partnership dedicated to accelerating the adoption of zero-emission trucks in China. Supported by the Energy Foundation, ZEFI brings together a diverse range of stakeholders, including research institutions, OEMs, energy providers, shippers, logistics companies, and industry associations. By fostering collaboration, promoting supportive policies, and building consensus on zero-emission freight pathways, ZEFI aims to drive the transition towards a cleaner and more sustainable freight sector in China.

SFC China is ZEFI's Secretariat, setting the agenda and leading discussions among stakeholders. SFC China has been instrumental in organizing workshops, conferences, and meetings to facilitate knowledge sharing and consensus-building on key topics such as charging infrastructure development, financing models, and policy incentives for zero-emission trucks. They have also developed and published several reports on zero-emission freight, providing valuable data and analysis to inform decision-making.

Beyond its role in ZEFI, SFC China has been actively involved in various zero-emission freight corridor projects, including the Beijing-Tianjin-Hebei (BTH) Zero-Emission Freight Demonstration Project. This project, launched in 2022, has successfully deployed over 400 new energy vehicles and established 8 zero-emission freight corridors in northern China, showcasing the viability of electric and hydrogen fuel cell trucks for freight transport. SFC China played a key role in this project by:

- Facilitating stakeholder engagement: They brought together key players from government, industry, and academia to create a collaborative ecosystem.
- Conducting research and analysis: They analyzed operational data, evaluated different technologies, and identified best practices for zero-emission freight corridors.
- Developing and disseminating resources: They created toolkits and guidance documents to support the replication of the project's successes in other regions.

The BTH project has achieved significant milestones, including the establishment of 7 hydrogen fuel cell long-haul corridors, 1 electric vehicle charging long-haul corridor, and 1 battery swapping corridor. The project's Beijing-Tianjin Daily Goods Hydrogen Corridor was even recognized as a "Zero Carbon Pilot Project" by the

Ministry of Transport. By developing and sharing toolkits and best practices, ZEFI and SFC China are helping to accelerate the adoption of zero-emission freight solutions across China.

Strategic Approach for Project Development

Real-world implementation projects have significant value in road freight electrification. Whether for temporary vehicle or infrastructure testing or towards scaled deployment, having a focused approach to project development is key. With these caveats in mind, the key areas of strategic value to be derived from this project include:

- Mobilizing the resources needed to initiate a sector-wide transition within the (limited) scope of an application area, by funding vehicles, infrastructure and aggregating demand.
- Generating real-world data and learnings to underpin implementation design and sectoral transition.
- Developing recommendations for the logistics sector, solution providers and governments for the scaling of similar projects.
- Creating awareness and increasing the sectoral competence of electric trucks and charging infrastructure within the logistics sector.

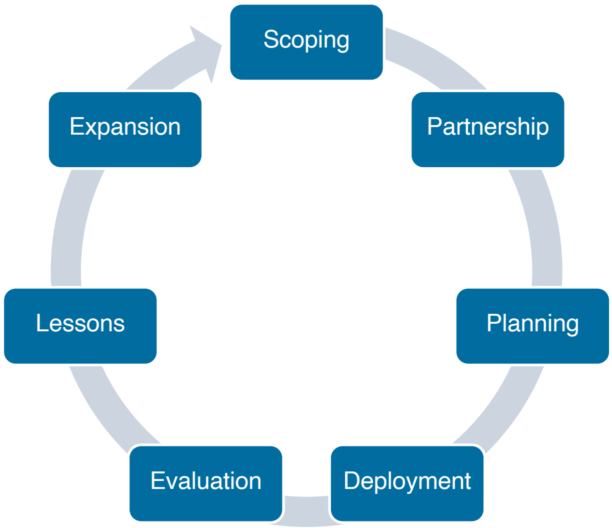

Figure 1. Key project stages

ZEFI's project development approach prioritizes collaboration and real-world impact (**Figure 1**). It begins with **Scoping**, where stakeholder needs, particularly those of shippers, are mapped to define the project's scope and aims. This ensures that projects are anchored in addressing practical challenges and meeting tangible demands. The **Partnership** stage focuses on building a strong consortium, bringing together diverse stakeholders like shippers, carriers, and technology providers, to foster collaboration and resource sharing. The remaining stages (**Planning**, **Deployment**, **Evaluation**, **Lessons**, and **Expansion**) follow a cyclical process of designing, implementing, assessing, and scaling pilot projects. This iterative approach allows for continuous learning and improvement, ensuring that projects effectively address shipper needs and contribute to broader sectoral transformation. (Refer to **Annex I** for a detailed outline of the process).

Project Objectives

The SDH Heavy Truck Electrification Pilot Project described in this report applies the project development approach in **Figure 1** to trucking operations within and from Shenzhen towards the neighboring cities Dongguan and Huizhou (**Figure 2**). The demonstration project in SDH region aims to:

- Investigate the critical factors necessary for widespread adoption of electric heavy-duty trucks in the SDH region. This includes evaluating current policies, charging infrastructure, vehicle technology, operational routes, and transport and logistics management practices.
- Conduct a pilot demonstration to validate the feasibility of operating electric heavy-duty trucks within the region and establish a viable zero-emission truck corridor.
- Gather practical experience and insights from the pilot project to inform the broader application and promotion of electric heavy-duty trucks in the Pearl River Delta and across China.

The project was coordinated by the ZEFI team, with strong support from the Shenzhen Xieli Innovation Center of New Energy and Intelligent Connected Vehicle (NEICV), with funding from the Rocky Mountain Institute.

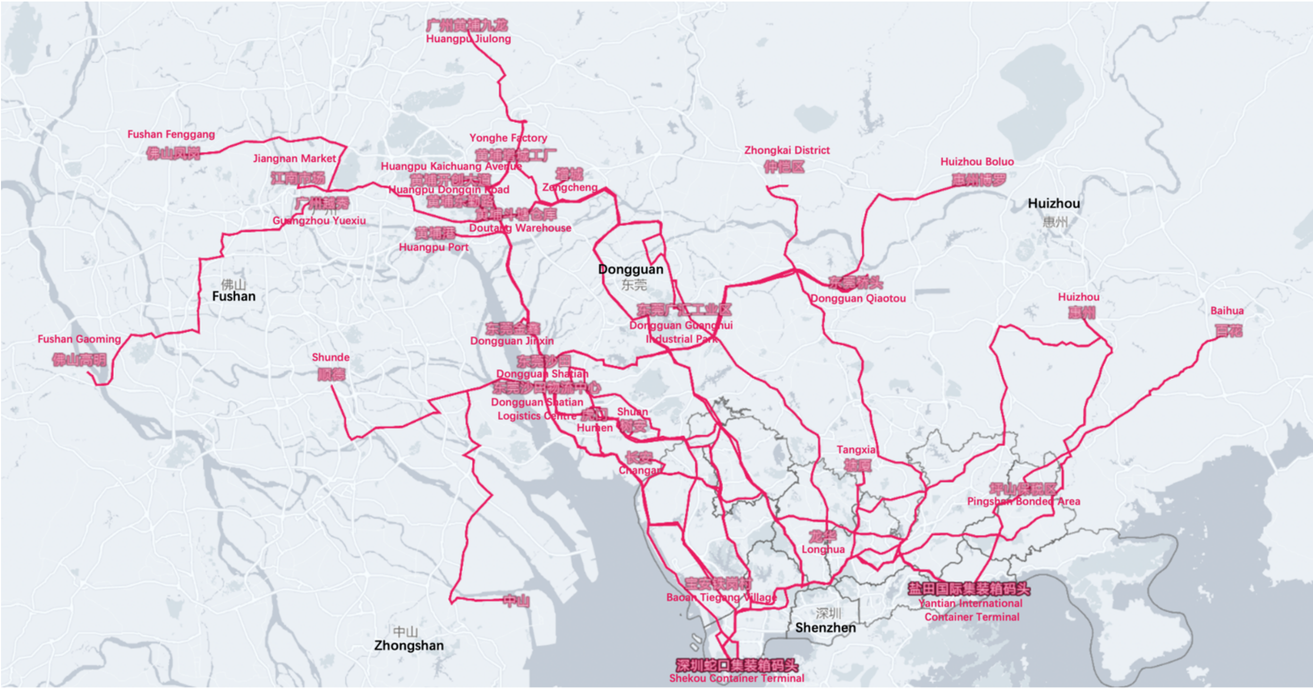

Figure 2. Main freight routes covered through the project

Scoping

Regional Developments in China and Shenzhen-Dongguan-Huizhou

China is demonstrating global leadership in the electrification of road freight. In the first half of 2024, China accounted for over 80% of global zero-emission truck sales, with a new sales share of 5.5%. This strong uptake of electric trucks is driven by several factors, including government support, rapid technological advancements, and increasing awareness of the environmental and economic benefits of electrification.

China's commitment to electrification is evident in its proactive policies and initiatives. The government has implemented various measures to incentivize electric truck production and purchase, such as subsidies, tax breaks, and preferential road access policies. Moreover, China is actively investing in research and development to advance battery technology, charging infrastructure, and other essential components of the electric vehicle ecosystem.

Shenzhen, a major economic and transportation hub in the Pearl River Delta, is at the forefront of this electrification drive. The city's high volume of road freight and its dedication to sustainable development make it an ideal location for piloting and scaling electric truck solutions. Shenzhen aims to lead the way in heavy-duty vehicle electrification by building demonstration projects and exploring suitable technologies and infrastructure. This will generate valuable lessons that can be applied across China and potentially to other countries facing similar challenges.

Electrification Progress in Shenzhen

Zero-emission vehicles in Shenzhen in 2023

Application areas	Number of ZEVs
Private cars and others	675,539
Logistics vehicle	130,920
Online ride-hailing service	118,631
Taxis	21,292
Public transportation	16,820
Sanitation vehicles	4,808
Dump truck	3,691
Concrete mixer truck	38
Road passenger transportation	1,556
Other Specialized Trucks	235
Total	**973,530**

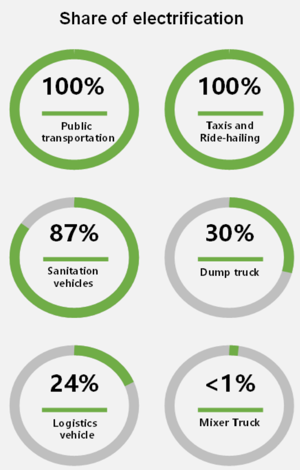

Figure 3. The number and share of zero-emission vehicles in Shenzhen in 2023 (Source: Smart Freight Centre China based on NEICV Annual Vehicle Ownership)

Regionally, Shenzhen has strong ambitions, aiming to electrify all road transport operating within its city. As seen in **Figure 3**, to-date, more than 675,000 private passenger vehicles on the road are electric. In 2023, all of Shenzhen's buses, cabs, and ride-hailing vehicles, as well as 87% of the city's sanitation vehicles have been fully electrified.

Almost one quarter of the city's logistics vehicles, or about 130,000 vehicles, are electric. Electric light-duty vehicles make up 30% of the light-duty vehicle segment, while the electric medium- and heavy-duty vehicles make up only 5% of its segment.

The Importance of Road Freight in the Shenzhen, Dongguan, Huizhou Region

Shenzhen plays a pivotal role as an international transportation hub. Shenzhen boasts a comprehensive transportation network connecting sea, land, and air routes, facilitating efficient resource allocation and trade both domestically and internationally. Its strategic importance is underscored by its designation as one of China's 45 national highway hubs and its ranking as the fourth busiest container port globally, handling nearly 30 million containers in 2023.

This robust infrastructure supports the thriving manufacturing industries of Dongguan and Huizhou. Dongguan, a key production base for electronics, machinery, clothing, and footwear, relies heavily on Shenzhen's port for exporting goods to global markets. Similarly, Huizhou, a major producer of electronics and automotive products, depends on efficient transport links between its factories and Shenzhen's port for both exports and imports. With these considerations in mind, this makes the road freight sector crucial to continue the movement of goods across the SDH region and beyond.

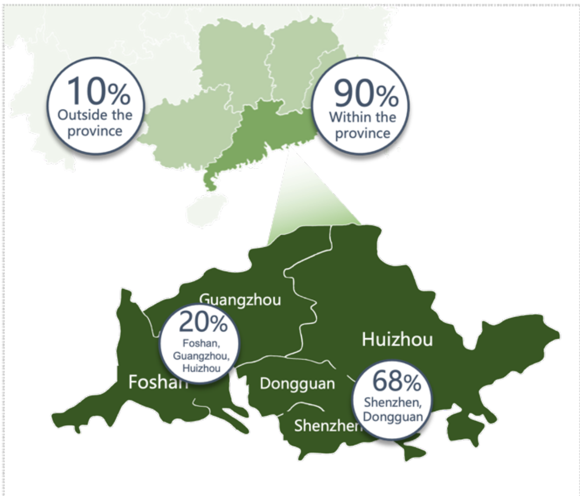

Figure 4. Daily distribution of operational destinations for medium and heavy trucks in Shenzhen. (Source: SFC China)

Shenzhen has approximately 127,000 heavy-duty trucks in operation. The majority of these trucks transport goods within the SDH area. This additionally highlights the area's critical role in regional and global supply chains. **Figure 4** shows that 90% of the operations by medium- and heavy-duty vehicles (MHDV) registered in Shenzhen operate within the Guangdong province, and almost 70% operate between Shenzhen and Dongguan.

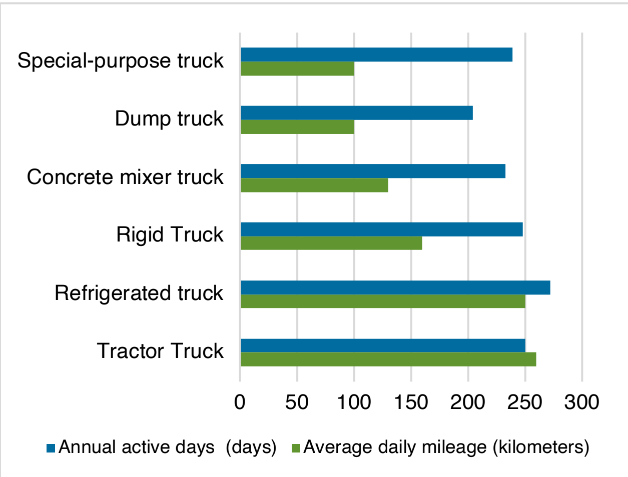

Figure 5. Annual active days and daily mileage of major operational trucks in Shenzhen (Source: NEICV)

Transport data collected within Shenzhen by NEICV depicts the operational demands of the current MHDVs registered in the city. The active days and average daily mileage of the fleet are summarized in **Figure 5**.

The trucks in the city demonstrate high utilization, averaging 242 operational days per year. However, there is variation across truck types. Refrigerated trucks, essential for transporting perishable goods, show the highest usage with 272 operational days, while dump trucks, likely tied to construction and infrastructure projects, have the fewest at 204 days. Tractor trucks and rigid trucks operate close to 250 days a year.

The trucks also demonstrate seasonality in operations, with high activity occurring within a 10-month period and considerably less in January and February in line with the national festivities.

The daily operational mileage shows a stronger variation across vehicle types. Tractor trucks and refrigerated trucks show the highest daily utilization of close to 250 kms driven per day. Rigid trucks run considerably less - on average 160 km per day. Special-purpose trucks and dump trucks run only about 100kms per day.

The operational data and freight activity within the region point to two key conditions necessary for scalable truck electrification. The first is operational feasibility. Current electric truck ranges available on the market are within the demands of current daily operational mileage for heavy-duty trucks. Second, high transport density in the region increases the viability and attractiveness of charging and grid infrastructure construction and upgrades, as well as other logistic synergies.

Project Objectives and Vision

In line with the broader aims of ZEFI to promote the widespread adoption of electric heavy-duty trucks in China, the demonstration project in the SDH region aims:

- To investigate the critical factors necessary for the widespread adoption of electric heavy-duty trucks in the SDH region. This includes evaluating policies, charging infrastructure, vehicle technology, operational routes, and transportation organization methods.
- To conduct a pilot demonstration to validate the feasibility of operating electric heavy-duty trucks within the region and to establish a viable zero-emission truck corridor.
- To gather practical experience and insights from the pilot project to inform the broader application and promotion of electric heavy-duty trucks in the Pearl River Delta and across China.

Project Development Process

Once the initial stage of project scoping is concluded, the work to define, facilitate, implement, and evaluate the project begins (**Figure 6**). The following chapters present the outcomes and main findings of each stage of the project.

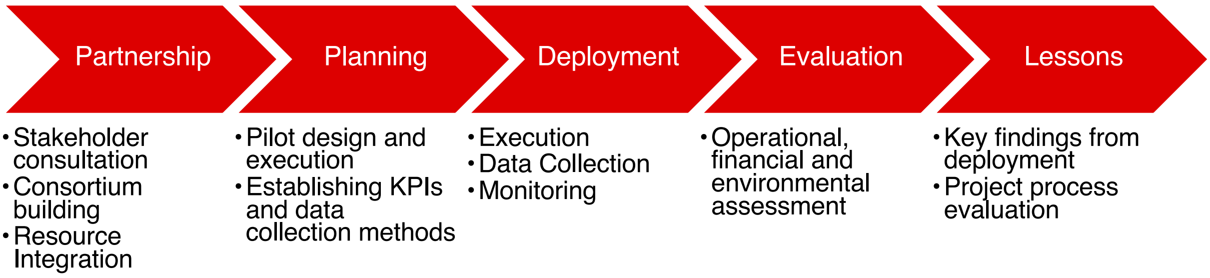

Figure 6. Project development process

Partnerships

To lay a strong foundation for the pilot project, the first step is to take stock of the resources the project will have access to, the conditions under which the project will be implemented, and to understand and elicit the cooperation from key stakeholders in the ecosystem (**Figure 7**). Developing a collaborative model that engages this network of key stakeholders is critical to the optimal deployment of the project. This section provides further details on each stakeholder's role in the project's development process. In total, 40 participants across 5 different stakeholder groups participated in the project. Thus, demonstrating the importance of collaborating effectively across different groups. A full list of project participants can be found in **Annex II**. A summary of stakeholder groups and key actions can be found in **Table 1**.

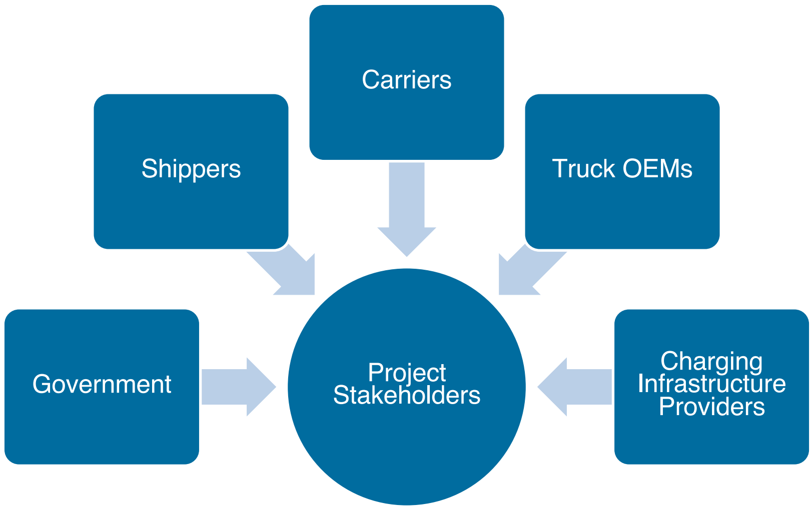

Figure 7. Key stakeholders in the project development process

Government

Government involvement was a key support pillar for the project's development. A strong commitment to support the adoption of electric heavy-duty trucks was demonstrated through early and continual active engagement throughout the project. It was identified early-on the importance of partnering with real-world projects to be able to better inform policy decisions, roadmaps and charging infrastructure deployment.

As a starting point, the project team's initial alignment with key government departments', such as the Ministry of Transport and the Ministry of Industry and Information Technology, national zero-emission transportation goals helped to facilitate action in line with government decarbonization priorities. Critical guidance on technology choices that were in alignment with national roadmaps helped to keep the project scope focused to be able to provide tangible results. In addition, connections were facilitated with relevant stakeholders in Shenzhen's logistics industry.

During the project, government representatives maintained close communication, monitoring progress and gathering valuable information about the challenges encountered in promoting electric trucks. Financial incentives, such as subsidies for electric vehicles and batteries, were also provided to encourage adoption.

Looking ahead, the government plans to leverage the project findings to inform policy development, including refining the dual credit policy to set realistic targets for OEMs and fleet operators. The findings will also guide updates to the national technology roadmap and inform strategic decisions about the placement and type of charging infrastructure needed to support the widespread adoption of electric heavy-duty trucks.

Shippers

Shippers, which form the core of ZEFI’s network, are integral to truck electrification on a wide-scale basis. Aggregating shipper demand to be able to support scalable deployment of electric heavy-duty trucks is a critical part of the project. The shippers that supported the project were multinational companies, such as IKEA, Mars, and Walmart, as well as Chinese companies, such as Hsu Fu Chi and JUSDA.

These companies were willing to participate in the project, and contributed the following:

- Shared operational plans and data for electric heavy-duty trucks through the pilot project;
- Recommended and introduced carriers to join the project; and,
- Suggested pilot routes based on the existing electric heavy-duty models under consideration and a set of selection criteria that was put together by the XieLi Innovation Center.

Having a strong shipper network to access not only facilitated the development of important operational data, but also necessary relationships to bring in carriers, provide aggregate estimates for vehicle demand to OEMs and inform charging infrastructure providers on key pilot routes.

Carriers

Carriers play a key role in truck electrification. They are the ones that will have to adopt the vehicles within their operations and put the upfront capital investment on the vehicles themselves. Most carriers involved in the project were identified by leveraging the shipper network. Some though were identified by vehicle manufacturers, dealers and industry associations.

During the research phase, the project team conducted intensive visits to various carrier sites to understand their actual operational conditions, as well as their awareness of and demands for electric heavy-duty trucks. (featured more in the next section). More than 20 companies were surveyed, with 10 companies currently participating in the project.

Participants of the projects received subsidies for renting the electric trucks. This is essential to reduce the investment needed for vehicle use, encouraging more carriers to join the pilot project and experience new energy heavy-duty trucks.

Truck OEMs

The project team engaged with 15 electric truck OEMs, which included major ones such as China National Heavy Duty Truck Group (CNHTC), SAIC Hongyan, Geely, Liuzhou Motor. The first step was to ascertain their willingness to participate in the project.

These companies saw the pilot project as an opportunity to promote new energy products and solutions in the Shenzhen-Dongguan-Huizhou area and the Pearl River Delta. They contributed by providing rental subsidies to carriers during the trial period. In addition, during the pilot project, the OEMs had the responsibility of coordinating the vehicle trials.

Charging Infrastructure Providers

The project team collaborated with charging infrastructure and battery swapping station providers, such as Teld, State Power Investment Corporation, Era Qiji Green Energy Technology, Che Dian Wang. Charging and swapping companies are highly focused on the operational plans and route planning for electric heavy-duty trucks in the SDH area, which provides important information about their future construction plans for charging and swapping stations.

For the pilot participants, they supported the project team in providing access to the services of the existing charging stations available for heavy-duty trucks in the Shenzhen area.

Table 1. Summary of stakeholder groups, motivation, and key actions

Stakeholder Group	Motivation for Supporting the Initiative	Engagement and Actions for Project
Government	▪ Align with national zero-emission transportation goals; ▪ Gather information and insights to inform policies, update technology roadmaps, and guide charging infrastructure development; ▪ Support the growth of a domestic electric vehicle industry.	▪ Engaged in pre-project planning to ensure alignment; ▪ Provided financial incentives; ▪ Were debriefed about project progress, results and learnings.
Shippers	▪ Demonstrate commitment to sustainability; ▪ Gain insights into electric truck operations; ▪ Potentially reduce freight costs and emissions; ▪ Improve supply chain efficiency.	▪ Shared operational data, ▪ Provided company's strategy and plan for sustainable logistics; ▪ Recommended carriers to join the project; ▪ Suggested pilot routes.
Carriers	▪ Gain firsthand experience with electric trucks; ▪ Potentially reduce operational costs and emissions; ▪ Gain a competitive advantage in the market; ▪ Operational testing with subsidized rental costs	▪ Operated vehicles in the pilot project; ▪ Provided operational data; ▪ Shared feedback on electric truck performance and challenges.
Truck OEMs	▪ Contribute to the development of the electric vehicle ecosystem; ▪ Gather real-world data on vehicle performance; ▪ Potentially used pilot findings for product development and marketing.	▪ Provided rental subsidies to carriers; ▪ Coordinated trial vehicles.
Charging Infrastructure Providers	▪ Gain insights into charging needs and operational patterns of electric trucks; ▪ Inform future charging infrastructure development plans; ▪ Expand their customer base and market share in the electric truck charging segment.	▪ Provided access to existing charging stations for pilot participants; ▪ Collaborated with the project team on route planning and charging strategies.

Planning

The deployment planning stage aimed to understand carrier requirements for vehicles and energy infrastructure, based on routes selected for the project. These had to be decided or optimized simultaneously, based on route operational demand, vehicle availability and capability, and the availability of energy infrastructure along those routes. The basis for the plan was informed through 20 carrier interviews. The selected carriers were recommended to the project by other shippers. Key aspects of this deployment plan can be found in **Figure 8**.

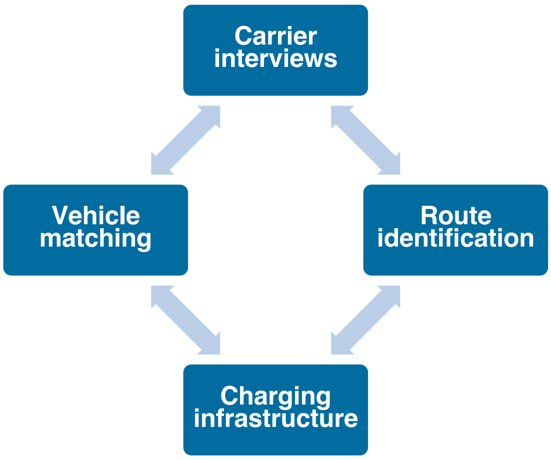

Figure 8. Key aspects of the deployment plan

Carrier Interviews

To identify suitable carriers for the electric truck pilot project, over 20 logistics and transportation companies were interviewed. These interviews assessed their operational needs and capabilities, including existing vehicle conditions, typical routes, energy consumption, and awareness of electric truck technology. Carriers who expressed a clear interest in participating and whose operations aligned with the available electric trucks and charging infrastructure were then asked to provide detailed information on their routes. This information, along with an evaluation of current electric truck technology, informed the development of the initial pilot project plan.

Route Identification

This pilot project involved a diverse range of participants and transportation scenarios. A total of 40 companies participated, utilizing both 4x2 and 6x4 electric heavy-duty tractors. These trucks were used for various short- and medium-distance transportation needs within the SDH region and the surrounding Pearl River Delta (**Figure 9**). Cargo types included general goods, sand and gravel, hazardous materials, and refrigerated food, with loads ranging from 8 to 30 tonnes. The trucks operated between ports, factories, and warehouses, covering an average daily distance of under 300 kilometers.

Figure 9. Overview of routes tested in the pilots

The operational profiles of the heavy-duty trucks were then categorized into three major groups:

- Port collection and distribution
- Short distance factory shuttle
- Short distance bulk shuttle

The typical annual mileage of the trucks used on these routes varies, not only depending on the type of operation but also according to the carriers operating the routes. An overview of the operations selected for the pilot are presented in **Table 2**.

Table 2. Summary of operation categories and scenarios for different routes

Operation Category	Scenarios	Typical Annual Mileage (km)
Port collection and distribution transportation scenario	Scenario 1：Chao Shidai	99,500
	Scenario 2：Weichai Zhike	15,700
	Scenario 3: Mingxin Logistics	23,700
	Scenario 4: Qihang Logistics	59,200
	Scenario 5: Dongguan Harbor	21,300
Short Distance Factory Shuttle Transportation Scenario	Scenario 6: Xiangyue Logistics	Route 1: 24,200 Route 2: 27,500
	Scenario 7: DST	4,800
	Scenario 8: Nansha	8,500
Short Distance Bulk Shuttle Transportation Scenario	Scenario 9 Yunfu Junpeng	68,200
	Scenario 10: Jiangmen	61,300

Matching the Right Electric Models with Participating Companies

The pilot project carefully matched electric truck models and battery capacities to the specific operational needs of participating companies (**Table 3**). This involved considering factors like daily mileage, typical routes, and cargo weight. The selected models included 4x2 and 6x4 pure electric tractors with varying battery capacities (141 kWh, 282 kWh, or 350 kWh), equipped with both charging and battery swapping capabilities. These specifications were chosen to effectively meet the diverse logistics and transportation demands within the SDH region and the broader Pearl River Delta.

Table 3. Electric heavy-duty truck models used in the pilot project

Figure	Details	Figure	Details
	***CNHTC ZZ4257V384GZ1*** Type: 6 x 4 Tractor Battery Capacity: 350 kWh		***BYD BYD4260C3EV1*** Type: 6 x 4 Tractor Battery Capacity: 355 kWh
	***CNHTC ZZ4257V384GZ1*** Type: 6 x 4 Tractor Battery Capacity: 282 kWh		***SAIC Hongyan CQ4180BEVSS44*** Type: 4 x 2 Tractor Battery Capacity: 350 kWh
	***CNHTC ZZ4187N421JZ1*** Type: 4 x 2 Tractor Battery Capacity: 282 kWh		***CAMC HN4253H36C8BEV*** Type: 6 x 4 Tractor Battery Capacity: 141 kWh
	***Faw Jiefang CA4250P66T1BEVA2*** Type: 6 x 4 Tractor Battery Capacity: 350 kWh		***Shaanxi Automobile SX4257MF4BEV1*** Type: 4 x 2 Tractor Battery Capacity: 282 kWh
	***Liuzhou Motor LZ4250H5DZBEV1*** Type: 4 x 2 Tractor Battery Capacity: 282 kWh		

Charging Infrastructure

To optimize charging station operations to best meet the needs of electric trucks, they were first screened based on specific criteria. This included the charging power (i.e. rated power output kW), accessibility for heavy-duty vehicles in terms of vehicle dimensions, and operating hours.

The next set of criteria assessed the strategic location of the chosen charging stations. The locations were chosen based on the specific routes and operational patterns of the pilot participants. Locations were selected based on factors such as route starting points, transit points and parking locations.

Carriers were involved in on-site inspections and continued communication with the station operators to ensure compatibility and to address any operational concerns. The distribution of these bus charging stations is presented in **Figure 11**. Most of these stations are concentrated in the Shenzhen and Dongguan cities.

The pilot project ultimately incorporated three energy replenishment modes:

- **Bus charging stations:** Operators of bus charging stations were approached to request for access during the pilot.
- **Private depot charging stations:** Some of the operators had charging stations intended for light duty vehicles. The project investigated whether the sites were suitable for the trucks running in the pilot (**Figure 10**).
- **Truck battery swapping stations:** Yunfu Junpeng provided a battery swapping station for use in the pilot (**Figure 12**).

Figure 10. Example of one of the bus charging stations. Currently used for light-duty vehicles

Figure 11. Locations of bus charging stations

Figure 12. Yunfu Junpeng's battery swapping station

Deployment

The deployment stage marked the transition from planning to action. It involved deploying electric trucks in real-world freight operations and closely monitoring their performance, along with the supporting charging infrastructure. This hands-on experience provided valuable data and insights into the practicalities of electric truck adoption, informing the evaluation of their performance and generating lessons learned for future applications.

Execution

To ensure the smooth operation of the pilot project, a coordinated vehicle delivery and carrier training process was implemented (**Figure 13**).

First, the project team worked closely with participating vehicle manufacturers to confirm truck availability and delivery schedules. This involved facilitating agreements between manufacturers and carriers for the use of 38 electric heavy-duty trucks, ultimately operated by 10 different carrier companies.

Before deployment, comprehensive training programs were conducted by the manufacturers to familiarize drivers with the operation and maintenance of electric trucks. To further support smooth operations, manufacturers provided ongoing technical support and arranged for personnel to monitor vehicle conditions and address any issues promptly. This ensured the safe and reliable performance of the electric trucks throughout the pilot project.

Figure 13. Vehicle delivery site (Source: SFC China)

After deployment, the drivers were also interviewed about their driving experience to understand the advantages and disadvantages of the electric truck from the drivers' perspective.

Monitoring

To ensure the collection of robust and reliable data during the pilot project, a comprehensive data collection strategy was implemented. This involved gathering two types of data:

- **Transport data:** This included information about the vehicles used, the routes they traveled, and the weight of the cargo being transported; and,
- **Vehicle and energy data:** This focused on the operational performance of the electric trucks, including distance traveled and electricity consumption.

Clear communication and coordination were essential to the success of this data collection effort. The project team worked closely with vehicle manufacturers to ensure the accuracy and completeness of the vehicle and energy data. They also communicated with carriers, providing them with templates and instructions for recording essential transport data, and followed up monthly to ensure data quality.

The project team successfully coordinated 283 vehicle months for the pilot schedule. From this the team collected 142 vehicle months of operational and monitoring data, with over 400,000 km driven by a fleet of 38 electric trucks. This valuable dataset will be used to analyze the performance of the electric trucks, assess their suitability for various transportation tasks, and evaluate their economic and environmental benefits.

Evaluation

The data collected from the real-world operational testing of the electric trucks will be used to evaluate their performance across three key dimensions: operational suitability, financial viability, and greenhouse gas emission benefits.

Operational Suitability

The pilot project demonstrated that electric trucks are well-suited to meet the operational demands of the SDH region.

As a major economic hub with established transportation routes, it offers a stable operating environment with high logistics demand. The region's focus on lighter cargo (15-20 tonnes) aligns well with the capabilities of current electric trucks, minimizing concerns about overloading or underutilization.

Furthermore, most heavy-duty trucks in the SDH area operate within a daily range of less than 300 km, mainly on urban roads, making them well-suited to the range and performance of current electric truck and charging technology. The pilot project also successfully demonstrated the effectiveness of a combined fast charging and battery swapping model, balancing transportation efficiency with cost-effectiveness.

The project identified over 130 charging stations suitable for heavy-duty electric trucks in the SDH region and the surrounding areas. These stations are strategically located in logistics hubs, parking lots, and bus depots, thus offering convenient access for charging and battery swapping. The availability of high-power charging infrastructure at these locations ensured efficient charging and minimized downtime for the electric trucks.

Overall, the operational suitability analysis indicates that electric trucks are a viable and effective solution for meeting the freight transportation needs of the SDH region. The alignment of transport demand, vehicle capabilities, and charging infrastructure creates a favorable environment for the wider adoption of electric trucks. Vehicle and operating data collected during the pilot can be seen in **Table 4**.

Table 4. Vehicle and operating data collected during pilot

Operation Category	*Scenarios*	*Vehicle Brand*	*Battery Capacity (kWh)*	*Number of vehicles*	*Total Distance Operated in Pilot (km)*	*Total Electricity Consumption (kWh)*	*Energy Consumption Rate (kWh/km)*
Port Collection and Distribution	Scenario 1 : Chao Shidai	SAIC Hongyan	350	2	97,082	102,865	1.06
	Scenario 2 : Weichai Zhike	CNHTC	350	1	503	770	1.53
	Scenario 3: Mingxin Logistics	CNHTC	282	1	6,920	8,440	1.22
	Scenario 4: Qihang Logistics	BYD	355	5	53,015	77,899	1.47
	Scenario 5: Dongguan Harbor	Liuzhou Motor	282	1	1,109	1,788	1.61
Short Distance Factory Shuttle	Scenario 6: Xiangyue Logistics	SAIC Hongyan	282	1	2,811	4,427	1.58
		CNHTC	350	1	989	1,328	1.34
	Scenario 7: DST	Geely	141	1	114	184	1.61
	Scenario 8: Nansha	SAIC Hongyan	282	9	221,793	301,596	1.36
Short Distance Bulk Shuttle	Scenario 9: Yunfu Junpeng	CNHTC	282	2	338	503	1.49
	Scenario 10: Jiangmen	CNHTC	282	10	19,375	33,504	1.73

The energy consumption rate based on the measured data of the pilots showed variability within operation types, as well as vehicle brands, when used in multiple operations. In particular, across the three categories:

- Port collection and distribution: the energy consumption rate ranged from 1.06 to 1.61 kWh/km, whereas its diesel consumption rate ranged from 0.25 to 0.30 liter/km.
- Short distance factory shuttle: the energy consumption rate ranged from 1.34 to 1.61 kWh/km, whereas its diesel consumption rate ranged from 0.30 to 0.50 liter/km.
- Short distance bulk shuttle: the energy consumption rate ranged from 1.36 to 1.73 kWh/km, whereas its diesel consumption rate ranged from 0.30 to 0.50 liter/km.

Financial Viability

The financial viability of 10 different operations (scenarios) using electric trucks was analyzed using a TCO approach (**Figure 14**).

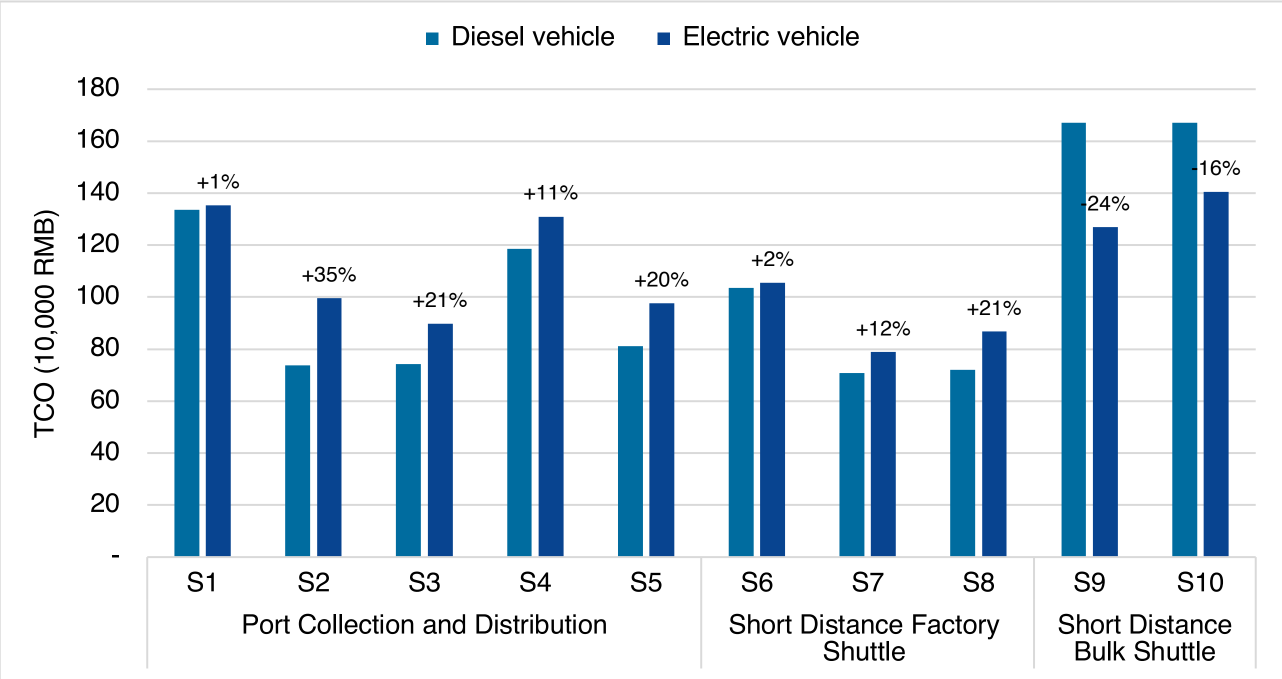

Figure 14. 5-year TCO comparison of diesel and electric vehicles

When analyzing the TCO results, some conclusions can be made. First, the TCO of electric vehicles for port collection and distribution as well as short distance factory shuttle operations was higher than diesel's TCO – but varied significantly from scenario to scenario. While both scenario 1 and scenario 6 came close to TCO parity, scenarios 2, 3, 5 and 8 had TCO gaps of 20% or more.

Second, the TCO gaps for both scenarios in the short distance bulk shuttles were significantly in favor of electric vehicles. Each vehicle was intensively used and therefore made use of the advantageous lower operating costs compared to diesel vehicles. This may enable operators to recuperate the costs of their investments more quickly.

Environmental Benefits

The evaluation of greenhouse gas emissions savings showed significant potential for emissions reductions of a transport operation (**Figure 15**). The emissions for each scenario were calculated based on the principles of the *Global Logistics Emissions Council Framework for Logistics Emissions Accounting and Reporting V3.0* (GLEC 3.0) and ISO14083. The emission-related default factors were based on the *GLEC Framework 3.0 China Default Emission Factors v1.0*, and local conditions were considered for selection or estimation.

In total, 256 tonnes of CO_2 were generated during the pilot due to electricity production. Avoided emissions from the substitution of diesel with electricity were at least 253 tonnes of CO_2.[1]

The emissions intensity reduction potential varied according to the operation category. In most cases, an emission intensity reduction of 25% was reached. Only scenarios 2 and 5 had an uncharacteristically low reduction potential.

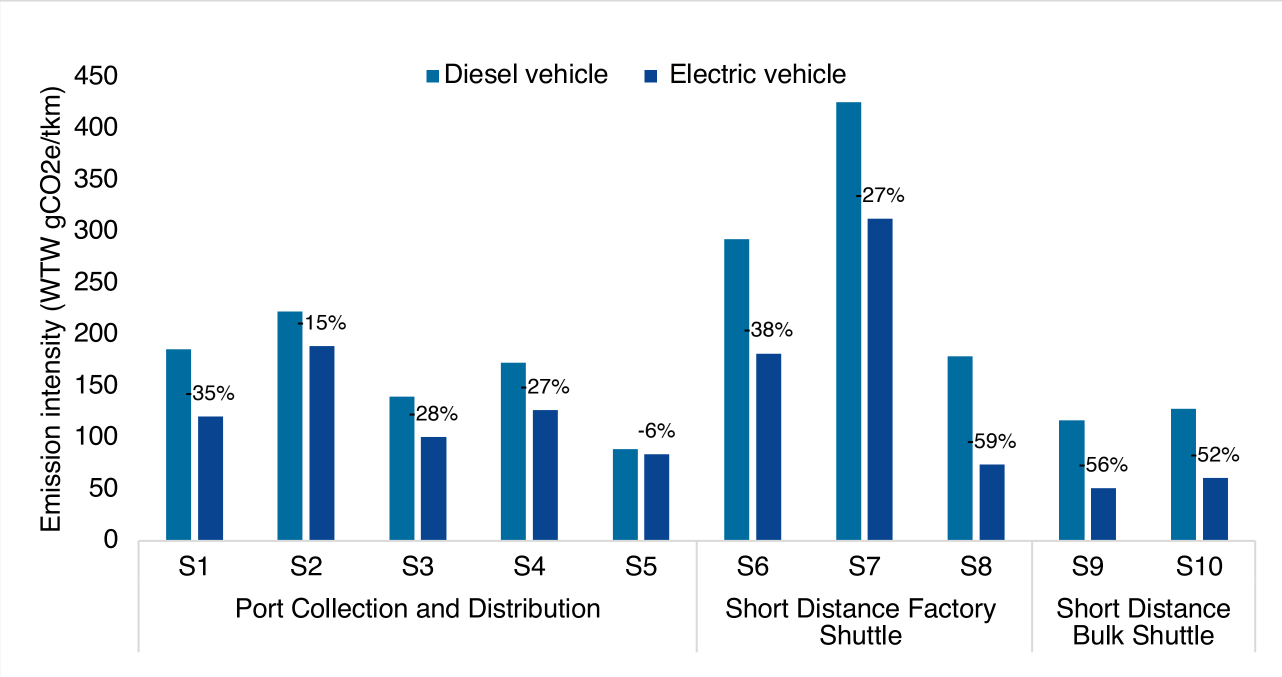

Figure 15. Well-to-wheel greenhouse gas emission intensity comparison for diesel and electric vehicles

Conclusions

Based on individual scenarios and operational conditions, it is evidently clear that there are significant variations in financial viability and emissions savings. Generally speaking, scenarios with higher total distances tended to have more lucrative TCO analysis in comparison to their diesel equivalents compared to shorter total distances. Of note, scenarios 9 and 10, with a particularly high total distance travelled had the most attractive TCO. When coupling intensity in kWh/km (translating to a higher cost of electricity per km), TCO that had low total distances with high energy intensities have less attractive TCO. For example, scenarios 2, 7 and 8.

In that same vein, higher amounts of displaced diesel equated to better overall emissions benefits due to the lower overall carbon intensity of electricity. Naturally, as the carbon intensity of China's electrical grid continues to decline, these emissions savings would only increase over time.

Overall, electric trucks demonstrated operational suitability for the routes chosen within the pilot. Due to most travel falling within a 300 km daily range, it was well within the current battery electric ranges offered by different

[1] Emissions factors for China's electrical grid were provided in CO_2 units only. Other pollutants such as NOx, SOx and CO were not included. Hence, to make the same unit comparisons, avoided emissions are also calculated in CO_2 units only, with the caveat that if including other pollutants, the emissions savings would be greater.

models and the available density of charging infrastructure. Considerations were also made between fast charging and battery swapping stations when balancing cost effectiveness with convenience.

Lessons Learned

Real-world deployment of electric trucks in the SDH pilot project provided valuable insights and highlighted key challenges. These lessons learned are crucial for informing future electric truck projects and optimizing implementation strategies.

Specific Challenges and Solutions Encountered During Deployment

Real-world project deployment provided key insights into the operational and economic reality of the transition to electric. Challenges faced at the time of the project included:

- **Lack of familiarity with electric trucks and technology:** Many transportation companies lack an accurate understanding of key concepts like "battery capacity," "charging," and "battery swapping." This lack of knowledge made it difficult for them to purchase models that were accurately aligned with their operational needs.
- **Lack of infrastructure to support operations:** While an effort was made to ensure a comprehensive charging network would be developed, many scenarios still required significant detours for recharging, which reduced operational efficiency. The network of charging facilities was found to not be dense enough to support the operational demands of the electric trucks.
- **Unsuitable dimensions of charging stations:** For trucks with a total length exceeding 17 meters (including the tractor and trailer), the challenge of charging at stations was prominent. Most locations required the trailer to be detached before entering the station for charging.
- **Unfavorable electric truck economic conditions:** In the SDH region, the annual mileage for trucks was generally low, and the per-kilometer cost difference between electric and fuel vehicles was minimal. In its current operational conditions this made it difficult for electric trucks to demonstrate a clear economic advantage over diesel vehicles.

These challenges are typical in the early stages of electric truck adoption and are expected to diminish as the vehicle and charging infrastructure markets mature. However, the pilot project demonstrates that carriers can already leverage the capabilities of current electric truck models and available charging infrastructure.

Based on the collective experience of the project participants, the following recommendations are offered to support wider deployment in the current market.

- **Increase the opportunity for fleet operator vehicle testing:** To bridge the gap between industry's familiarity with the technology, optimal operating conditions and ways to optimize the business case, the sector can provide more opportunities for vehicle trials. One option is for manufacturers to offer fleet operators opportunities to test vehicles and extend the trial should further testing be required. This would allow companies to fully understand the actual performance of the vehicles and how it can align with their day-to-day operations.
- **Use vehicles with battery capacity over 350 kWh in future trials:** This would ensure a fully charged range of over 200 km. A larger battery would also reduce current limitations around insufficient range and an underdeveloped charging infrastructure network.
- **Create a charging infrastructure strategy:** More specifically identify suitable charging or battery swap stations for different scenarios and use causes to improve infrastructure access and truck operation along routes.
- **Create fit-for-purpose charging infrastructure:** Build small bay-type battery swap stations or high-power fast charging stations to meet the energy needs of large trucks in urban areas.
- **Support a sector-wide charging infrastructure strategy:** Foster collaboration between the government and industry to redesign and build a dedicated charging and battery swap service network for electric trucks. The model should adopt a hybrid of large, centralized stations and smaller distributed ones, and combine charging and battery swapping stations in one area to address insufficient energy infrastructure.
- **Identify TCO-optimal conditions for the operations:** Assess the routes to allow the consortium to prioritize piloting electric heavy trucks on routes with high operational demand and sufficient mileage. This

would preferably use charging instead of battery swapping, due to better economics. Nighttime charging should be prioritized to reduce energy costs.

Conditions for Project Development Success

Based on SFC's approach to the development of electric truck deployment projects and the project team's experience in the SDH region, the team has identified several key success factors for each stage in the project. A key aspect of the project's success highlights the importance of collaboration amongst different stakeholders to optimize operating conditions.

Scoping and Partnerships

- **Securing strong government support:** at the national, regional, and local levels to ensure favorable policies, incentives, and infrastructure development for electric trucks; and,
- **Building a diverse and committed stakeholder network:** that includes shippers, carriers, OEMs, industry associations, and research institutions, all aligned on the project's value proposition.

Planning and Execution

- **Optimizing routes:** based on detailed analysis of traffic patterns, charging infrastructure availability, and operational efficiency to maximize the effectiveness of electric truck deployments;
- **Developing a comprehensive charging infrastructure plan:** that maps existing facilities and outlines strategic expansion to meet the growing needs of electric truck operations;
- **Demonstrating the economic viability of electric trucks:** through rigorous TCO analysis, showcasing the cost-effectiveness of battery electric trucks compared to diesel alternatives; and,
- **Implementing a robust data collection and analysis system:** to gather insights on truck performance, charging behavior, and other operational factors. Thus enabling data-driven decision-making and optimization.

Evaluation

- **Maintaining flexibility and adaptability:** to effectively address unforeseen challenges and adjust strategies throughout the project lifecycle;
- **Dedicate time within the project for reviews, reflections and lessons learned:** to share knowledge, improve future electric truck deployment projects, and create an iterative approach to implementation strategies;
- **Fostering a culture of continuous improvement:** to encourage ongoing learning, optimize processes, and enhance project outcomes over time.

Expansion

The deployment of electric trucks in the SDH region is expected to be the first step in the planned electrification of road freight in Shenzhen. The experience gained throughout the project highlights not only the challenges that still lay ahead in scaling up the adoption of electric trucks, but also the opportunities. In light of this planned expansion, the project team has highlighted two strategic actions to shape the next phase of work which include:

- Extension of deployment projects towards corridor electrification.
- Measures for industry-wide collaboration.

Extension of Deployment Projects Towards Corridor Electrification

Understanding the distribution of logistics operations in Shenzhen is crucial for analyzing the potential for electric heavy-duty truck adoption. Shenzhen boasts a comprehensive logistics network, including 6 logistics parks, 22 highway freight hubs, 31 express sorting centers and 11 supermarket distribution centers, covering a total area of 34 km². These facilities are strategically located, with logistics parks concentrated around comprehensive transportation hubs such as ports, airports, and railways (**Figure 16**).

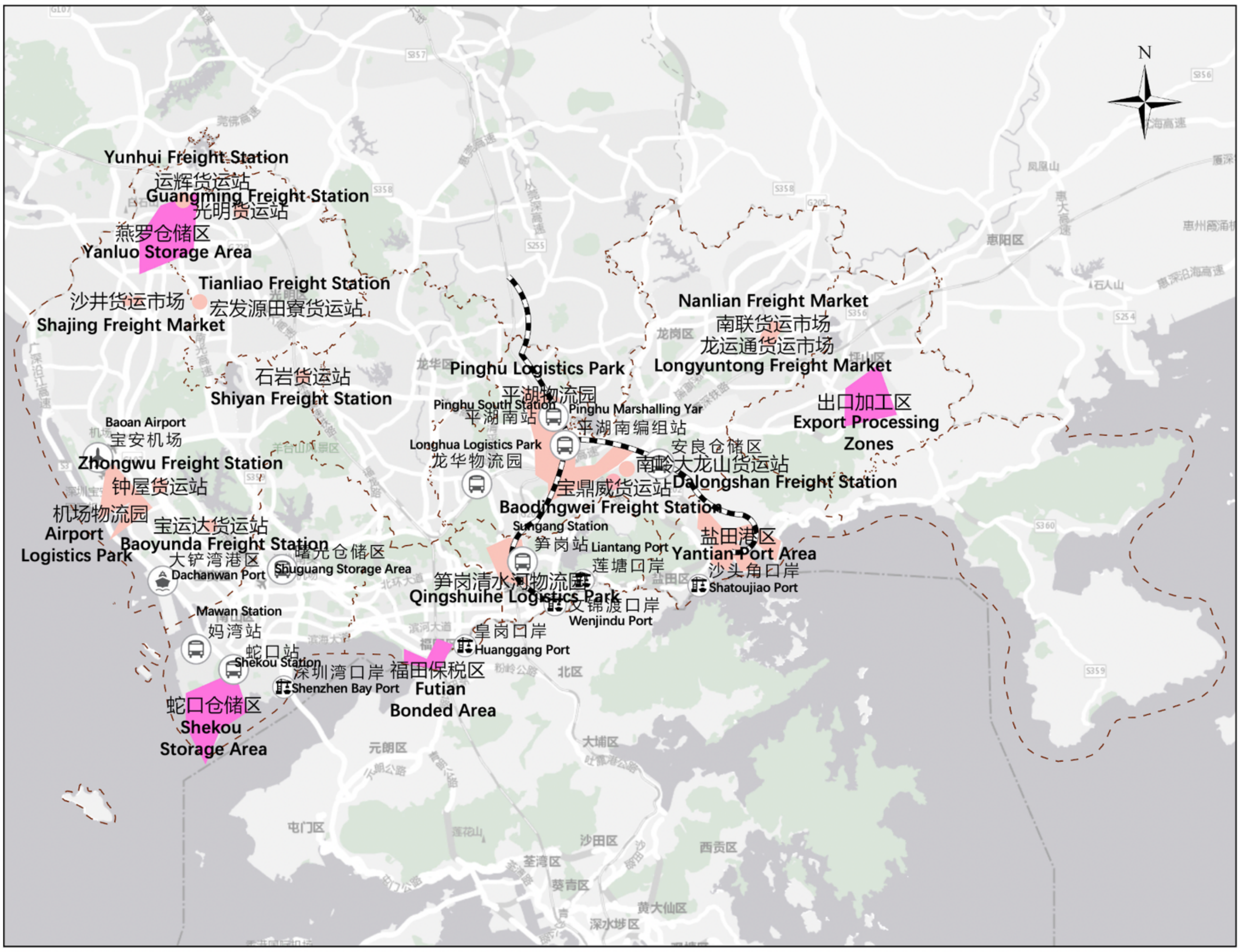

Figure 16. Shenzhen city's overall logistics infrastructure layout map (Sources: Shenzhen Modern Logistics Hub Layout Plan (2021-2035)

When analyzing truck activity heatmaps in the Shenzhen area it reveals a clear pattern (**Figure 17**). Truck operations are largely centered around logistic hubs, with the highest activity concentrated within those areas. Key freight corridors, including the Guangzhou-Shenzhen Highway, Nanping Expressway, Longda

Expressway, Yanpai Expressway, and the Pearl River Delta Ring Road, also experience significant truck traffic. This highlights the importance of prioritizing these areas for future electrification efforts. Logistics stations and freight corridors surrounding key logistics nodes should be the focus of both vehicle deployment and energy infrastructure planning. This includes the development of zero-emission freight corridors, which should be strategically designed around these high-activity nodes and transportation channels.

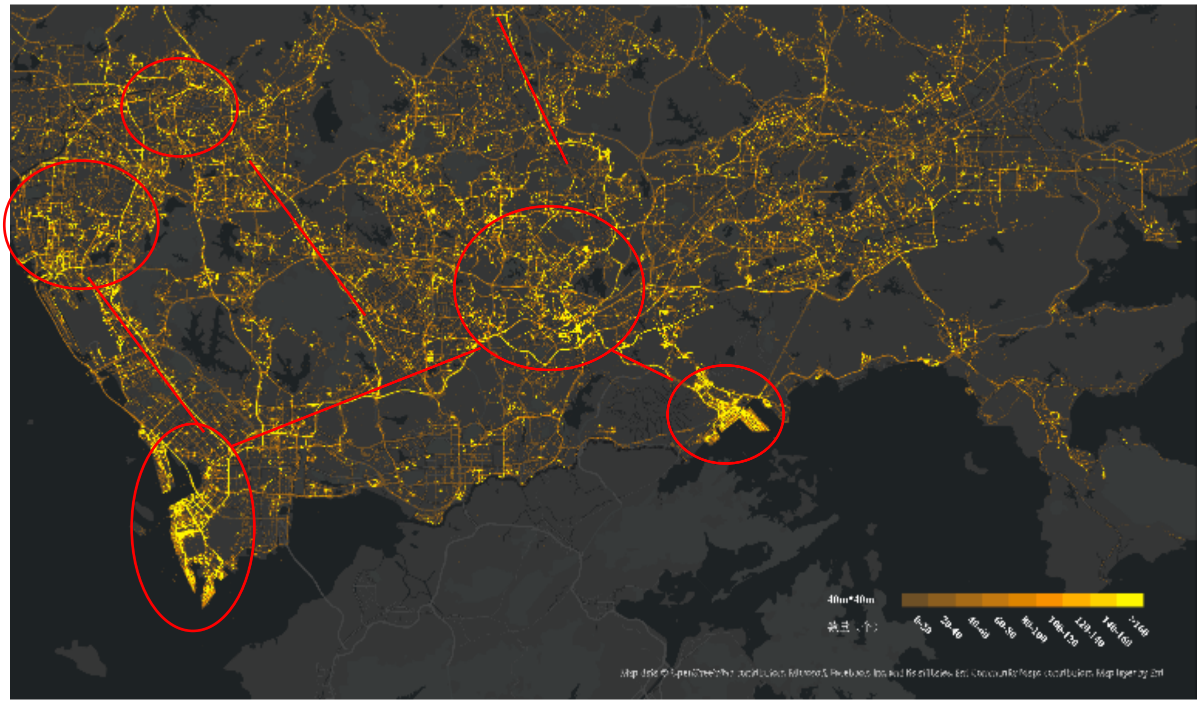

Figure 17. Heatmap of freight vehicle operations in Shenzhen (Source: New Energy Logistics Vehicle Monitoring Platform)

Goals of a Shenzhen - Freight Corridor Pilot

Considering where freight vehicle operations are concentrated in Shenzhen, the next step is to identify objectives to the expansion of a pilot project within this area. The development of a follow-up zero-emission freight corridor pilot with Shenzhen as its focal city would be guided by the following objectives. These objectives are:

- Building a zero-emission freight corridor along a strategic network:
  - **Focus:** Identify and deploy typical application scenarios that align with Shenzhen's equipment performance and transportation needs.
  - **Scope:** Towards the development of Shenzhen's "*Four Vertical and Two Horizontal*" zero-emission freight corridor network, covering major cities in the Guangdong-Hong Kong-Macao Greater Bay Area.
- Deploying multiple zero-carbon fleets at scale:
  - **Timeline:** Within a year of corridor initiation, establish more than 5 heavy-duty road freight "zero-carbon fleets" across at least two application scenarios.
  - **Scale:** Deploy, at least, 200 new pilot vehicles for these fleets.
- Installing sufficient infrastructure:
  - **Goal:** Install sufficient infrastructure based on the future needs of the corridor.
  - **Type:** Construct a batch of charging and battery-swapping stations and other supporting infrastructure.

With these objectives in mind, identifying geographic areas for corridor development will be important. The following corridors highlighted below have been identified for further exploration in the Shenzhen area.

Shenzhen-Hong Kong Cross-Border Fresh Produce Zero-Emission Freight Corridor

The next deployment project that has been identified will connect the Pinghu Haijixing Vegetable Wholesale Market and Qingshuihe warehouse in Shenzhen with the Chang Sha Wan Wholesale Vegetable Market and Sheung Shui in Hong Kong. The one-way distance is approximately 70 km. This corridor will primarily use pure electric medium and heavy-duty trucks (**Figure 18**).

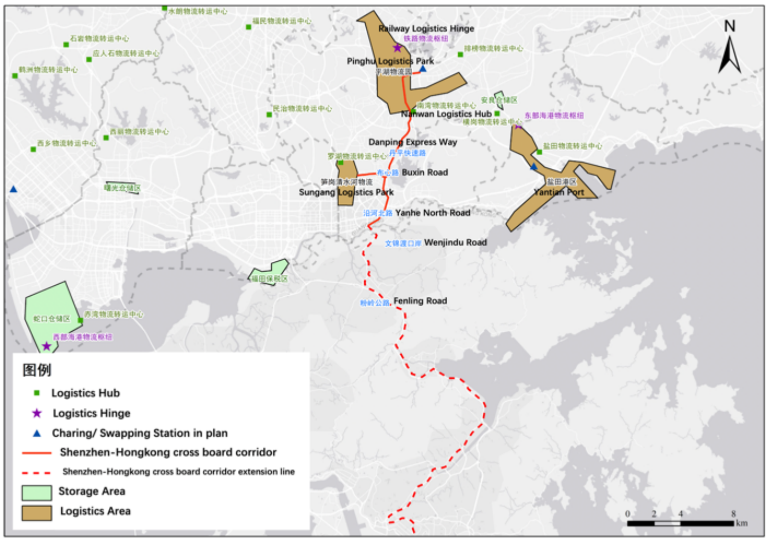

Figure 18. Route map for the Shenzhen-Hong Kong Cross Border Produce Corridor

East Port Zero-Emission Freight Corridor

The corridor connects the Eastern Port Area of cargo sources in Shenzhen, Dongguan, Guangzhou with cities on the western side of the Pearl River Delta (**Figure 19**). The maximum one-way transport distance is 200 km. The proposed vehicle types mainly include 4x2 or 6x4 electric tractor-trailers, with a focus on battery-swapping technology.

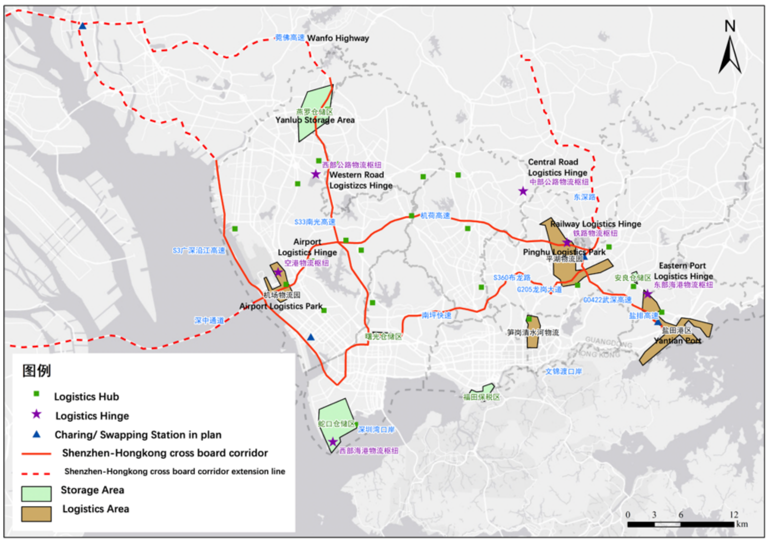

Figure 19. Route map for the East Port Corridor

Future Expansion of Zero-Emission Freight Corridors

Once the two sides of the corridor are completed, the following extensions would be carried out to ensure a comprehensive and well-connected electrified network (**Figure 20**):

- **Shenzhen (Dongguan) to Guangzhou Intercity Zero-Emission Freight Corridor:** Collaborating to establish an intercity zero-emission freight transport corridor with cities such as Guangzhou and Dongguan;
- **Shenzhen Western Port Area Zero-Emission Freight Corridor:** Constructing a zero-emission freight corridor in the Western Port Area building on the experience in the Eastern Port; and,
- **Shenzhen-Hongkong Cross-Border Zero-Emission Freight Corridor:** Expand the scope of the trial of the cross-border transportation zero-emission freight corridor between Shenzhen and Hong Kong, as well as the ports of entry.

Figure 20. Connecting zero-emission freight corridors

Measures for Industry-Wide Electrification

To further accelerate the adoption of electric heavy-duty trucks and to ensure the success of the zero-emission freight corridor initiative, a multi-faceted approach encompassing enhanced support measures, regional collaboration, priority access policies, and innovative incentives is crucial.

Enhancing Support Measures

Three support measures in the vehicle ecosystem are needed:

- First, accelerating the deployment of charging and battery swapping infrastructure is essential. This involves strategically building these facilities in the core areas of the freight corridor and surrounding regions, ensuring convenient and reliable energy replenishment for electric trucks.
- Next, establishing a comprehensive after-sales system with maintenance service points and emergency response mechanisms along the corridor will further support the operation of these vehicles, and ensure high vehicle uptime.
- Finally, strong coordination with relevant stakeholders, such as the Shenzhen Logistics Center Leading Group, and government departments of Development and Reform, Industry and Information Technology, Transportation, Science and Technology, Energy, Market Regulation, and Finance, is needed to optimize trial conditions, address challenges, and incentivize the use of electric trucks.

Strengthening Regional Collaboration

Expanding the initiative requires strong regional collaboration. This includes securing additional outbound vehicle quotas specifically for zero-emission trucks operating from Shenzhen to Hong Kong and Macau. Streamlining procedures for certification, driver licensing, and emergency charging in the Hong Kong section of the corridor will further facilitate cross-border operations. The trials could also explore the use of adapters for different charging standards (e.g., China or EU standards).

In addition, civil organizations in Shenzhen and Hong Kong could be coordinated towards fostering greater interoperability and industry consensus on the development of electric heavy-duty trucks in the Greater Bay Area.

Priority Road Access Policy

Granting priority road access to electric trucks is crucial for promoting their adoption. This involves relaxing road access restrictions and allowing electric trucks to operate freely within the pilot areas, regardless of existing traffic limitations. Implementing green channel policies at ports, terminals, and logistics parks will prioritize access and expedite loading and unloading for electric trucks. This, coupled with measures like electronic toll collection (ETC), would improve the operational efficiency of electric trucks and incentivize their use.

Innovative Financial Support Measures

Innovative financing models, such as the "battery as a service" model for trucks with battery swapping capabilities, can further encourage adoption. This approach, combined with specialized financial solutions and tailored insurance products can reduce upfront costs and make electric trucks more accessible to fleet operators. Other incentives like vehicle purchase subsidies, toll reductions, and carbon emission reduction rewards will further incentivize the transition to electric trucks. The government, manufacturers and financial institutions could explore how these measures can be implemented.

Vehicle Promotion Measures

Supporting the early retirement and replacement of older, polluting trucks with new energy vehicles is essential. This can be achieved by aligning with national policies for scrapping and updating aging freight trucks. Encouraging freight companies to prioritize the use of electric trucks during bidding processes will further promote their adoption. Ongoing operational monitoring and analysis, including the measurement of energy efficiency and carbon emission reductions according to ISO 14083 standards would provide valuable data to support continuous improvement and demonstrate the benefits of electric trucks.

Annex I: SFC Project Deployment Process

Stages	Guiding Questions	Methods
Scoping: This initial stage focuses on understanding the project's context. It involves conducting research to identify key policies, infrastructure considerations, and technological requirements, as well as mapping and analyzing the needs and expectations of various stakeholders.	What are the key policy and regulatory considerations for electric truck deployment in this region? What are the existing infrastructure requirements and limitations (e.g., grid capacity, charging standards)? What are the technological needs and potential challenges for different electric truck applications? What are the needs and responsibilities of key stakeholders?	Desktop research Stakeholder consultation and mapping
Partnership: This stage emphasizes building a strong foundation for collaboration. It involves forming a consortium of diverse partners and integrating their resources (funding, expertise, etc.) to achieve shared project goals.	How can we build a diverse and effective consortium of partners with complementary expertise and resources? How can we ensure alignment and shared commitment to the project goals among all stakeholders? What mechanisms can we establish for effective communication and collaboration throughout the project?	Stakeholder consultation Consortium building
Planning: This stage focuses on developing a detailed plan for the pilot project. It involves designing the pilot, determining data collection methods, and establishing key performance indicators to track progress and evaluate outcomes.	What are the specific objectives and desired outcomes of the pilot project? What data needs to be collected to track key performance indicators and evaluate the project's impact? How can we design the pilot to ensure it effectively addresses the research questions and objectives? What methods will be used for data collection and analysis?	In-depth interviews, site visits Data collection, modelling
Deployment: This stage involves putting the plan into action. It includes executing the pilot project in a controlled environment and collecting data through various methods (e.g., in-depth interviews, site visits, data collection, modeling).	How can we ensure the smooth execution of the pilot project according to the plan? What measures are needed to maintain data quality and integrity throughout the data collection process? How can we effectively monitor and manage any challenges or unexpected issues that arise during deployment?	Project management Performance Monitoring
Evaluation: This stage focuses on assessing the pilot project's impact and identifying areas for improvement. It involves analyzing the collected data to evaluate the project's success in achieving its objectives (economic viability, environmental benefits) and comparing its performance to baseline data or alternative solutions.	What are the appropriate metrics and methods for evaluating the project's success in achieving its objectives? How can we compare the performance of electric trucks to baseline data or alternative solutions? What are the key areas for improvement and optimization based on the evaluation findings?	Carrier interviews Total cost of ownership Emission calculation according to ISO 14083 Stakeholder consultation
Lessons: This stage emphasizes capturing and sharing knowledge gained from the project. It involves	What are the most important lessons learned from the project, and how can these be effectively documented?	Stakeholder consultation

documenting the project's processes, results, and lessons learned, and identifying best practices for sharing these insights with stakeholders.	What are the best practices for sharing knowledge and insights with stakeholders and the wider community? How can we ensure that the lessons learned are used to inform future projects and improve implementation strategies?	
Expansion: This final stage focuses on scaling up the project and applying lessons learned to other contexts. It involves developing a plan for expanding the project, replicating its success in other regions or sectors, and identifying further steps and supportive measures to ensure long-term sustainability.	How can we effectively scale up the pilot project and replicate its success in other contexts? What are the key factors to consider when developing a plan for expansion? What additional support measures or resources are needed to ensure the long-term sustainability of the initiative?	Stakeholder consultation Research

Annex II: List of Participants in the Project

Company Name	Company Category	Company Name	Company Category
IKEA China	Shipper	Dongfeng Liuzhou Automobile Co.	OEM
Mars China	Shipper	Shaanxi Heavy Duty Automobile Co., Ltd	OEM
Hsufuchi Foods	Shipper	Geely Farizon	OEM
JUSDA Supply Chain Management International Co., Ltd.	Shipper	Shanghai JJ New Energy Company	OEM
Weichai Power	LSP	Shenzhen Optimus Trucks Trading Co.	OEM
HK Sailing Logistics Company	LSP	Jiangmen Jingsheng Automobile Trading Co.	OEM
Shenzhen Chaoshidai Logistics Company	LSP	Shenzhen Guangjutong Automobile Trading Co.	OEM
Dongguan Harbor Innovation Supply Chain Co.	LSP	Shenzhen Shandong Era Truck Trading Co.	OEM
Shanghai International Port (Group) CO., LTD.	LSP	Shenzhen Guangdatong Automobile Trading Co.	OEM
Guangzhou Xiangyue Logistics CO., LTD.	LSP	Shenzhen Harbor Technology Automobile Trading Co.	OEM
Jiangmen Junan Logistics Company	LSP	Xinge New Energy Technology (Shenzhen) Co.	OEM
Bei Ye New Brother Supply Chain Management CO., LTD.	LSP	Greater Bay Technology (Guangzhou Greater Bay Technology Co., Ltd	OEM
Shenzhen Mingxin Logistics Company	LSP	Teld	Charging Infrastructure Provider
Yunfu Junpeng New Energy Technology Company	LSP	Guangzhou Electric Energy Bank Company	Charging Infrastructure Provider
Digital Sustainable Transport (DST) Company	Electrification Solution Providers	Shenzhen CEGN CO., LTD.	Charging Infrastructure Provider
Shenzhen GCTL Battery Company	Battery Banks, Battery Swapping Operator	CNNP Rich Energy Co.,LTD.	Charging Infrastructure & Battery Swapping Operator
Shanghai Qiyuan Green Power Technology CO., LTD.	Battery Banks, Battery Swapping Operator	Shenzhen Huitian Smart Energy Company	Charging Infrastructure & Battery Swapping Operator
Shanghai Enneagon Energy Company	Battery Banks, Battery Swapping Operator	Beijing Xiaoju Technology Co., LTD.	Charging Infrastructure & Battery Swapping Operator
China National Heavy Duty Truck Group (CNHTC)	OEM	Shanghai GreenHub Energy Technology Co., Ltd.	Battery Swapping Operator
FAW Jiefang	OEM		
SAIC Hongyan Company	OEM		

Annex III: Detailed Total Cost of Ownership Breakdown

Scenarios	Vehicle brand	Purchase (10,000 RMB)	Operating (10,000 RMB)	Maintenance (10,000 RMB)	EV 5-Year TCO (10,000 RMB)
Scenario 1：Chao Shidai	SAIC Hongyan	62.00	67.75	5.50	135.25
Scenario 2：Weichai Zhike	CNHTC	67.00	27.00	5.50	99.50
Scenario 3: Mingxin Logistics	CNHTC	55.00	29.20	5.50	89.70
Scenario 4: Qihang Logistics	BYD	67.00	58.50	5.50	131.00
Scenario 5: Dongguan Harbor	Liuzhou Motor	60.00	32.15	5.50	97.65
Scenario 6: Xiangyue Logistics	SAIC Hongyan	55.00	34.10	5.50	94.60
	CNHTC	67.00	33.45	5.50	105.95
Scenario 7: DST	Geely	48.00	18.85	5.50	72.35
Scenario 8: Nansha	CNHTC	60.00	21.35	5.50	86.85
Scenario 9: Yunfu Junpeng	SAIC Hongyan	60.00	61.40	5.50	126.90
Scenario 10: Jiangmen	CNHTC	67.00	68.00	5.50	140.50