Technology Integration and Sandbox Pilot for Low-Carbon, High-Efficiency Logistics

Background

According to the National Greenhouse Gas Emission Inventory Report (國家溫室氣體排放清冊報告), Taiwan's transportation sector greenhouse gas emissions reached 36.294 million metric tons of CO_2 equivalent in 2023. Under the Taiwan Carbon Reduction Action Plan (臺灣總體減碳行動計畫), the transportation sector must reduce emissions by 7.6 million metric tons by 2030 compared to the baseline year, representing a 20% reduction target. However, as of 2023, only a 4.4% reduction has been achieved. Since over 90% of transportation sector carbon emissions come from gasoline and diesel vehicles, accelerating vehicle electrification over the next five years is critical for carbon reduction. The government has set targets for 2030 including a 5% penetration rate for electric light commercial vehicles, 600 electric heavy-duty trucks, and 34,000 public charging stations. However, current logistics vehicle electrification is constrained by high vehicle costs, insufficient energy replenishment infrastructure, and the lack of established low-carbon business models.

To achieve carbon reduction targets and promote logistics industry transformation, the approach of utilizing " Technology Integration and Sandbox Pilot for Low-Carbon, High-Efficiency Logistics" as a strategic implementation tool has been planned. Through sandbox pilot demonstration, combined with AI intelligent dispatching, port logistics AI optimization, and autonomous vehicle logistics across three major dimensions, cross-domain technology integration and institutional innovation trials will be conducted to establish reproducible and scalable low-carbon logistics business models, supporting Taiwan's national net-zero transportation policy objectives.

Global Outlook and Domestic Progress

1. Global Outlook

1.1 RoAD to the L4 (Japan)

Japan’s RoAD to the L4 (Project on Research, Development, Demonstration and Deployment of Automated Driving toward Level 4) is a logistics-oriented autonomous driving initiative jointly promoted by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) and the Ministry of Economy, Trade and Industry (METI). The project aims to advance Japan’s logistics automation from the experimental stage to practical Level 4 autonomous driving applications through an integrated strategy encompassing research, demonstration, and deployment. As a key pillar of Japan’s mid- to long-term policy roadmap for automated logistics, the project adopts a three-phase framework addressing technology maturity, infrastructure readiness, and the institutionalization of regulations.

The first phase (2023–2025) focuses on environmental preparation, installing road sensors, V2X communication devices, remote monitoring systems, and emergency response mechanisms to build foundational conditions for safe autonomous operations. Phases two and three (2026–2035) advance from demonstrations on a 100-km Shin-Tomei Expressway section (Suruga Bay–Numazu to

Hamamatsu) using Level 2 trucks with safety drivers—testing night operations, tunnel communication issues, faults, and mixed traffic at 70 km/h—to large-scale Level 4 deployment across Kanto to Kansai, with legalized frameworks and centralized multi-operator monitoring for a comprehensive autonomous logistics ecosystem.

1.2 StreetDrone (UK)

StreetDrone (UK), in partnership with Kramer Group (Netherlands) and Terberg Special Vehicles (Belgium), has deployed a fleet of autonomous terminal tractors at the Port of Rotterdam to enable Level 4 automated driving for intra-terminal logistics in a controlled port environment.

The system incorporates remote teleoperation capabilities, allowing a single operator to oversee up to 10 vehicles simultaneously for emergency interventions, thereby optimizing operational efficiency, reducing labor requirements, and maintaining safety standards. Additionally, it achieves carbon emission reductions through minimized brake wear, optimized low-energy routing, and integration with electric trucks, demonstrating a scalable commercial model for industrial park logistics decarbonization.

2. Domestic Progress

Taiwan's transportation sector has clearly defined its carbon reduction direction based on the Third-Period Transportation Sector Greenhouse Gas Reduction Action Plan Strategy (第三期運輸部門溫室氣體減量行動方案策略), establishing three major pillars: "Improving public and shared transportation," "Promoting vehicle electrification and decarbonization," and "Enhancing transportation energy efficiency."

Regarding logistics vehicle electrification, the government provides commercial vehicle replacement subsidies through the Carbon Reduction Flagship Plan (減碳旗艦計畫), offering 500,000 NTD per light commercial vehicle and 600,000 NTD per heavy-duty truck, encouraging businesses to adopt low-carbon emission or electric vehicles. Simultaneously, a national public charging infrastructure deployment plan is being promoted, targeting 34,000 charging stations.

Regarding maritime operations, Taiwan Port Corporation is actively implementing the "Green Port Incentive Program," encouraging the replacement of cargo handling equipment with electrified alternatives, including low-carbon tugboats and cranes, helping ports transition to low-carbon operations. Additionally, Taiwan's maritime and port information systems have undergone multiple data integration initiatives, establishing service platforms under respective regulatory authorities, including MTNet (Maritime Transport Network), TPNet (Taiwan Port Network), CPT (Customs-Port-Trade Single Window), and IoT AIoT 24/7 monitoring systems. These platforms provide online services from vessel arrival forecasting, port entry requests, post-container discharge customs clearance, and dynamic tracking from container trucks to cargo owners, already providing the foundation for establishing a port logistics AI platform. Through port intelligent transportation initiatives, real-time traffic information from both port areas and surrounding roads is integrated, enabling smooth operations and supporting electric commercial vehicle deployment.

Regarding air cargo, Taoyuan International Airport Corporation is actively advancing an aviation cargo information integration platform, coordinating various units to provide basic data interconnection functions, including real-time statistics and tracking of various cargo inflow, outflow, and transshipment volumes, and integrating information from flights, ground service companies, warehouse operations, and transportation providers. The corporation has also introduced automated storage and retrieval systems, replacing manual dispatching with automated warehousing and forklift systems.

The Ministry of Transportation continues promoting intelligent transportation and drone technology development, having established the "Drone Technology Industry Task Group" (無人機科技產業小組) to lay foundations for future logistics automation and emerging vehicle applications. The Civil Aviation Administration has compiled drone operations manual, providing standards and guidelines for government agencies, schools, and legal entities conducting drone activities, including capability reviews and operation manual development. The Executive Yuan approved the "Autonomous Vehicle Industry Development Coordinating Plan" (無人機產業發展統籌型計畫) in October 2025, establishing a drone industrial ecosystem and diverse applications.

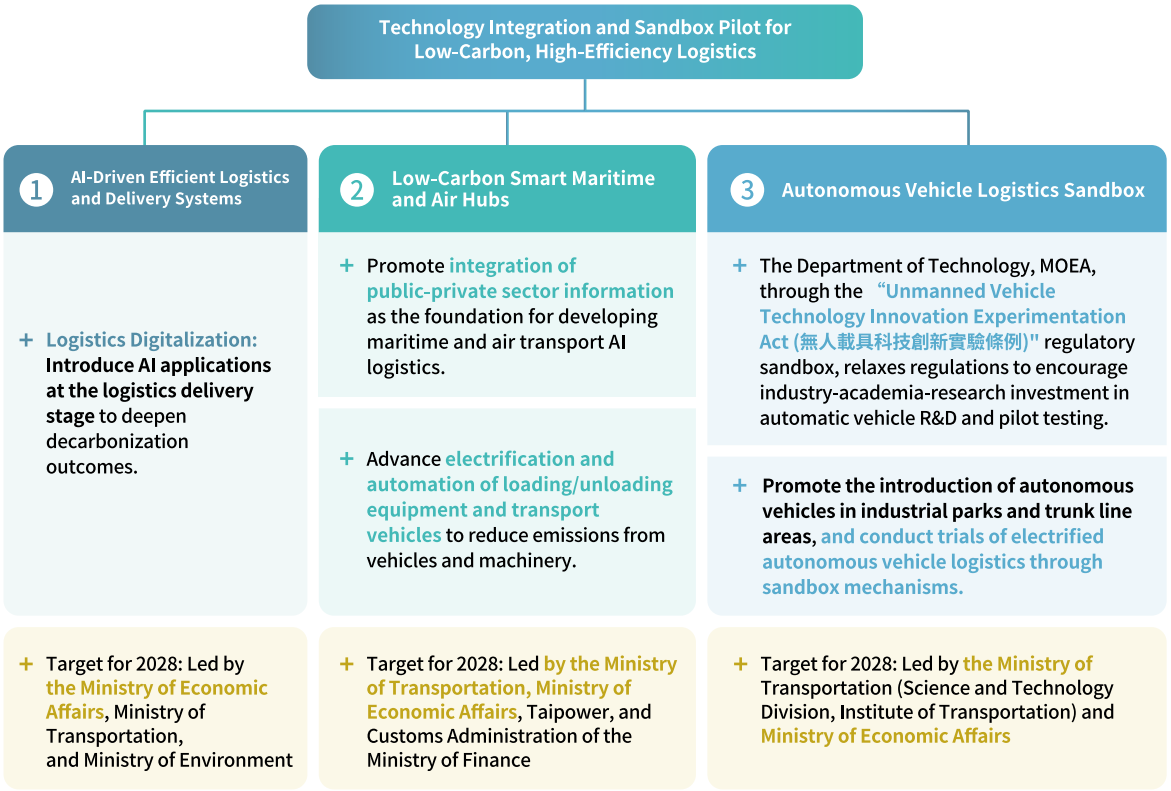
Meanwhile, the Department of Industrial Technology of the Ministry of Economic Affairs leverages the regulatory sandbox under the Unmanned Vehicle Technology Innovation Experimentation Act (無人載具科技創新實驗條例) to relax regulatory constraints, accelerating industry-academia-research collaboration in the R&D and real-world validation of land, sea, and air unmanned vehicles while establishing an autonomous supply chain and commercialization pathways.

However, current logistics vehicle implementation of AI

energy management, intelligent dispatching, and drone delivery applications remains in early stages, requiring evidence-based pilot demonstration of technology maturity and regulatory framework feasibility. Future integration of low-carbon vehicles, AI smart logistics, and autonomous vehicle sandbox trials will help develop systematic solutions for low-carbon and efficient logistics, providing concrete evidence for the Ministry of Transportation's net-zero transportation policy advancement.

Strategic Planning Frameworks

This strategy proposes three key technological initiatives: AI-enhanced efficient logistics delivery models, low-carbon green smart maritime and air hubs, and autonomous vehicle logistics sandboxes



Strategy 1: AI-Driven Efficient Logistics and Delivery Systems

To improve energy efficiency and carbon reduction outcomes across Taiwan's logistics transport system, incentives should be designed to encourage logistics operators to adopt AI-integrated delivery management systems. These systems would incorporate energy-efficient cold chain technologies, intelligent scheduling, and evolutionary route optimization algorithms. By analyzing real-time data on traffic flows, weather conditions, cargo characteristics, and delivery demands, the systems would automatically generate optimal transport routes and schedules, thereby reducing empty running rates and redundant trips. This approach would not only significantly enhance the overall energy efficiency of electrified logistics networks but also help operators lower operational costs.

Strategy 2: Low-Carbon Smart Maritime and Air Hubs

Consider establishing a public port operations information platform and promoting public-private sector integration of information services as the foundation for advancing port digitalization and AI applications, thereby improving operational efficiency and facilitating decarbonization. For air transport, develop an integrated air cargo information platform to strengthen operational coordination and information transparency. Port handling equipment should transition to electrification and

automation, enabling autonomous loading/unloading, intelligent path planning, and efficiency gains.

Additionally, both ports and airports should promote the electrification and automation of transport vehicles, including the introduction of electric container trucks and autonomous transport vehicles in port and airport zones, alongside dedicated vehicle power replenishment systems.

Strategy 3: Autonomous Vehicle Logistics Sandbox

Newly developed industrial parks offer substantial potential for large-scale planning and pilot implementation, positioning them as priority demonstration sites for commercializing electrified autonomous logistics vehicles. It is recommended to conduct closed-loop pilots in designated areas such as intra-park roads, inter-park trunk lines, and logistics distribution centers through a regulatory sandbox mechanism. This would systematically accumulate operational data, safety records, and commercial viability evidence for domestic autonomous driving technologies. Concurrently, provide financial incentives via vehicle technology R&D subsidies, vehicle and charging equipment subsidies, and operational cost support to enhance industry participation. Sandbox trials would validate autonomous vehicle safety mechanisms while enabling regulatory flexibilities essential for commercialization.

Potential Benefits

By establishing low-carbon logistics sandbox validation sites, this strategy would complete pilot demonstrations of optimized low-carbon high-efficiency logistics, creating benchmarks for decarbonization across Taiwan's land, sea, and air logistics domains. Aligned with the "Commercial Vehicle Electrification and Decarbonization Flagship Action Plan" (商用車輛電動化及無碳化減碳旗艦行動計畫) and the " Unmanned Vehicle Industry Development Coordinating Plan," (無人載具產業發展統籌型計畫) the low-carbon logistics transition would drive achievement of targets such as 3,600 electric heavy trucks by 2035 and 1.33 million tons of CO_2 reductions, while fostering autonomous vehicle logistics applications.

References

[1] National Council for Climate Change Policy (2025, January 23). Taiwan's National GHG Reduction Action Plan and 20 Flagship Mitigation Programs Across Six Sectors.

[2] Executive Yuan. National Autonomous Vehicle Industry Development Program. Retrieved from MOEA website: https://www.moea.gov.tw/MNS/populace/news/News.aspx?kind=1&menu_id=40&news_id=120787

[3] Climate Change Administration, Ministry of Environment. Taiwan's National Greenhouse Gas Inventory Report 2025. Retrieved from https://www.cca.gov.tw/information-service/publications/national-ghg-inventory-report/13123.html

[4] Ministry of Transportation and Communications. Phase III GHG Reduction Action Plan for the Transport Sector (Draft). Retrieved from https://www.cca.gov.tw/information-service/info/13437.html

[5] Ministry of Economy, Trade and Industry, Japan. National Digital Lifeline Development Program. Retrieved from https://www.meti.go.jp/policy/mono_info_service/digital_architecture/lifeline_portal/index.html

[6] Ministry of Land, Infrastructure, Transport and Tourism, Japan. Cyber Port. Retrieved from https://www.cyber-port.net