Electric Truck Cross-Border Drayage Comparative Pilot Study at Laredo-Nuevo Laredo

Texas Commission on Environmental Quality

December 11, 2025

North American Development Bank

TEXAS CENTER FOR BORDER ECONOMIC & ENTERPRISE DEVELOPMENT
TEXAS A&M INTERNATIONAL UNIVERSITY

Texas A&M Transportation Institute

Project Overview

Evaluate the feasibility of adopting **Zero-Emission Vehicles (ZEVs) and Low-Emission Vehicles (LEVs)** for **cross-border drayage in the Laredo-Nuevo Laredo corridor** – a critical North American trade gateway.

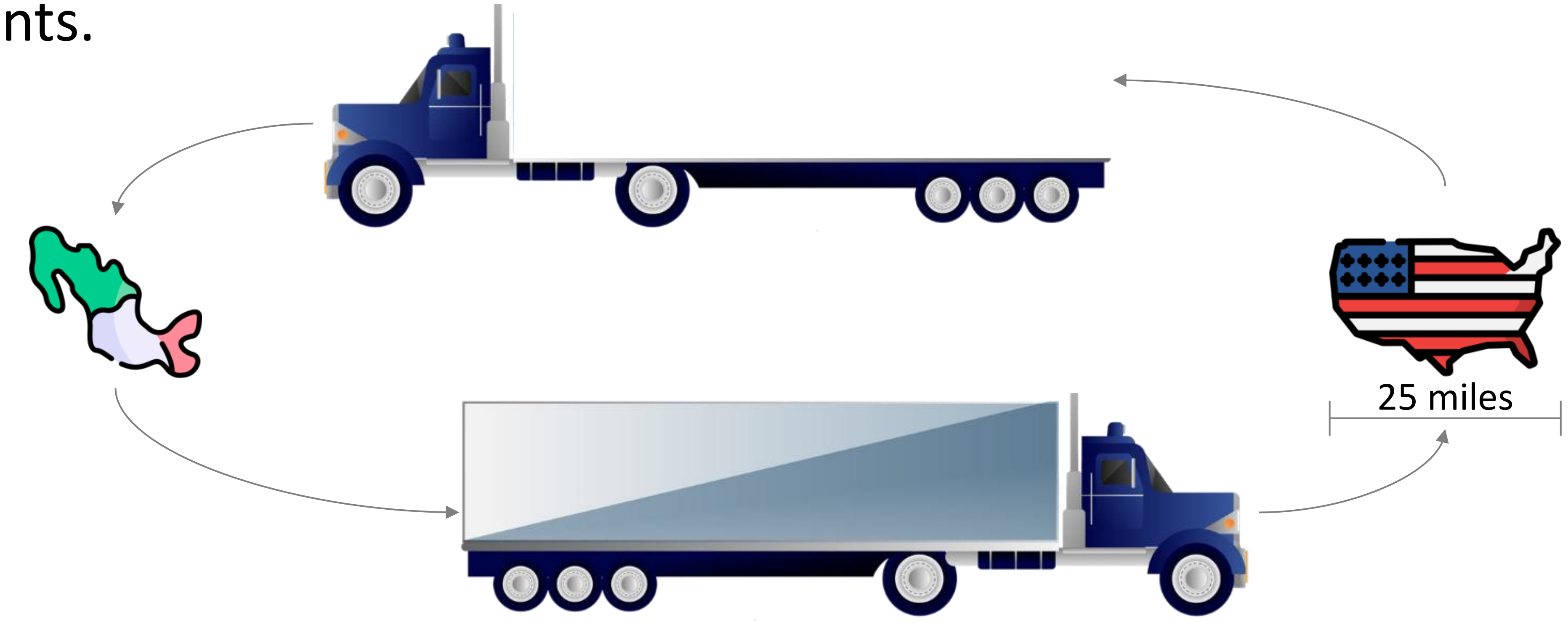
Operational, Infrastructure and Emissions Impacts of Three Technologies:

ICE	BEV	CNG
Internal Combustion Engine	Battery-Electric	Compressed Natural Gas

Project Overview

Cross-Border Drayage

Cross-border drayage primarily involves **short-haul movements** between the U.S. and Mexico, covering **~90%** of all cross-border freight movements.



300+ Carriers

150 Truck Yards

59 Industrial Parks

Cabotage: Transporting of goods between two points within the same country by a foreign operator.

Project Overview

Laredo-Nuevo Laredo Port

The **Laredo-Nuevo Laredo port** is the most critical hub for U.S.-Mexico binational commerce handling **~40% of all U.S.-Mexico trade** valued at **$331.2 billion** out of the $839.9 billion total.

This commercial activity is processed through:

Colombia-Solidarity Bridge

~707K CMV northbound crossings in 2024

World Trade Bridge (WTB)

~2.3M CMV northbound crossings in 2024

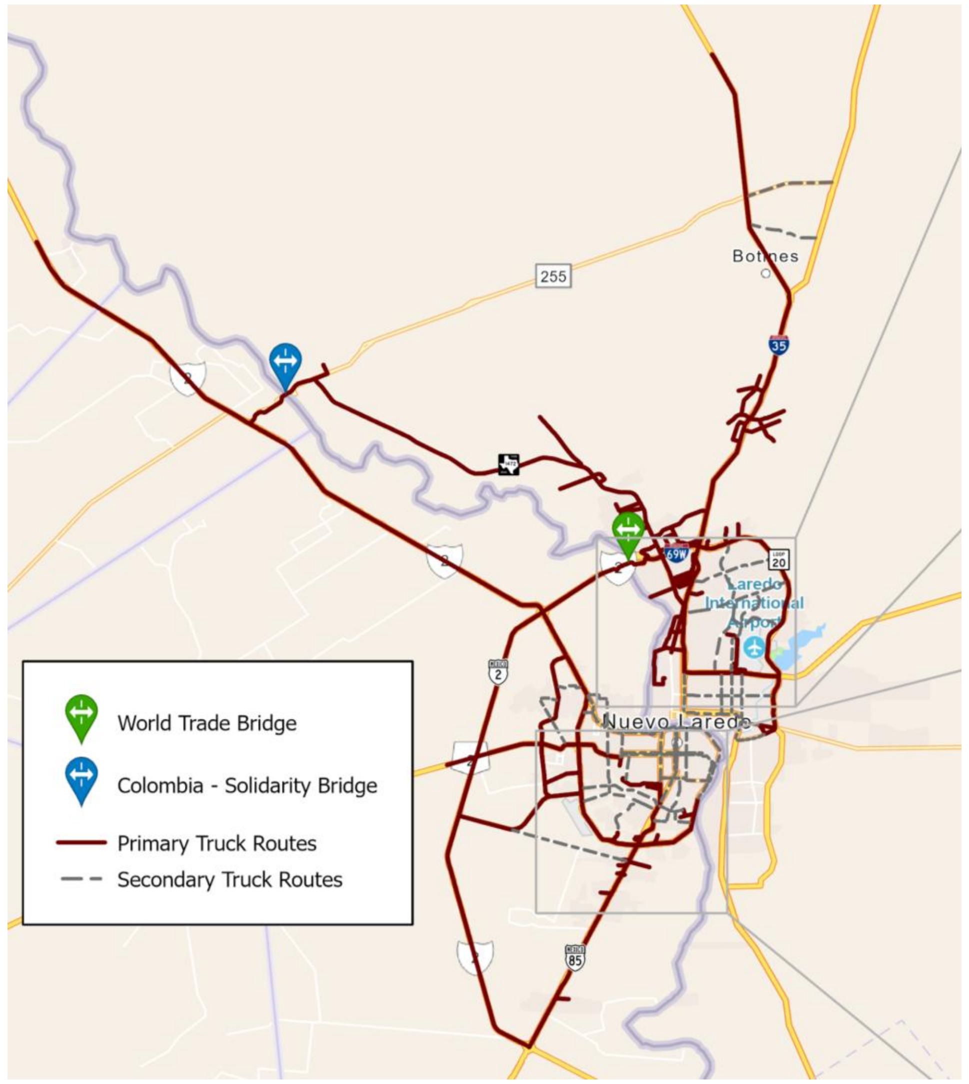
Texas-Mexico Railway Bridge

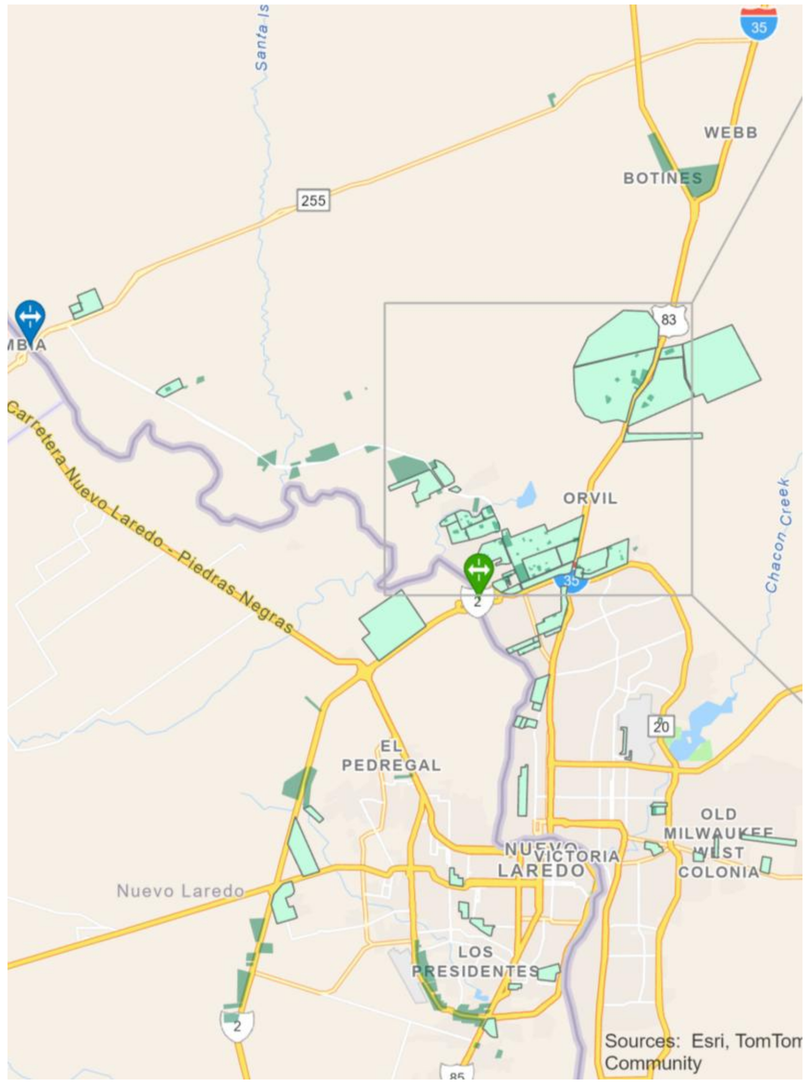
In 2024, more than **6 million** trucks crossed through Port Laredo , including both inbound and southbound traffic.

Baseline Foundation

Typical Drayage Routes

- Mapped drayage truck routes from regional carriers’ GPS data:
  - **Primary, heavily traveled** routes (maroon line)
  - **Secondary, least traveled** routes (gray line)
- Typical routes provide an overview of **truck travel and traffic patterns.**
- **Regional trade activity mirrors typical drayage routes** and is enabled by seven corridors:
  - **MEX-85** (toll-free) and **MEX-085D** (tolled) to Nuevo Laredo
  - **MEX-002** to the World Trade Bridge (WTB)
  - **Calle Aeropuerto** connecting to Carretera Nuevo – Laredo Piedras Negras (MEX-002) toward the Colombia Solidarity International Bridge
  - Mines Road (**FM 1472**)
  - **Loop 20**
  - Interstate 35 (**I-35**)

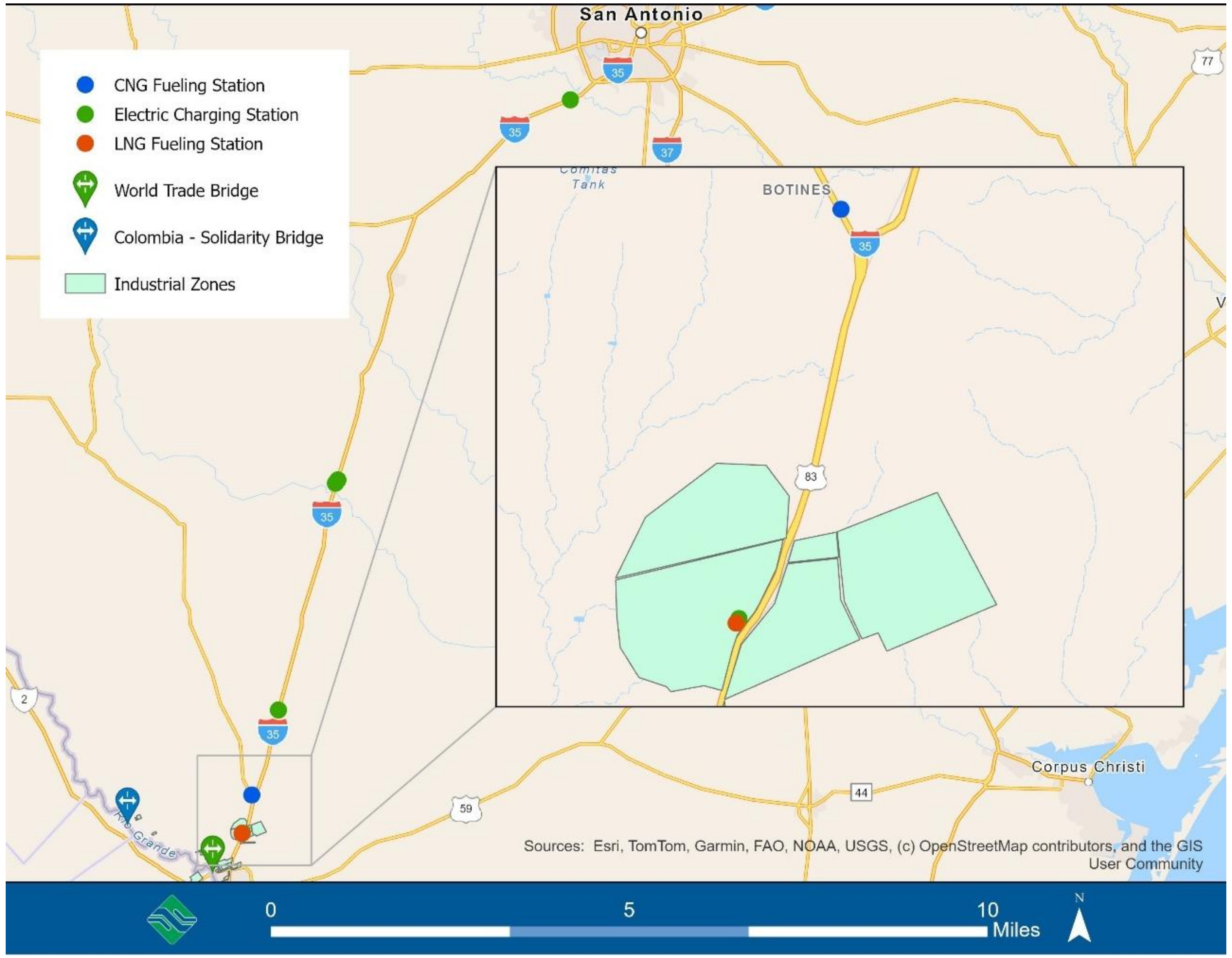




Logistics & Infrastructure Analysis

Charging Stations

- 1 CNG fueling station and 5 electric charging stations along I-35.
- Due to limited public infrastructure and unreliability of regional energy capacity, many carriers have built private BEV and CNG fueling facilities; but **power availability remains an issue.**
- Most public electric charging stations are not designed for heavy-duty vehicles.



Mexican drayage carriers use older, retired long-haul tractors as cost-effective short-haul vehicles. Nearly half the fleet is over 15 years old.

Logistics & Infrastructure Analysis

Energy Consumption Scenario

Based on feedback from local carriers, the typical daily cross-border drayage activity is **80 miles for two-round trips**. The results from the energy consumption scenario suggest that BEV trucks can efficiently complete multiple daily cross-border trips **if border wait times (BWT) are kept below 90 minutes**.

BWT	Loaded Truck	Empty Truck
Distance	40 miles	40 miles
Total Energy Consumption (60 min BWT)	95.2 kWh	71.2 kWh
Total Energy Consumption (90 min BWT)	100.8 kWh	76.8 kWh

Total energy consumption (including transit, idling, loading, and unloading) remains within current battery capacities of 200-300 kWh.

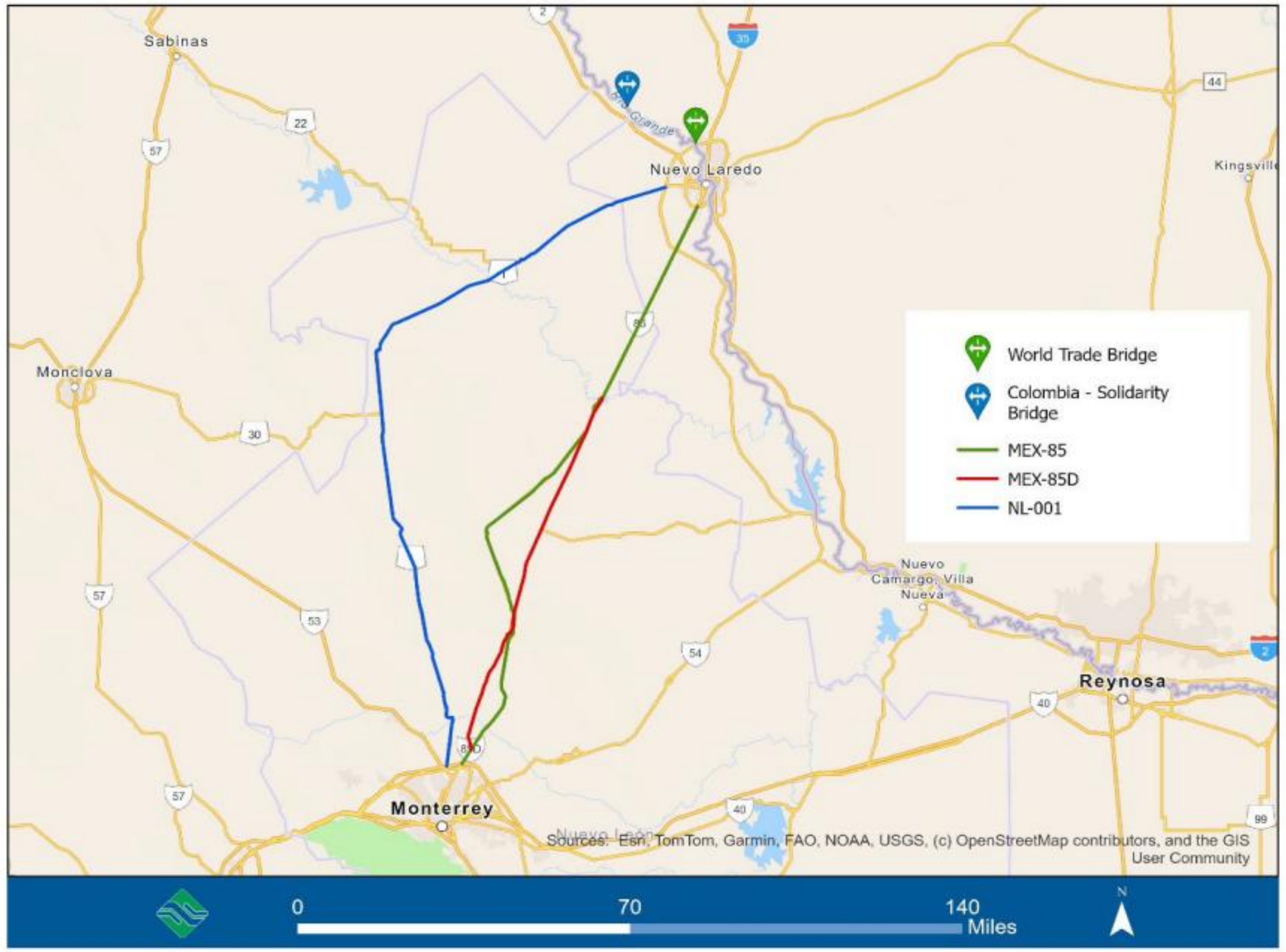
Emissions Analysis

Overview

Comprehensive emissions analysis on primary corridors using EPA's Motor Vehicle Emission Simulator (MOVES) to estimate **environmental impacts of ZEV adoption** for cross-border drayage.

Methodology and Data Collection:

- **Eight heavy-duty trucks** were equipped **with onboard GPS data loggers** monitoring second-by-second location, speed, and engine performance.
- Vehicle Operating Mode or Op-Mode distributions categorized by truck activity states: **idling, running, accelerating, decelerating**.
- **Link-level analysis** - Bureau of Transportation Statistics and GIS data for visual corridor mapping from Monterrey to Nuevo Laredo.



Emissions Analysis

MOVES Characteristics

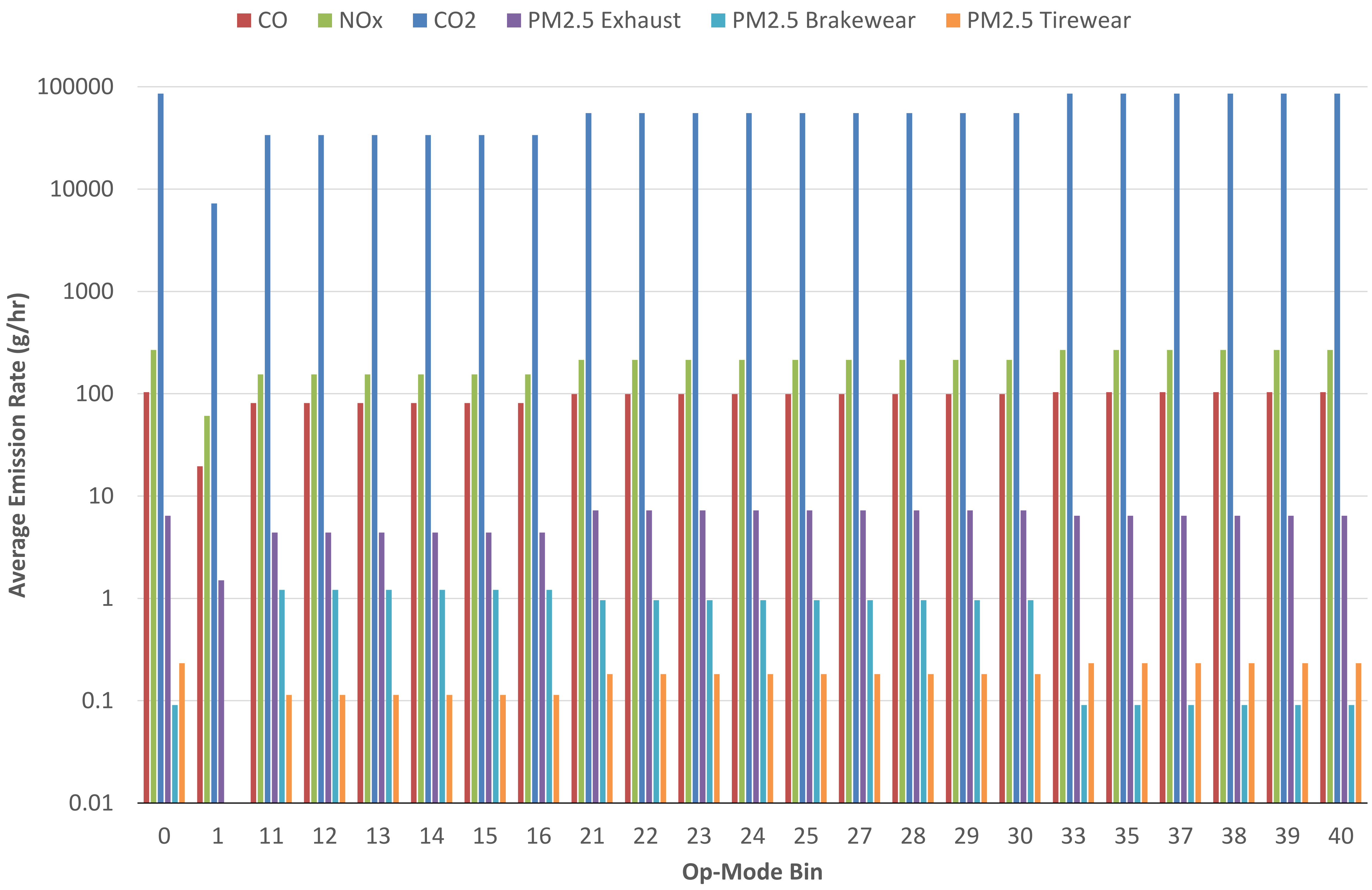
MOVES Characteristics	Examples of Parameters
Vehicle Type Input	heavy-duty diesel vs. passenger car, etc.
Fuel Type Input	Diesel, CNG/LNG, electricity, etc.
Operating Conditions Input	Aspects of the Driving Cycle- (e.g. Speed & acceleration, climbing a grade, or idling)
Environmental Conditions Input	Ambient temperature, humidity
Pollutants Estimation	Carbon monoxide (CO), Oxides of nitrogen (NO_X) , Total gaseous hydrocarbons (THC), Particulate matter (PM), Greenhouse gases (CO_2, CH_4, N_2O)
Emissions Estimate	Second by second or aggregated (hourly, daily, annual)

Emissions Analysis

ICE Emissions

MOVES-default running exhaust base emission rates (g/hr) are plotted against Op-Mode bins.

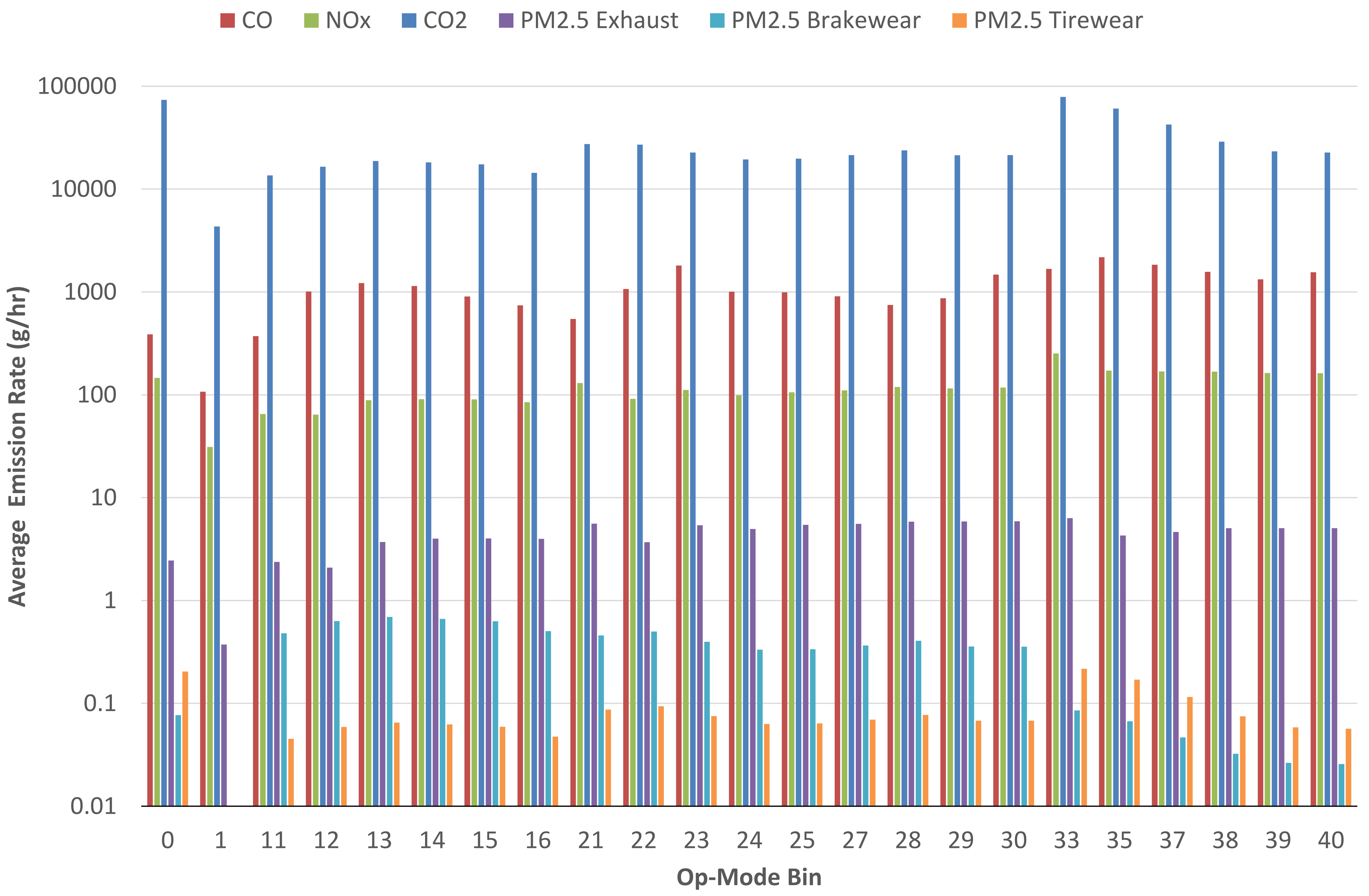
- Diesel emission rates are substantial across all major pollutants, **particularly CO_2,** reflecting the **high fuel consumption** of heavy-duty drayage vehicles.
- **CO and NO_x show higher rates** at higher load bins (Op-Modes 21–30, corresponding to **25–50 mph**).
- **Exhaust $PM_{2.5}$ is mostly constant**, while $PM_{2.5}$ from brake and tire wear are relatively low, typically from low-speed bins where braking is frequent.



Emissions Analysis

CNG Emissions

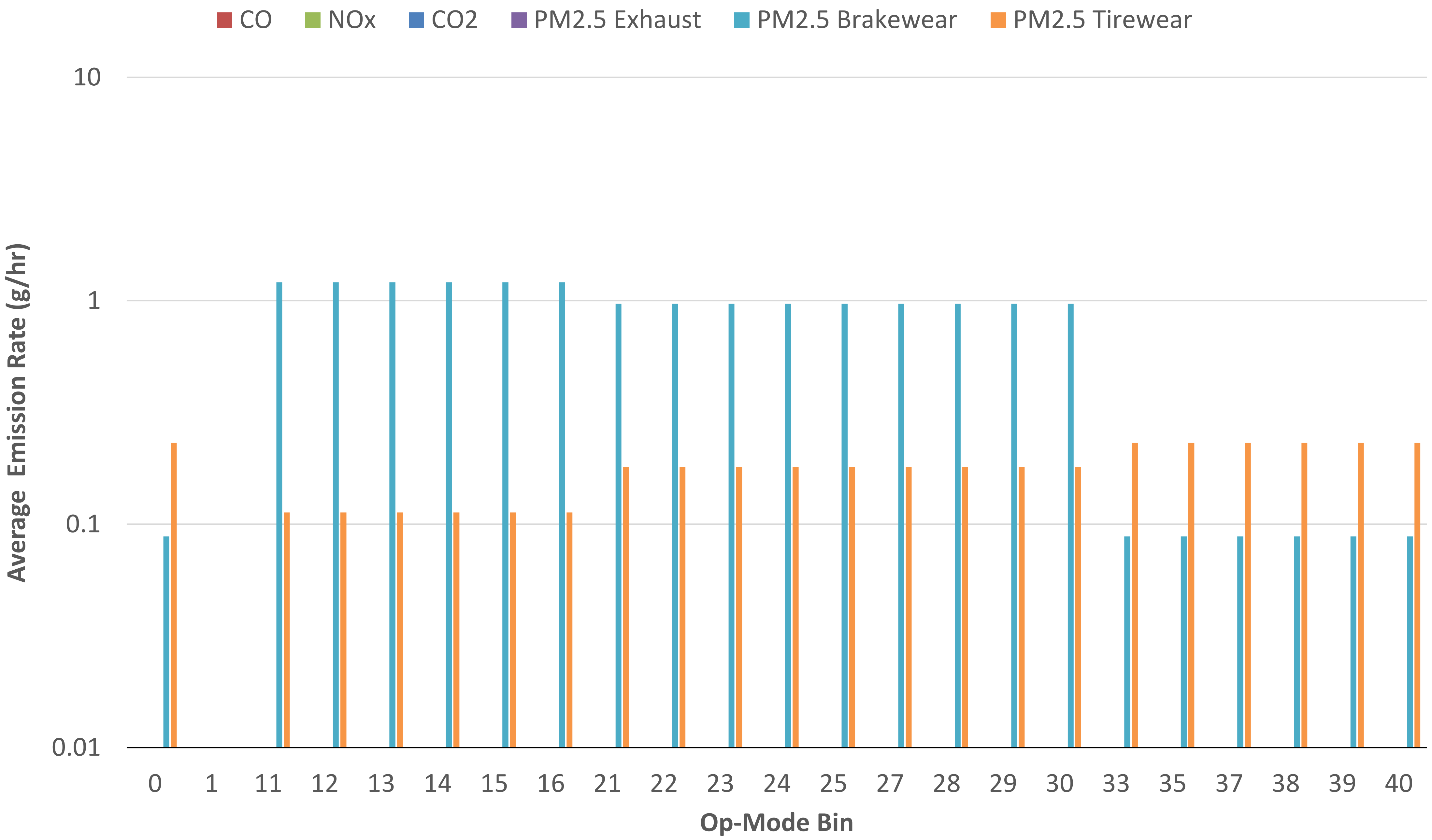
- **CNG CO_2 emission rates are lower than diesel**, consistent with the lower carbon intensity of CNG fuel.
- **NO_x rates are lower** compared to ICE.
- **CO rates are higher than ICE**, consistent with incomplete combustion tendencies of CNG engines under certain conditions.
- **Exhaust $PM_{2.5}$ is lower than diesel**, reflecting the absence of heavy hydrocarbon particulates, while brake and tire wear **$PM_{2.5}$ remain at levels similar to diesel.**



Emissions Analysis

BEV Emissions

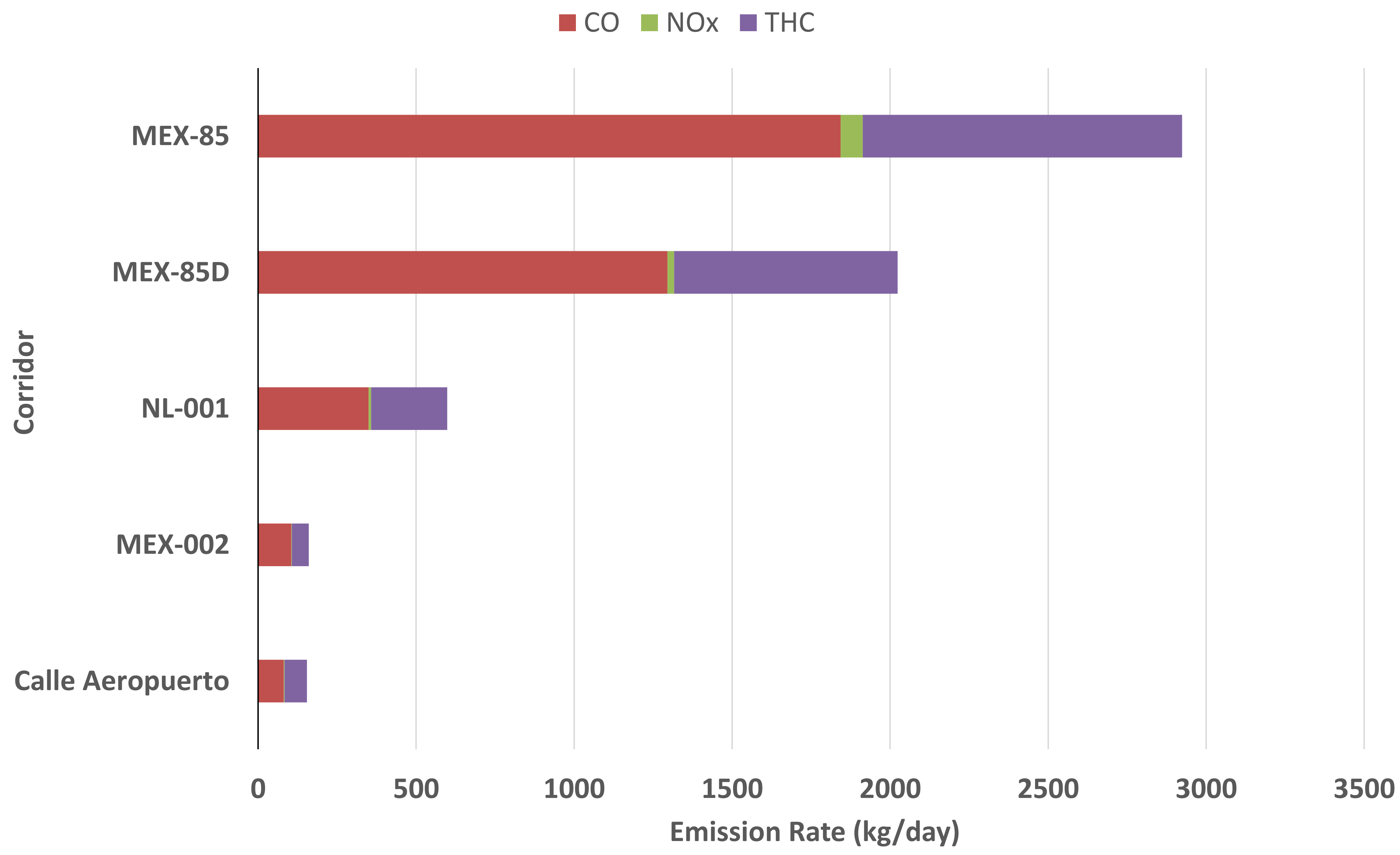
- **BEVs have zero tailpipe exhaust emission** for CO, NO_x, and CO_2.
- Only emit **minimal non-exhaust $PM_{2.5}$** sources from brake wear and tire wear.
- Brake wear $PM_{2.5}$ is notable in the lower speed and stop-and-go bins, though **regenerative braking is expected to reduc these values in real-world operation** compared to MOVES defaults.



Emissions Analysis

Corridor Emissions

- Corridors **MEX-85 and MEX-85D** account for a disproportionate share of total emissions due to their **high AADTT and longer route lengths**.
- MEX-85 corridor alone contributes **nearly 3,000 kg/day of combined pollutants** in the baseline scenario.
- **Policy interventions and infrastructure investments**, such as the deployment of charging and fueling infrastructure, could be prioritized to transition to ZEVs.

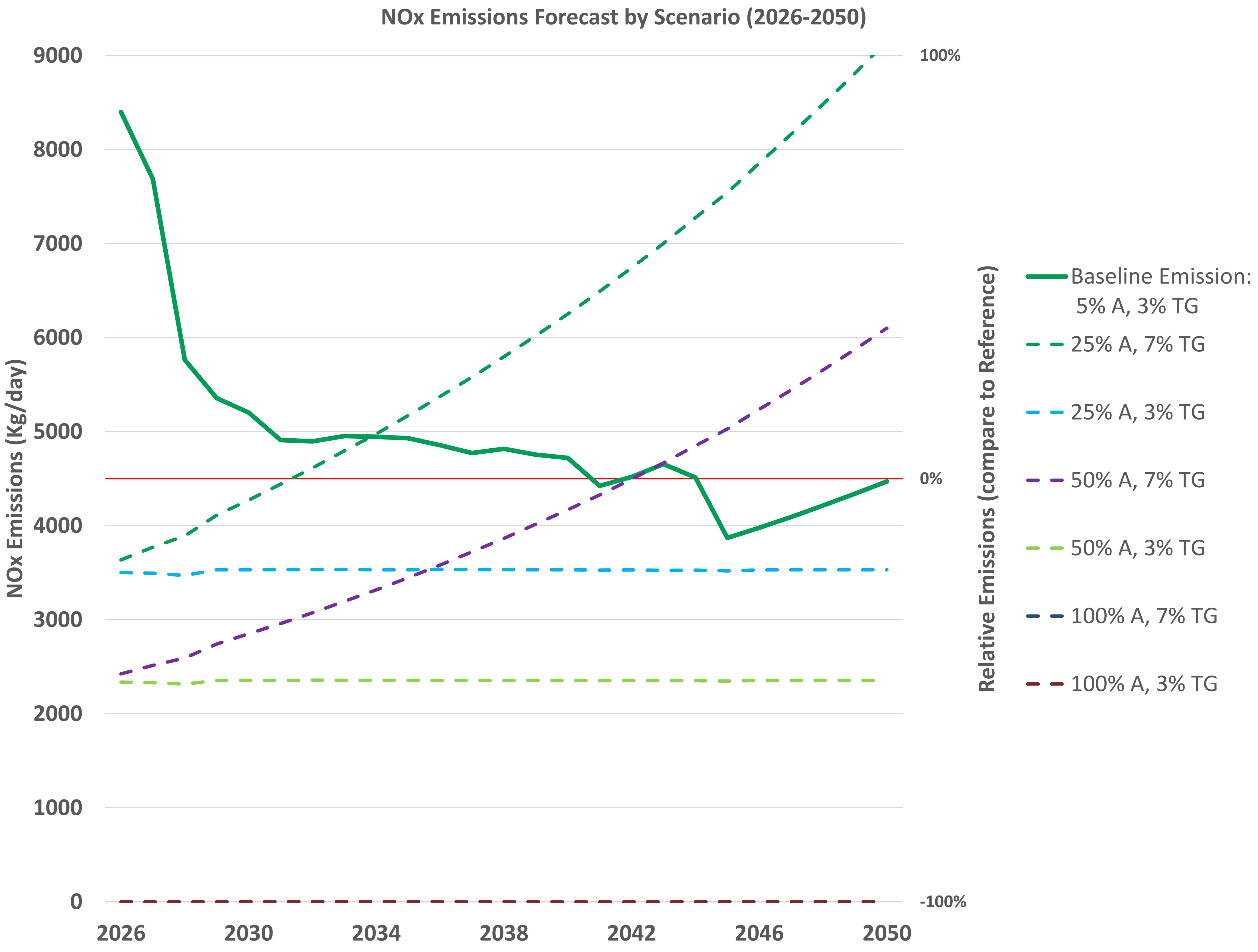


Emissions Analysis

2026-2050 Emissions Forecast

- Scenarios with **50–100% ZEV adoption** show **sustained to full elimination of NOx, CO, and THC** despite projected truck traffic growth

- These reductions could **improve air quality and lower community exposure** to diesel-related emissions, suggesting meaningful public health benefits.

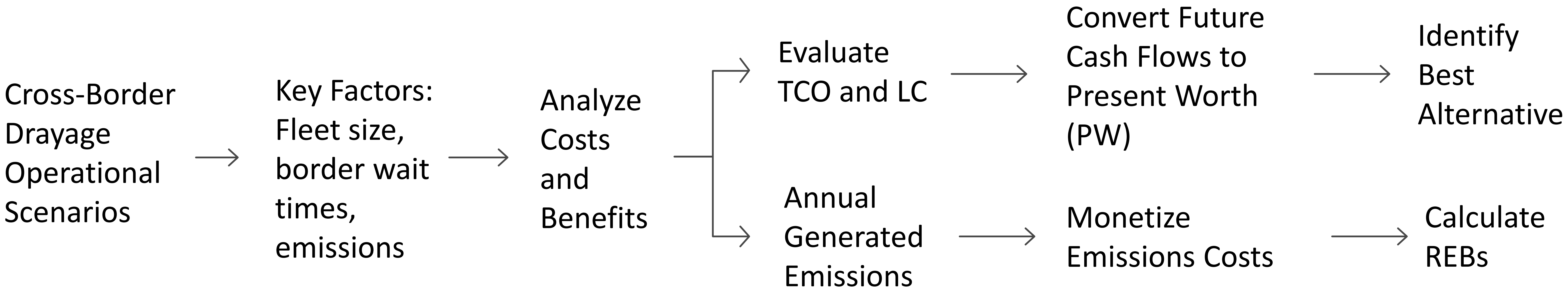


Cost-Benefit Analysis

Overview

- Total cost of ownership (**TCO**) – Vehicle cost
- Logistics costs (**LC**) – Charging stations
- Reduced Emission Benefits (**REBs**) – Emissions costs/benefits

Cost-Benefit Analysis Flow Chart



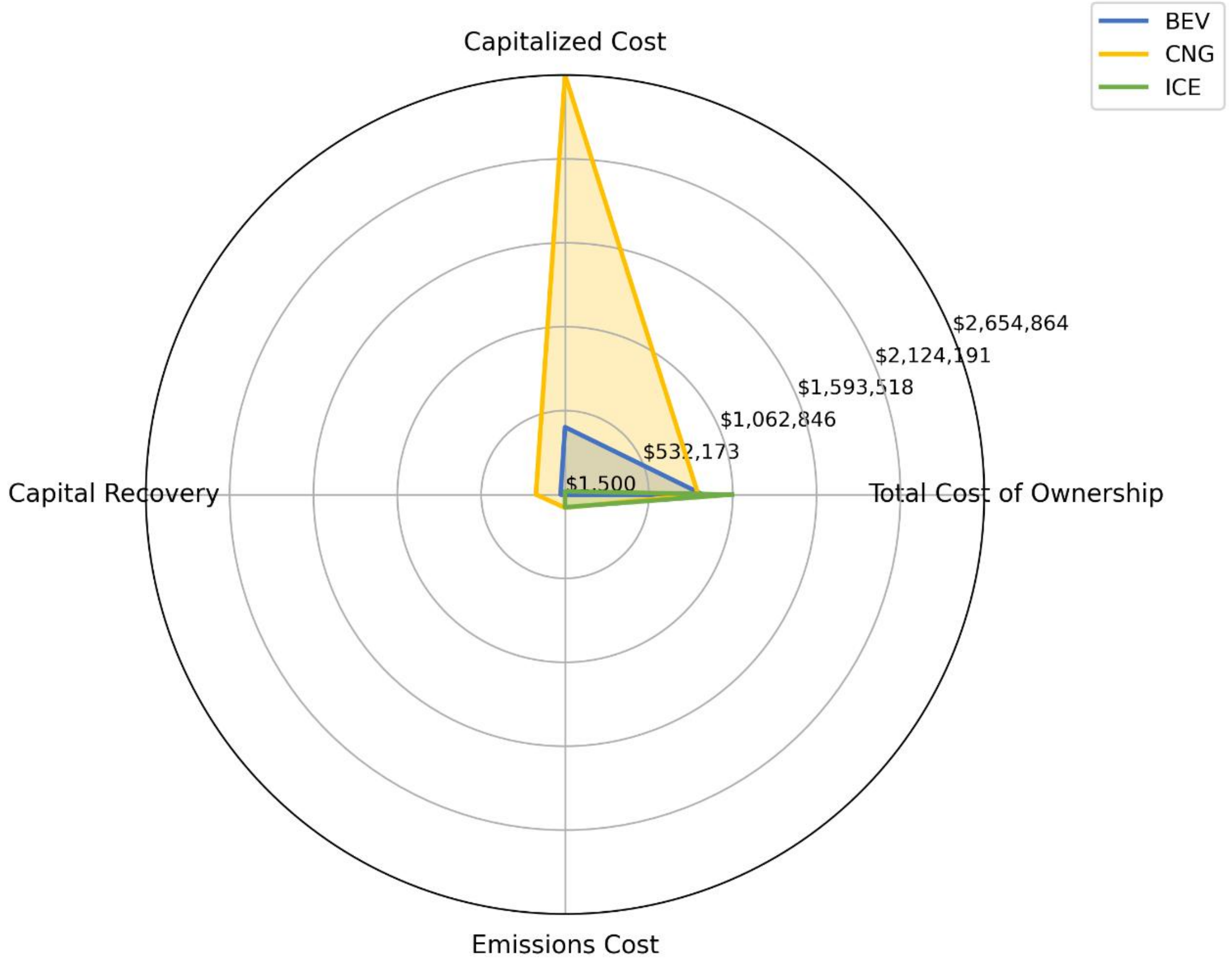
Cost-Benefit Analysis

Conclusions

Summing it all together:

- BEVs achieve the **best overall balance**, combining **low operating costs** with minimal environmental impact.
- CNGs are the **best TCO alternative** but present **high logistics costs and poor environmental performance**, limiting its practical advantage.
- ICE remains the **least competitive economically**, performing well only in infrastructure-related metrics due to its established fueling network.

Cost Dimensions of ICE, BEV and CNG Trucks



Cost-Benefit Analysis

Conclusions

- BEVs offer **55% to 67% lower OpEx** than CNG and ICE trucks.

- When compared to ICE, 100-truck BEV and CNG fleet transition results in **~ $18.5 million to $21 million savings** after 18 years.

- Installation of fuel or charging stations is the highest logistical cost: **CNG stations are 6X more expensive than BEV stations.**

- In a 100-truck fleet transition scenario from ICE,, **BEVs** emission reduction benefits can reach **~$7.8 million**, whereas **CNGs may result in -$300,000** due to elevated CO emissions.

- **BEVs offer the best overall balance among TCO, LC, and REBs**, resulting as the most sustainable and economically balanced choice for long-term cross-border drayage adoption.

Qualitative Analysis of Cost Dimensions per Truck Technology

Technology	TCO	LC	REBs
ICE	H	L	M
BEV	M	M	H
CNG	L	H	L

Next Set

Adoption Timeline

Near-Term
Early Adoption

2025 – 2030
15% – 25% Adoption

Mid-Term
Scaled Deployment

2031 – 2040
50% Adoption

Long-Term
Comprehensive Transition

2041 – 2050
Near 100% Adoption

Install Depot Charging at Top 10 Facilities

Implementing charging stations at high-volume logistics hubs

Establish Fast-Charging Corridors

Creating public charging routes along I-35 and Loop 20

Integrate Charging into Bridge Expansion

Incorporating charging infrastructure into WTB project

Expand Depot Charging to 50%

Increasing charging availability at regional logistics facilities

Develop Border-Crossing Charging

Setting up charging stations at border staging areas

Establish Cross-Border Networks

Creating charging networks that serve carriers across borders

Achieve Comprehensive Charging Coverage

Ensuring charging availability across all logistics zones

Integrate Renewable Energy

Combining charging infrastructure with renewable energy sources

Harmonize Charging Standards

Unifying charging standards and payment systems across borders

Contact Information

Madhusudhan Venugopal
Air Quality and Environment
M-Venugopal@tti.tamu.edu
972. 994.2213

Araceli Lopez-Acosta
International Trade and
Border Transportation
a-acosta@tti.tamu.edu
979.703.9385

North American Development Bank

TEXAS CENTER FOR BORDER ECONOMIC & ENTERPRISE DEVELOPMENT
TEXAS A&M INTERNATIONAL UNIVERSITY

Texas A&M Transportation Institute