

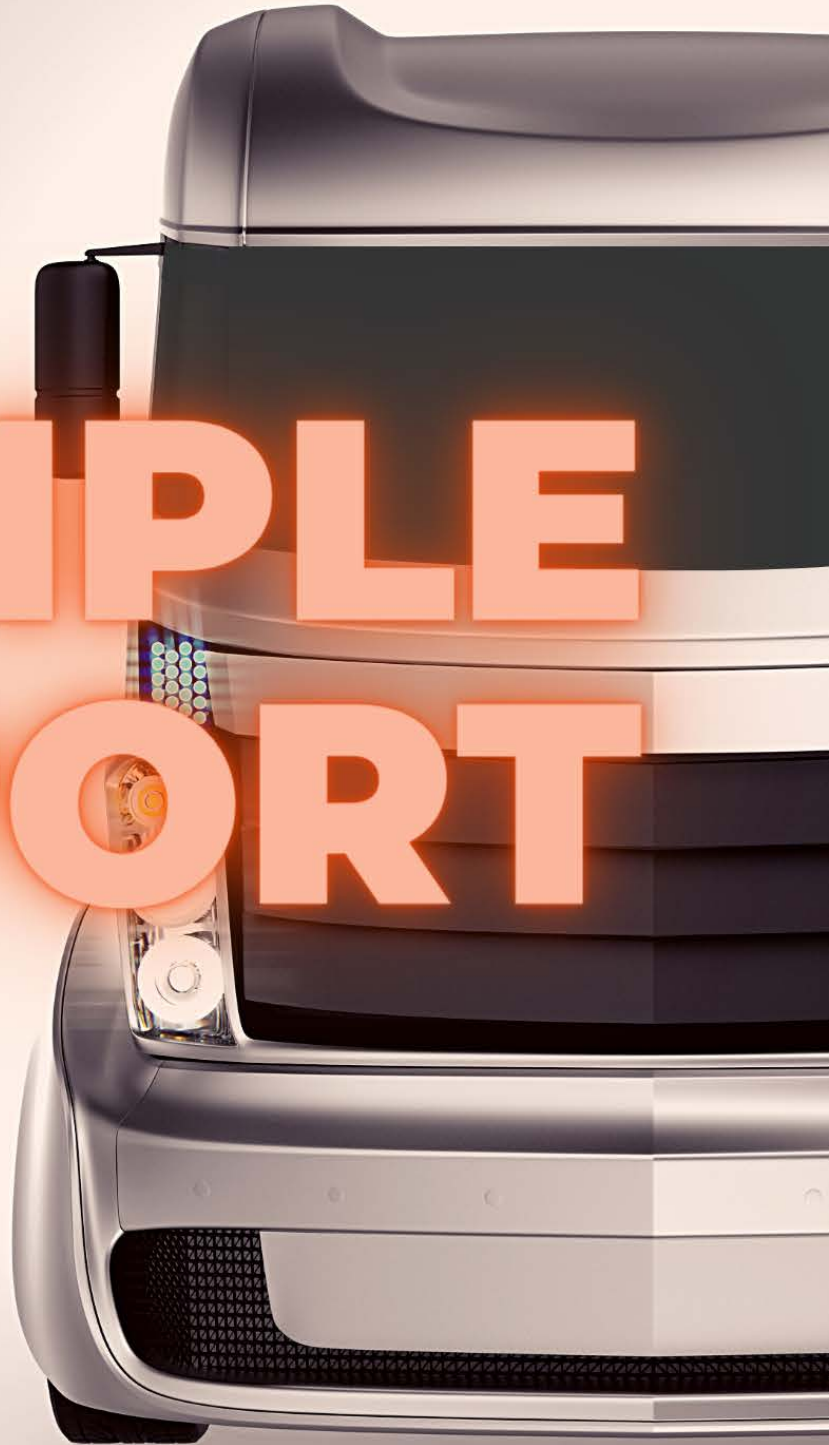
# CHARGING FORWARD REPORT

THIRD EDITION

2024-2040  
DECARBONIZATION  
FORECAST & ANALYSIS

NORTH AMERICA

CHARGING FORWARD: 2023-2040 Decarbonization Forecast & Analysis is published by Americas Commercial Transportation Research Company (ACT), 4440 Middle Road, Columbus, IN 47203. Phone: 812.379.2085, Fax: 812.378.5997, email: [trucks@actresearch.net](mailto:trucks@actresearch.net). Copyright 2023 by ACT, with all rights reserved. Reproduction, copying, or publication of this report in whole or part is not permitted without prior approval. This document is for internal use only. Questions and subscription requests should be directed to K.W. Vieth, Publisher.



# TABLE OF CONTENTS

<b>Section 1</b>	<b>Executive Summary</b>	
<b>Section 2</b>	<b>BEV &amp; FCEV Forecast</b>	
	Introduction.....	2-1
	North America.....	2-2
<b>Section 3</b>	<b>Economic Assumptions</b>	
	Global Economic Assumptions.....	3-1
	North America Economic Assumptions.....	3-3
	Known Unknowns.....	3-5
<b>Section 4</b>	<b>Market Overview</b>	
	Introduction.....	4-1
	Decarbonization Targets and Goals.....	4-1
	CV Decarbonization Market: OEM Product Offerings.....	4-3
	Zero-Emissions Vehicle Applications.....	4-4
	Heavy Duty Applications.....	4-5
	Medium Duty Applications.....	4-6
	Bus Applications.....	4-7
<b>Section 5</b>	<b>Second Life Considerations</b>	
<b>Section 6</b>	<b>Propulsion Systems Technology</b>	
	Introduction .....	6-1
	Efficiency Comparisons of BEV   FCEV   ICE.....	6-1
	Wheel to Well Comparisons.....	6-3
	ZEV propulsion Systems: Existing Configurations & Future Trends.....	6-4
	Hydrogen Internal Combustion Engines (H2 ICE).....	6-6
<b>Section 7</b>	<b>Battery Technology</b>	
	Introduction .....	7-1
	Battery Chemistry and Cell Format .....	7-1
	Durability, Reliability and Safety .....	7-4
	Li-ion Battery Manufacturing Capacity.....	7-5
	Battery Raw Material and Supply Chain Considerations.....	7-7
	Lithium.....	7-7
	Nickel.....	7-17
	Cobalt.....	7-21
	Battery Cost .....	7-24
	Reuse, Repurpose, and Recycle .....	7-27
	Technology Progression.....	7-34
<b>Section 8</b>	<b>Fuel Cell Technology</b>	
	Hydrogen Fuel Cell Systems.....	8-1
	Fuel Cells Applied to HD Commercial Vehicles .....	8-3
	Key Components within the Stack and the Balance of Plant.....	8-4
	Hydrogen Tanks.....	8-5
	Vehicle Integration Challenges and Concerns.....	8-6
	Safety.....	8-6
	Durability.....	8-7
	Hydrogen Fuel Cell Costs.....	8-9
	Reuse, Repurpose and Recycle .....	8-10
	Technology Progression.....	8-11
<b>Section 9</b>	<b>Government: Regulation &amp; Subsidies</b>	
	Global Decarbonization Goals.....	9-1
	Overview.....	9-2

## TABLE OF CONTENTS

GHG/CO2 Emissions: Overview.....	9-3
GHG/CO2 Emissions North America: US and Canada.....	9-4
Tailpipe NOx Emissions: Overview.....	9-11
NOx Emissions: United States / EPA Heavy-Duty Engine and Vehicle Standards.....	9-11
NOx Emissions: Canada.....	9-13
NOx Emissions: CARB Low NOx Heavy-Duty Omnibus Regulation.....	9-14
ZEV Mandates: Overview.....	9-16
ZEV Mandates: United States / CARB Advanced Clean Trucks.....	9-16
ZEV Mandates: US Multi-State Medium-& Heavy-Duty Zero Emission Vehicle MOU.....	9-18
ZEV Mandates: US / California CARB Advanced Clean Fleets.....	9-18
ZEV Mandate: United States / Bus Specific Regulations and Mandates.....	9-20
Subsidies/Incentives: Overview.....	9-23
Subsidies/Incentives: North America Low Carbon Fuel Standards.....	9-23
Subsidies/Incentives: United States Federal Infrastructure Investment & Jobs Act (aka BIL).....	9-24
Subsidies/Incentives: United States Inflation Reduction Act (IRA).....	9-26
Subsidies/Incentives: Canada / iMHZEV Program.....	9-27
Road Use Taxes United States.....	9-27
Weight Limits Relaxed North America.....	9-27
ICE Bans, Air Quality Districts North America.....	9-28
<b>Section 10 Electricity Supply &amp; EV Charging Infrastructure</b>	
Electricity Supply Overview, Renewables, Grid Reliability.....	10-1
Electricity Generating Capacity: Overview.....	10-2
Electricity Generating Capacity: United States.....	10-2
Electricity Generating Capacity: Canada.....	10-3
EV Charging Equipment.....	10-4
EV Charging Infrastructure.....	10-4
Vehicle-To-Grid.....	10-5
Standardization.....	10-6
Private/Depot Charging.....	10-7
Public Charging: North America.....	10-9
<b>Section 11 Hydrogen Supply &amp; Fueling Infrastructure</b>	
Overview: Hydrogen Economy.....	11-1
Global Alliances.....	11-2
Hydrogen Applications.....	11-3
Hydrogen Production.....	11-4
Challenges Facing Green Hydrogen's Adoption.....	11-7
Hydrogen Infrastructure.....	11-8
Public-private Efforts.....	11-9
Public Infrastructure.....	11-10
North America Public Infrastructure.....	11-10
<b>Section 12 Natural Gas Fueling Infrastructure</b>	
<b>Section 13 Fleet, Operator, &amp; User Feedback</b>	
<b>Section 14 Total Cost of Ownership (TCO)</b>	
Total Cost of Ownership (TCO) Model Summary.....	14-1
TCO: Definition.....	14-1
TCO: Regulatory Impacts.....	14-2
TCO: Costs.....	14-3
How the Model Works.....	14-7
Total Cost of Ownership by Application .....	14-8
North America: Overview.....	14-8

## TABLE OF CONTENTS

North America: Class 8 Regional Truckload.....	14-9
North America: Class 8 Local Truckload.....	14-10
North America: Class 8 Long-Haul Truckload.....	14-12
North America: Class 8 Less-Than-Truckload, Linehaul.....	14-14
North America: Class 8 Straight Truck - Refuse.....	14-16
North America: Class 8 Straight Truck - Construction/Dump.....	14-17
North America: Class 8 Straight Truck - Local Distribution.....	14-19
North America: Class 8 Yard Spotter.....	14-21
North America: Class 6-7 - Less-Than-Truckload P&D.....	14-23
North America: Class 6-7 - Reefer Box Truck.....	14-25
North America: Class 6-7 - Utility Aerial/Lift Truck.....	14-26
North America: Class 6-7 - Beverage Truck.....	14-28
North America: Class 4-5 -Parcel Delivery Truck Short-Range.....	14-29
North America: Class 4-5 -Parcel Delivery Truck Long-Range.....	14-31
North America: Class 4-5 - Service/Utility/Work Truck.....	14-32
North America: BUS - Transit Bus (Class 8).....	14-34
North America: BUS - School Bus (Class 6-7).....	14-36

## EXECUTIVE SUMMARY

The ACT Research team has spent the last seven months in an extensive research effort into the prospects for commercial vehicle (CV) decarbonization through 2040 timeframe. ACT has been gaining experience and knowledge investigating alternative powertrains for commercial vehicles for well over the past decade, starting with a multi-client study in 2011-2012 on the potential of natural-gas to replace diesel in some commercial vehicle segments. That study was revisited and refined in a 2014. In 2018, ACT Research completed its first multi-client study on Commercial Electric Vehicles (CEV) in North America. In Q1 2021 we completed the 1<sup>st</sup> edition North American CEV study “Charging Forward”, and in Q4 2021 we completed the 2<sup>nd</sup> edition that updated our previous effort and expanded the analysis to a global scope in seven key regions: North America, Europe, China, Japan, South Korea, India, and Brazil.

In addition to our 2021-ending study needing a refresh, in Q4 2022 we recognized the need to expand the scope of analysis to investigate the full compliment of decarbonization solutions, and to focus on the three key global regions for commercial vehicles, North America, Europe and China. This then became the genesis of ACT Research’s 3<sup>rd</sup> edition “Charging Forward”, with an expanded scope to focus on the suite of decarbonization solutions for commercial vehicles. In addition to battery-electric (BEV) and fuel cell electric vehicles (FCEV), we have included analysis of hydrogen internal combustion engines (H2-ICE), Natural-gas internal combustion engines, and plug-in hybrid powertrains (PHEV).

One will note that all of ACT’s fuel choice studies have been done in a multi-client format. It is our belief that in bringing disparate stakeholders together, better insights can be derived. Bearing this notion out, the benefits of conducting these studies in a multi-client format have provided invaluable feedback, as inputs from a variety of industry sources allow us to raise better questions that in turn help to paint a more complete picture of this host of emerging technologies.

The purchase of a commercial vehicle, in contrast to most passenger vehicle purchases, is not a “life-style” purchase for the buyer, but a business decision. This is true not only with for-profit businesses, but also non-profits and governmental agencies (school districts for school buses, regional transit authorities for city/transit buses, municipalities, and sanitary districts for refuse) who purchase vehicles based on TCO financial considerations. Recognizing that most commercial vehicles are working in competitive situations, questions surrounding operating costs are fundamental and are at the heart of ACT’s methodology in this multi-client build-up of knowledge.

*Will an electric-powered vehicle offer a better ROI than other alternatives?*

At the heart of this study is the financial analysis driven by our TCO models that detail for each region unique vehicle applications for Medium-duty, Heavy-duty, and Bus vehicle segments. The analysis includes the following regions: North America (US + Canada), Europe, and China, and includes detailed TCO models for 53 stand-alone vehicle applications.

The TCO models driving the study's conclusions have been developed using a "bottom-up" approach to the unique factors impacting different market subsegments. Those models take into account drivetrain component costs, operational costs based on duty cycles, fuel costs, maintenance costs, taxes and more. They also factor in costs for supporting infrastructure. The TCO models generate two key financial measures: payback period and total lifetime cost savings. With that data in hand, ACT Research has developed a proprietary algorithm that converts these financial metrics into share points to derive adoption rates. The modeling allows us to compare decarbonized vehicle alternatives (BEV, FCEV, PHEV, H2-ICE, NG-ICE) against incumbent ICE powered vehicles. For the most part the incumbent ICE powertrain is diesel, but there are some applications and regions where lower GVW medium-duty vehicles use both diesel and gasoline powered vehicles.

Assumptions are at the heart of every model, and beyond proven demand modeling, a big part of the multi-client process is to hone the assumptions we feed into the model(s). The costs associated with battery-electric vehicles will fall over time, thanks to rising volumes and continued technology improvements, while incumbent ICE costs will rise as increased emissions regulations are adopted across the globe. The impact of these two dynamics: battery-electric costs dropping, and ICE costs rising, results in rising market shares for battery-electric vehicles throughout the forecast period as already competitive TCOs get even better.

The *consistent* findings across all of the three regions analyzed in the study are that yes, **decarbonization solutions have the ability to offer a better ROI than incumbent diesel internal-combustion engine (ICE) powered vehicles**, dependent of course on each application's unique duty cycle, along with projected advancements in decarbonization technologies.

Over the past eighteen months since 2<sup>nd</sup> edition Charging Forward study was completed, there have been significant changes in the influencing factors for CV decarbonization, and hence the impetus for this 3<sup>rd</sup> edition. First and foremost are regulatory changes that have either been enacted or proposed in all three key global regions, that were either hinted at back in 2021, or were virtually non-existent a mere 18 months ago.

In November 2021 the United States passed the Infrastructure & Jobs Act, aka Bipartisan Infrastructure Law (BIL), followed by the Inflation Reduction Act (IRA) in August 2022. Both pieces of US legislation offered multiple incentives and subsidies to encourage adoption of decarbonization solutions for the transportation industry along with supporting infrastructure and supply chain incentives. In December 2022 the US EPA adopted a final rule, "Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards," that set NOx and PM emissions reduction standards (EPA Low NOx rule). In early April 2023, the EPA filed a notice of decision to grant CARB's waiver for the Advanced Clean Truck Act, and in mid-April, the EPA released NPRM for greenhouse gas (GHG) Phase 3 emissions standards. The effect of those three regulations either mandate percentages of ZEVs, infer adoption of ZEV due to CO2 levels, or by increasing TCO of diesel ICE powertrains, help tip the scale towards more favorable total cost of ownership (TCO) of decarbonization solutions.

Europe has also either passed or proposed a number of key legislations that will have a dramatic effect on CV decarbonization. In November 2022 the European Union (EU) released proposed EURO 7 regulations for increased NOx stringency, in February 2023 released proposed amendments for increased CO2 reductions, and in March 2023 reached an agreement to adopt the Alternative Fuels Infrastructure Regulation (AFIR). The recently proposed CO2 regulations call for a 45% reduction by 2030, 65% by 2035, and 90% by 2040, and require all city/transit buses to be ZEV by 2030.

China has also been moving the needle towards increased adoption of decarbonization solutions for commercial vehicles, and in 2022 issued a draft for Stage 4 fuel consumption that calls for a 14% reduction in CO2 in 2026 compared to Stage 3 (enacted in 2021). China also continues to offer incentives towards adoption of zero-emission commercial vehicles.

Beyond the regulatory influences that are shaping adoption of decarbonization for commercial vehicles, the players in our industry are moving forward to respond to societal and government pressures. Over the past two years, global CV OEMs have continued to develop and launch decarbonized solutions, and have committed to aggressive targets on zero-emission product offerings, as well as zero-emissions in their manufacturing operations. Infrastructure is coming on stream through both public and private efforts, though admittedly not fast enough and not enough focused on CVs. Battery technology continues to advance resulting in improved energy densities and fast charging capabilities, along with a significant expansion in battery manufacturing capacity, bolstered by raw material extraction and processing.

This is a dynamic period in our industry, with a pace of change and advancement that seems unrivaled in our lifetimes. As Ferris Bueller so famously stated “Life moves pretty fast. If you don’t stop and look around once in a while, you could miss it” ... But that is what this study and this report is all about, the team at ACT Research has put together the details and key considerations that will shape the future of our industry. This report enables subscribers to stay informed and up to speed to ensure one is making the best decision for their part of this industry. Many thanks to our Charter Subscribers for being part of the journey.



## **CHARGING FORWARD: 2024 - 2040 DECARBONIZATION FORECAST & ANALYSIS**

2019 LAWRENCE R. KLEIN BLUE CHIP AWARD WINNER

Contributor to Blue Chip Economic Indicators and WSJ Economic Forecast Panel

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