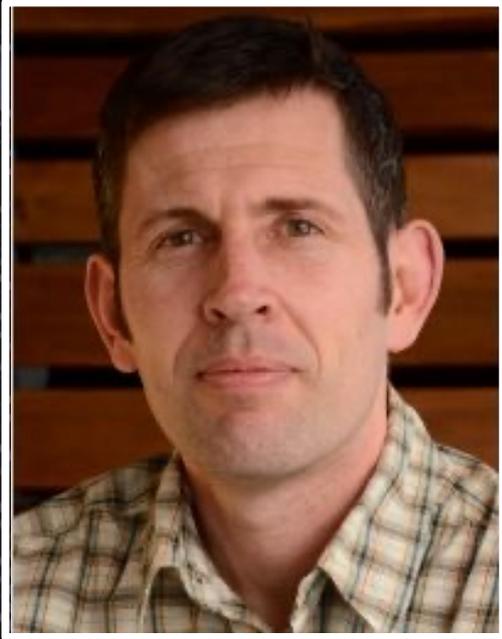


The Future of **Hydrogen & RNG** in Canada

*Part 4: Pathways for Reducing Heavy-Duty Transport
Emissions in B.C.*

June 30, 2021



Opening remarks

Simon Dyer

Deputy Executive Director
Pembina Institute

Leading Canada's transition to clean energy

The Pembina Institute is a non-profit think-tank that advances a prosperous clean energy future for Canada through credible policy solutions.



Presenting partner



Supporting partners





Moderator

Tahra Jutt

Director, Clean Economy (B.C.)
Pembina Institute



Dave Earle

President & CEO
British Columbia
Trucking Association



Traci Kraus

Director, Government
Relations
Cummins, Inc.



Nicolas Pocard

Vice President, Marketing &
Strategic Partnerships
Ballard Power
Systems



Karen Hamberg

Chair Emeritus
CALSTART



Speaker

Dave Earle

President & CEO
British Columbia Trucking
Association



De-Carbonization in Commercial Transport

Pembina
June 30, 2021

Dave Earle
BC Trucking Association

Industry Overview

- ~60,000 heavy (>11,794kg) vehicles registered in BC
- ~160,000 medium (>4,527kg, <11,794kg)
- No method to know how many extra-provincial vehicles transit BC; based on fuel taxation data, best estimate is a like number
- BCTA – primarily HD, 50% interprovincial
- ~16,000 trucking companies registered with WSBC
- 22 have 100+ employees
- The most visible sector in Metro Vancouver? Drayage:
 - As of Dec 7, 1,661 trucks in the drayage fleet
 - About 1% of the industry

Emissions

- #1 cost for carriers is diesel – real motivation to reduce consumption
 - BC-based carriers, 29% of operating costs on average, can be up to 51%
- NOx, SOx, particulate, GHG
- NOx / Sox / particulate addressed in legislation in both the US and Canada, MY trucks 2004, 2007 and 2010
- Technology was NOT developed
- Eliminated NOx / Sox / particulate, but at significant capital cost, reliability and fuel consumption (5-10% loss)
 - Anyone recall Volkswagen group scandal? Same idea, different execution
- “Delete” kits, Glider kits, anything to reduce diesel burn
- Refitting, if possible, leads to a 5-10% increase in GHG emissions

Where Are The Unicorns?

- Nikola (out – class 6 and 7 only, partnership with GM)
- Tesla – on the road in 2019. Or 2021. Or....but coming!
- All major OEMs have projects
 - Terminal to terminal, SW and SE United States
 - Port of LA/LB – electric ZEVs, Hydrogen Fuel cell
- In Canada? Electric BYD (~120k range) and Lion (up to ~400km range)
- No fuel cell, but hydrogen co-burn on the road now

VHS vs. Beta

➤ Electrification

- ❑ Unproven, but big potential for RTB
- ❑ Infrastructure expensive and not always possible
- ❑ No quick emergency recovery, long charging time
- ❑ Tare (empty) weight penalty = 10% reduction in efficiency
- ❑ Scary capital cost

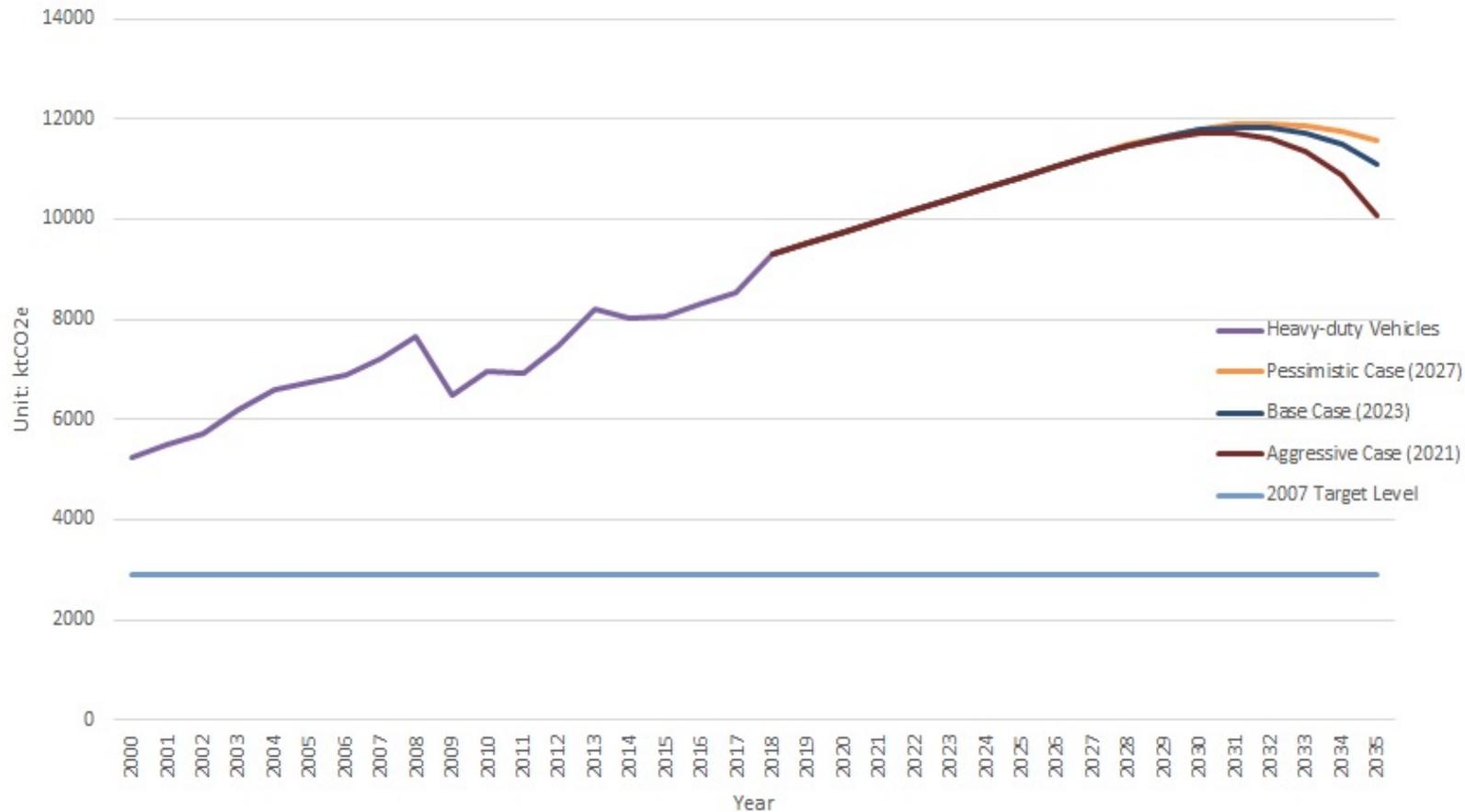
➤ Hydrogen

- ❑ Infrastructure rare and expensive
- ❑ Grey, blue, green – colour matters!
- ❑ Terrifying capital costs

The Cold, Hard Math

- Recall, ~60,000 HD vehicles in BC
- BC's fleet grows by ~600 HD vehicles per year
- Average MY is 2008; 2.9% average fleet turnover (not linear)
- At 2.9% turnover per year, ~1,800 fleet sales per year. Add ~600 from growth, and this aligns with the ~2400 new unit sales we hear from OEMs
- 2008 saw the first ZEV light vehicle sold in BC; 2020, 10% of new car sales
- Total light fleet ZEV penetration after 12 years? 54,000. ~2.4%
- 2021 will (maybe) see the first ZEV HD vehicle operating in BC

Road Transportation GHG Emissions



Assumptions, ICBC Data:

MHD - Class 3 to 6, GVWR 4,527 kg to 11,794 kg (~160,000)

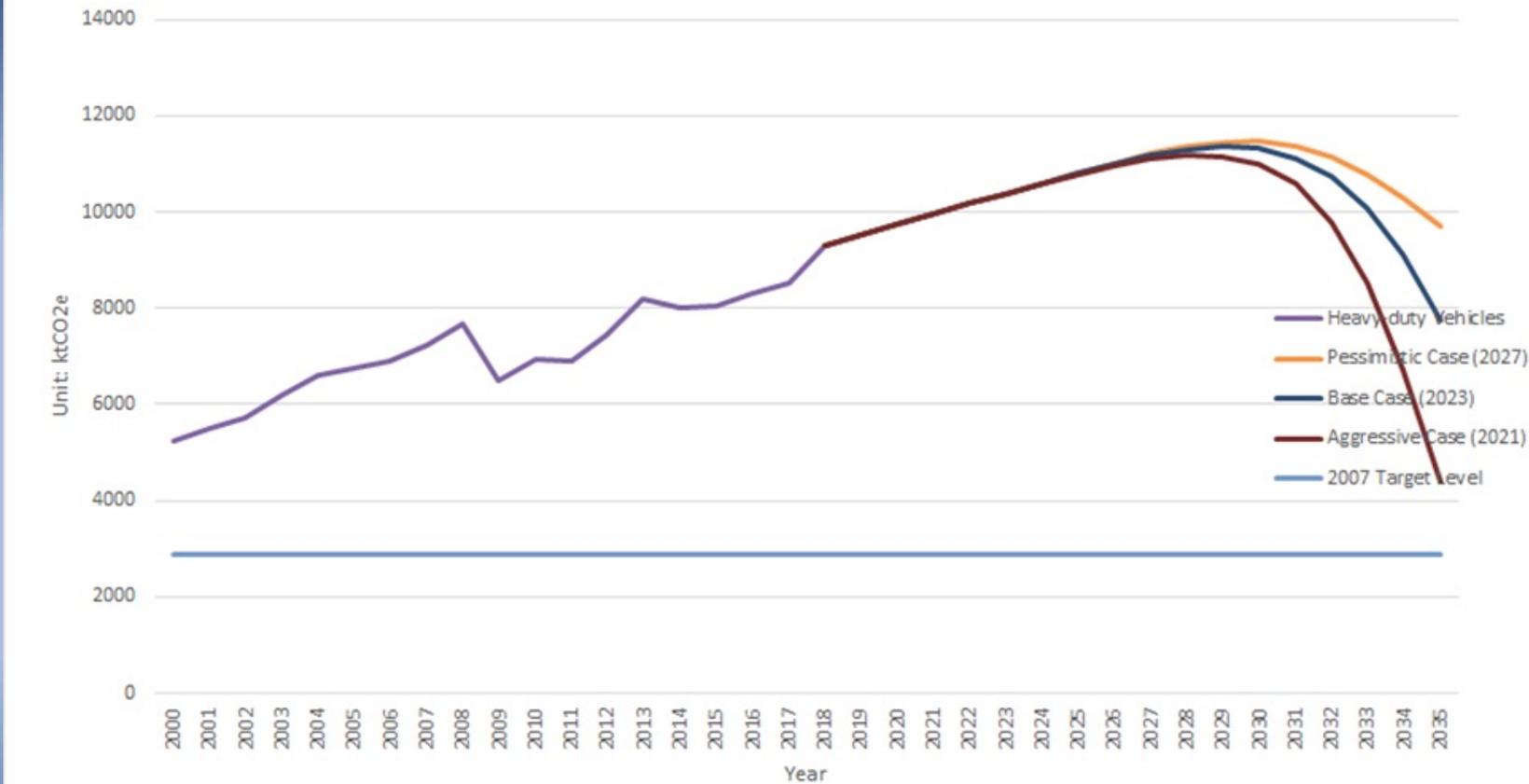
Heavy Duty Vehicles - Class 7 and 8, GVWR > 11,794 kg (~60,000)

Vehicle turnover, based in ICBC data for 2017, 2018, 2019 2.9%/year

MHD zero electric vehicle (ZEV) uptake consistent with ZEV passenger vehicles

2019 Average MY MHD was 2008 (source: ICBC data)

Road Transportation GHG Emissions



Assumptions:

Fleet turnover rate doubled immediately

ZEV adoption 750% of light vehicle rate immediately

Still not there

To get to 40% of 2007 by 2035 requires 1000% acceleration of ZEV adoption

AND

fleet turnover of 10%

A 40% reduction from 2007 levels by 2030 would require 100% of all sales to be ZEV as of January 1, 2021.

OR

Fleet turnover of 15% and 100% of all sales to be ZEV by 2025

Do More With What We Have

- Right sizing – big fleets possible, but not small (<30)
 - Note: 94% of trucking companies <10 trucks
- HDVE
- Improve infrastructure (LCV routes)
- Accelerate fleet turnover
- Pilot, test, build ZEV infrastructure
- Remove red tape (e.g. hybrid drive axles)



Speaker

Karen Hamberg

Chair Emeritus
CALSTART

Chair
Clean Technology Economic
Strategy Table

ZERO EMISSIONS PATHWAY

*Diverse Vehicle Models, Expanding Supply Chains,
A Growing ZEV Market*



Source: CALSTART Global Commercial Vehicle Drive to Zero (available at <https://globaldrivetozero.org/about/program/>)

Enabling Conditions	Enabling Policies
Model availability	Manufacturer sales requirements
Installed fueling infrastructure	Fleet procurement requirements
Vehicles achieve cost parity	Fleet-friendly purchase incentives
Enabling policies adopted	Congestion zones and pricing
Fleets adopt ZECVs	Preferred access lanes and zones
Demand from freight users	Low/zero emission zones
Residual market value	ICE vehicle exclusion
Supply chain resiliency	Vehicle registration limits
Direct infrastructure investment	Weight exemptions
Fleet education/awareness	Low carbon fuel standards
Successful pilots and demonstrations	Utility regulatory policy
Innovative business models	Aligned jurisdictional policies



Supportive Ecosystems for MD/HD Zero Emission Vehicles



Speaker

Nicolas Pocard

Vice President, Marketing & Strategic
Partnerships

Ballard Power Systems

The Ballard logo is displayed in white, bold, sans-serif capital letters on a teal rectangular background in the top-left corner of the image. The background of the entire slide is a photograph of a white semi-truck with a yellow trailer driving on a two-lane road through a rural landscape. The sun is low on the horizon to the left, creating a lens flare effect. The sky is blue with scattered white clouds. The road is flanked by green grass and trees.

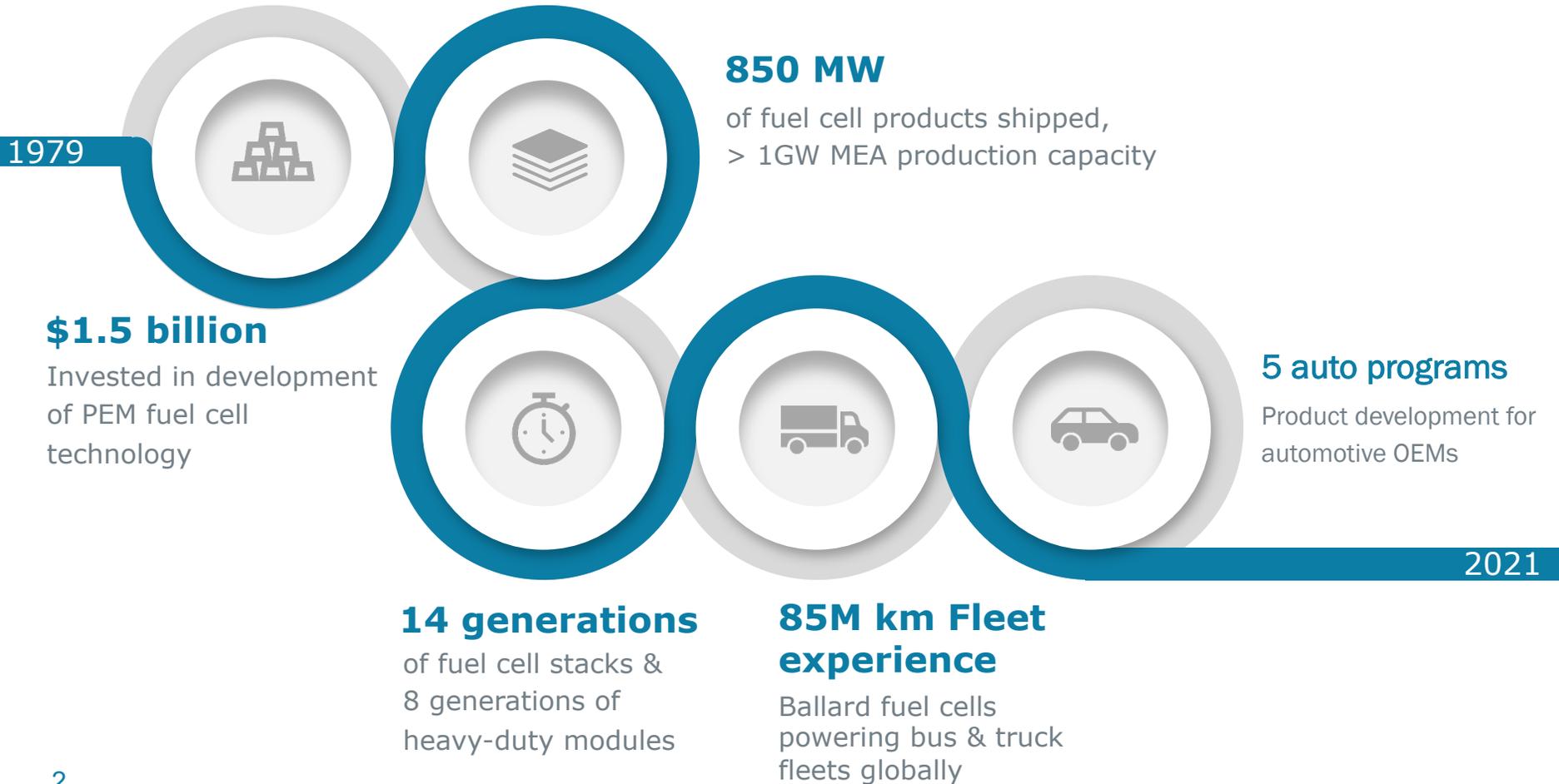
BALLARD™

Fuel cell technology for zero emission trucks

JUNE 2021

About Ballard

We have fuel cell expertise and experience with leading technology



Ballard Today

- 3,500+ buses & trucks operating
- 97% availability of heavy-duty power modules in vehicles
- >30,000 hour product lifetime
- >4.5 L/kW power density
- 1,300 patents & applications
- Rigorous technology & product development processes

Hydrogen is most competitive in heavy duty motive applications



Buses & Coaches



Trucks



Trains



Vessels

Fuel cell technology is needed to decarbonize the heavy duty transportation sector

BALLARD™

Hydrogen H₂

zero emission H₂

Fuel Cell Trucks: The Best Zero-Emission Alternative to Diesel



Refuel:
5 min



longest range



Refuel:
15 min



minimal payload impact | long range



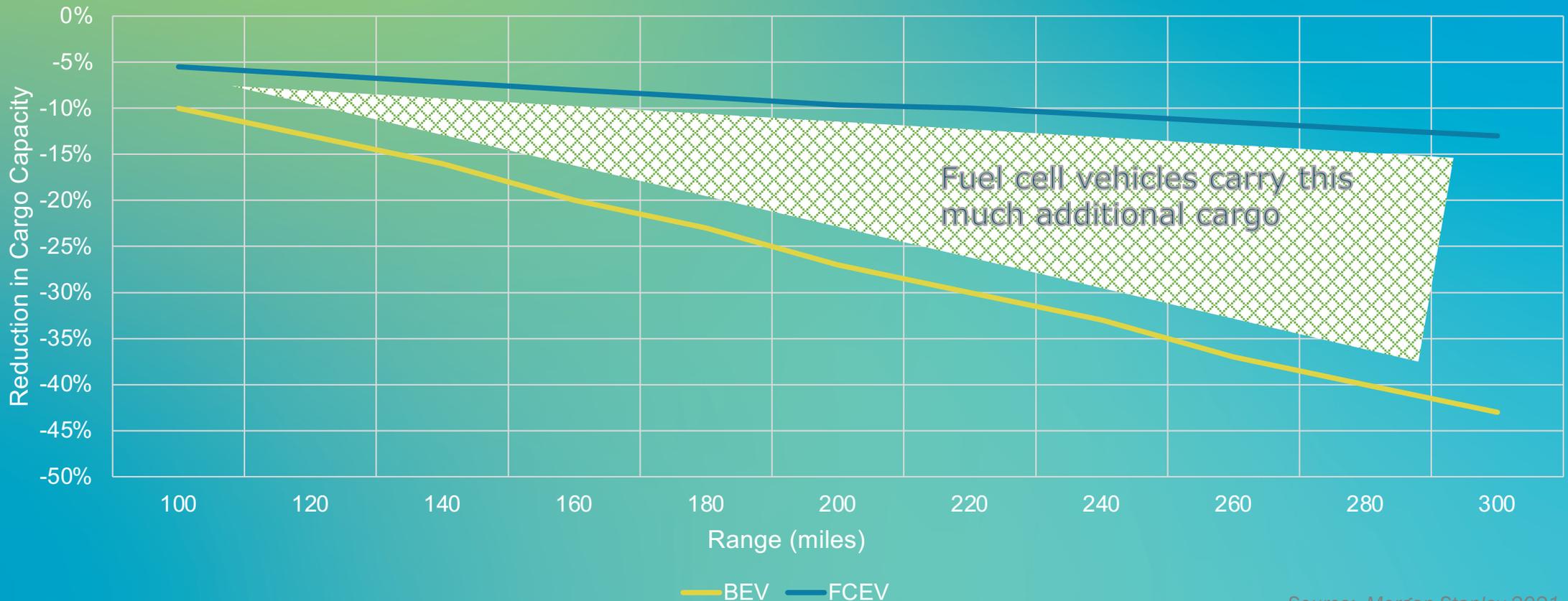
Recharge:
3-5 Hours



significant payload impact | shorter range

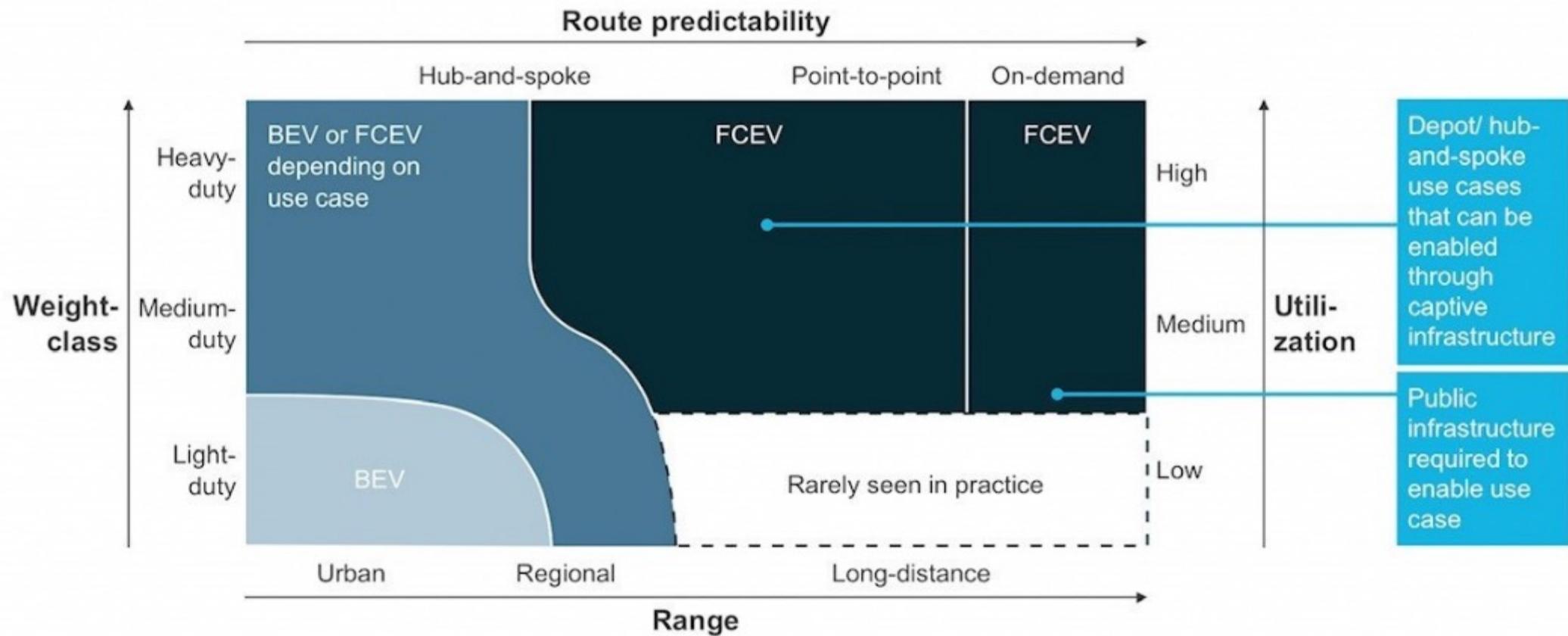
FCEVs offer a 30%+ cargo capacity advantage over battery electric vehicles at a 300 mile range

Change in Cargo Weight Capacity
Battery Electric and Fuel Cell Electric Trucks



Fuel cell vehicles carry this much additional cargo

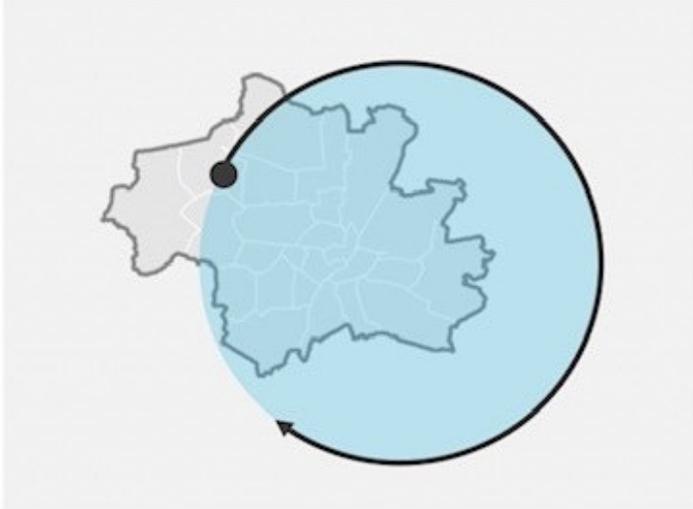
Range, weight-class and route predictability make fuel cell powertrains ideal for trucks



Predictable routes need minimal captive infrastructure to enable zero-emission trucking with FCEVs

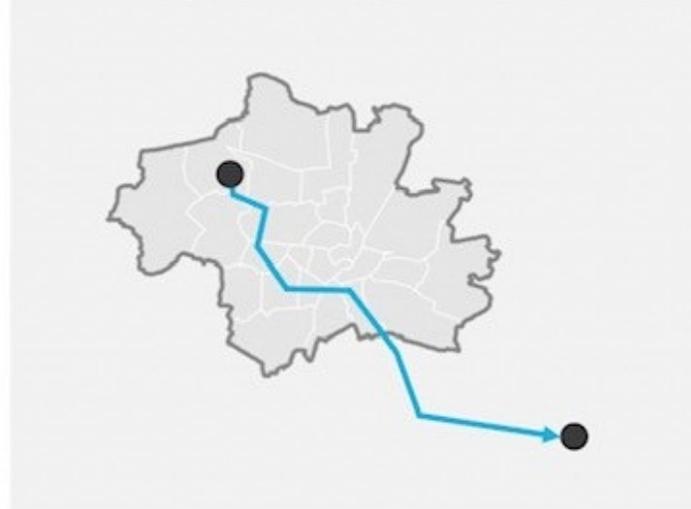
Minimal infrastructure required

Distribution



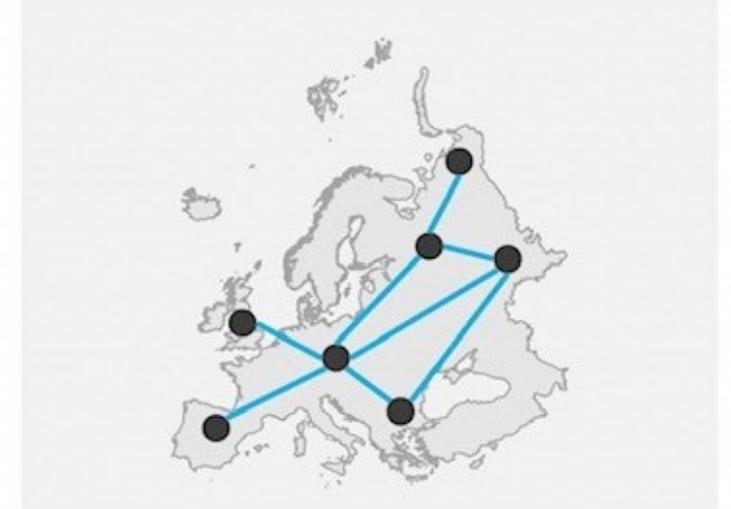
Round trips from depot with typical driving ranges of up to 350 km
Singular hydrogen refueling station required at depot to refuel fleet

Linehaul/point-to-point



Travel between 2 depots, covering a distance between 150-500 km
Hydrogen refueling station required at each depot served to refuel fleet

On demand



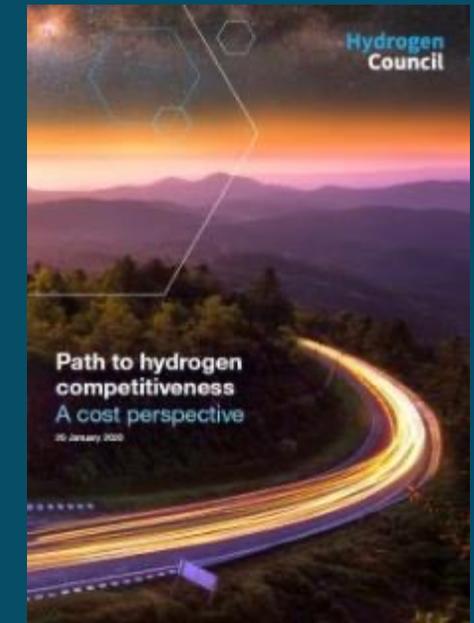
Travel to multiple drop-off locations, covering distances up to 1,000 km
Broad refueling station network required to enable use case

Trucks powered by Ballard

- Over 2,300 urban delivery trucks in service in China (3-9t)
- Class 8 demonstration truck at Port of Long Beach
- UPS Class 7 parcel delivery trucks for California
- 60t truck demonstration project – Alberta
- Refuse trucks in Europe
- 26t, 27t and 44t trucks in Europe (H2 Share, Hylux)
- Mining trucks in China and South Africa



“In less than 10 years, it will become cheaper to run a fuel cell electric vehicle than it is to run a battery electric vehicle or an internal combustion engine vehicle for certain commercial applications.”



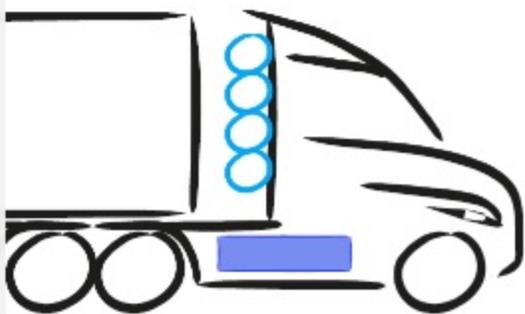
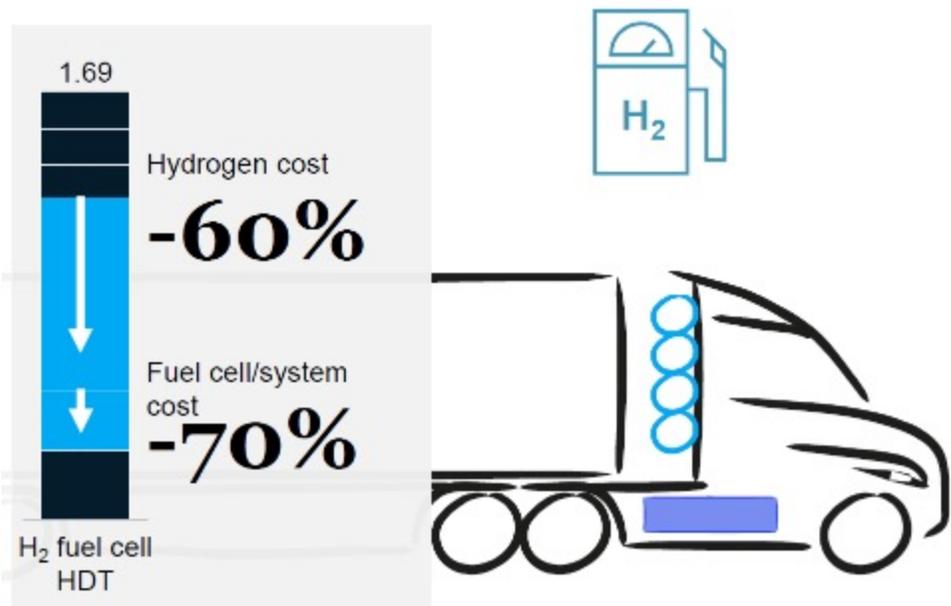
Deloitte/Ballard – Fueling the Future of Mobility (2020)

McKinsey & Company - Path to Hydrogen Competitiveness (2020)



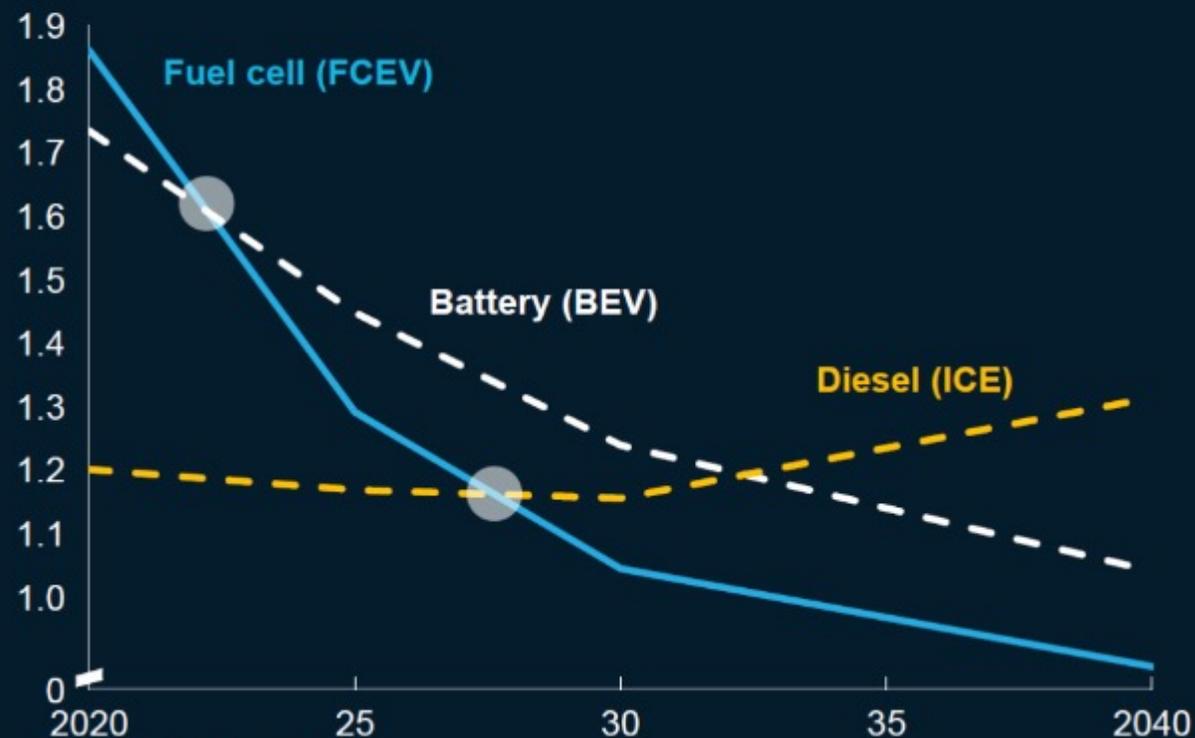
Major cost reduction levers are H2 cost, fuel cell stack and system/tank cost

HDT long haul, TCO in EUR/km, Europe



Total cost of ownership (TCO)¹

EUR / km



¹ HDT / Class 8 truck, with 35 t gross weight

The Ballard logo, featuring the word "BALLARD" in a white, bold, sans-serif font with a registered trademark symbol, set against a solid blue square background.

BALLARD™

The text "Thank you" in a white, sans-serif font, centered on the left side of the image.

Thank you

The website address "www.ballard.com" in a white, sans-serif font, positioned below the "Thank you" text.

www.ballard.com

The slogan "Here for life" in a light blue, sans-serif font, with a trademark symbol, located in the bottom right corner of the image.

Here for life™



Speaker

Traci Kraus

Director, Government Relations
Cummins, Inc.

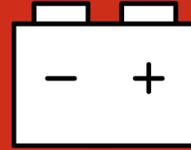


Pathways for Reducing Heavy Duty Transport Emissions

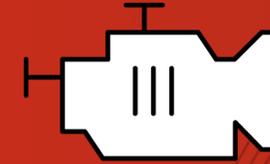
Traci Kraus

June, 2021

Cummins is a
global technology
leader with a
broad portfolio of
power solutions



**BATTERY
ELECTRIC**



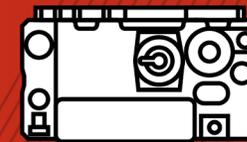
**ADVANCED
DIESEL**



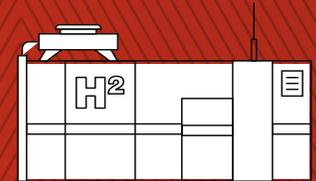
**NATURAL
GAS**



HYBRID



**FUEL CELL
ELECTRIC**



ELECTROLYSIS

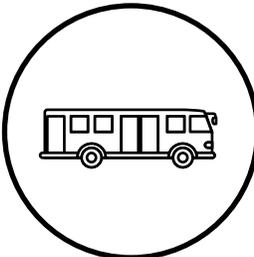
We serve many markets and applications



Heavy-duty
Truck



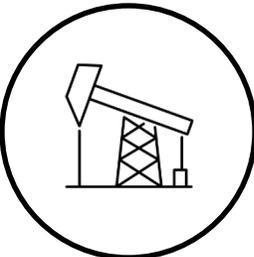
Medium-duty
Truck



Bus



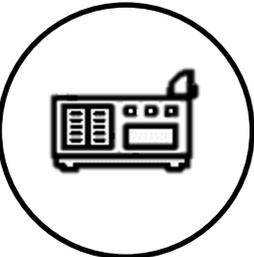
Construction



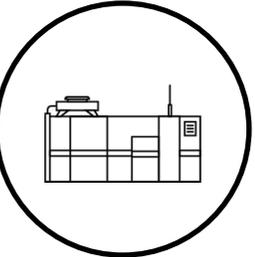
Oil & Gas



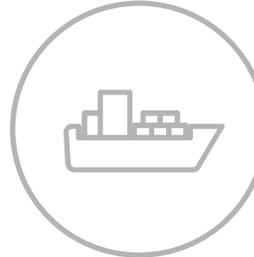
Fire &
Emergency



Power
Generation



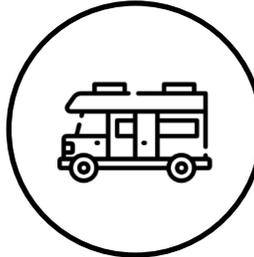
Electrolysis



Marine



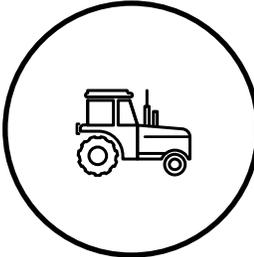
Mining



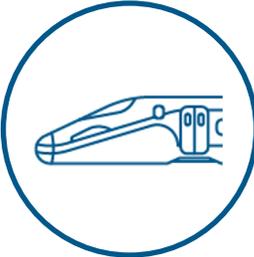
Light-duty Automotive
& Recreational
Vehicle



Defense



Agriculture



Rail

This is not an exhaustive display of Cummins-powered markets. Please refer to cummins.com for the most updated product information.

PLANET 2050 aspirational targets

COMMUNITIES ARE BETTER BECAUSE WE ARE THERE

2050 Targets

- Net positive impact in every community in which we operate
= sum of environmental good > local environment footprint
- Near zero local environmental impact

DOING OUR PART TO ADDRESS CLIMATE CHANGE AND AIR EMISSIONS

2050 Targets

- Customer success powered by carbon neutral technologies that address air quality
- Carbon neutrality and near zero pollution in Cummins' facilities and operations

USING NATURAL RESOURCES IN THE MOST SUSTAINABLE WAY

2050 Targets

- Nothing wasted
 - Design out waste in products and processes
 - Use materials again for next life
 - Reuse water and return clean to the community



PLANET 2050

PROSPERITY | LEADERSHIP | ADVOCACY | NURTURE | ENVIRONMENT | TOGETHER

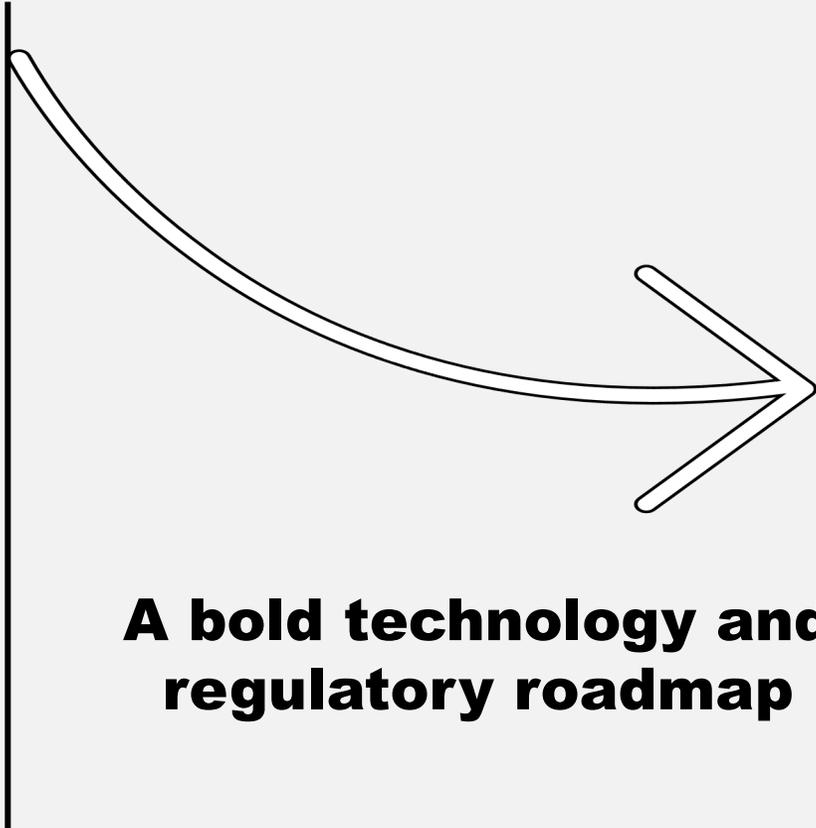
NOTES References to “facilities” relate to all consolidated operations and joint ventures subscribing to Cummins’ Enterprise Environmental Management System. Goals will be periodically assessed for progress and continued practicability

Cummins' Path to Zero emissions

PLANET 2050

PLAN

RESOURCES



A bold technology and regulatory roadmap



Zero emissions

We put our **people and resources** behind the **Path to Zero**

RESOURCES



11,000

of the brightest engineers
innovating for our customers



\$1B

average annual spend on
research and technology



55

global technical centers
to develop our product portfolio

Core Technologies



ELECTRIFIED POWER

Creating technologies and products for commercial battery electric vehicles

- On-highway: transit bus, school bus, medium-duty truck, walk-in van
- Off-highway: construction equipment, terminal tractor, material handling



FUEL CELLS

Creating and integrating components for hydrogen fuel cell electric vehicles and rail

- Electric vehicles: urban transit bus, commercial fleet, utility vehicle, electric lift truck
- Installation: freestanding electrical power plant



HYDROGEN GENERATION

Creating solutions for industrial and commercial hydrogen generation and MW-scale energy storage

- Industrial processes and fueling stations: PEM generator, alkaline hydrogen generator
- Critical and uninterruptible power supply, power-to-gas technology



Reducing well-to-wheel emissions

ALONG THE PATH TO ZERO EMISSIONS



Innovate and
scale low
carbon fuels



Modernize the grid
and decarbonize with
renewable energy



Develop the
hydrogen
economy



Improve efficiency
of converting
energy to useful
power

Complementary measures

SEVERAL FACTORS NEED TO OCCUR TO ENABLE THE ENERGY TRANSITION



Technology



Regulations



Infrastructure
Readiness



Total Cost of
Ownership



®

Questions

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Pembina Institute

pembina.org

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