



Cummins Transition to Hydrogen in Commercial Powertrains

SMMC 2022

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VP SO and Advanced Exploratory Technologies

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**Making people's lives
better by powering a
more prosperous world
requires a healthier planet.**

PLANET 2050

Leveraging our unique skills, experiences, and stakeholder relationships, we are committed to addressing climate change and air emissions, using natural resources in the most sustainable way, and ensuring our communities are better because of our presence in them. We have quantifiable goals for 2030 and visionary longer-term aspirations for 2050.

DESTINATION ZERO

Our strategy to go further, faster to reduce the greenhouse gas and air quality impacts of our products in a way that is best for our customers and all stakeholders.

CUMMINS WATER WORKS

Our initiative to address the global water crisis by strengthening communities through access to sustainable water.

Reducing well-to-wheels emissions

BY INNOVATION OF THE ENERGY SOURCES AND THE POWER SOLUTIONS

ENERGY SOURCES

POWER SOLUTIONS



Innovate and
scale low
carbon fuels



Decarbonize
and improve
resiliency of
the grid



Develop and
mature the green
hydrogen
economy

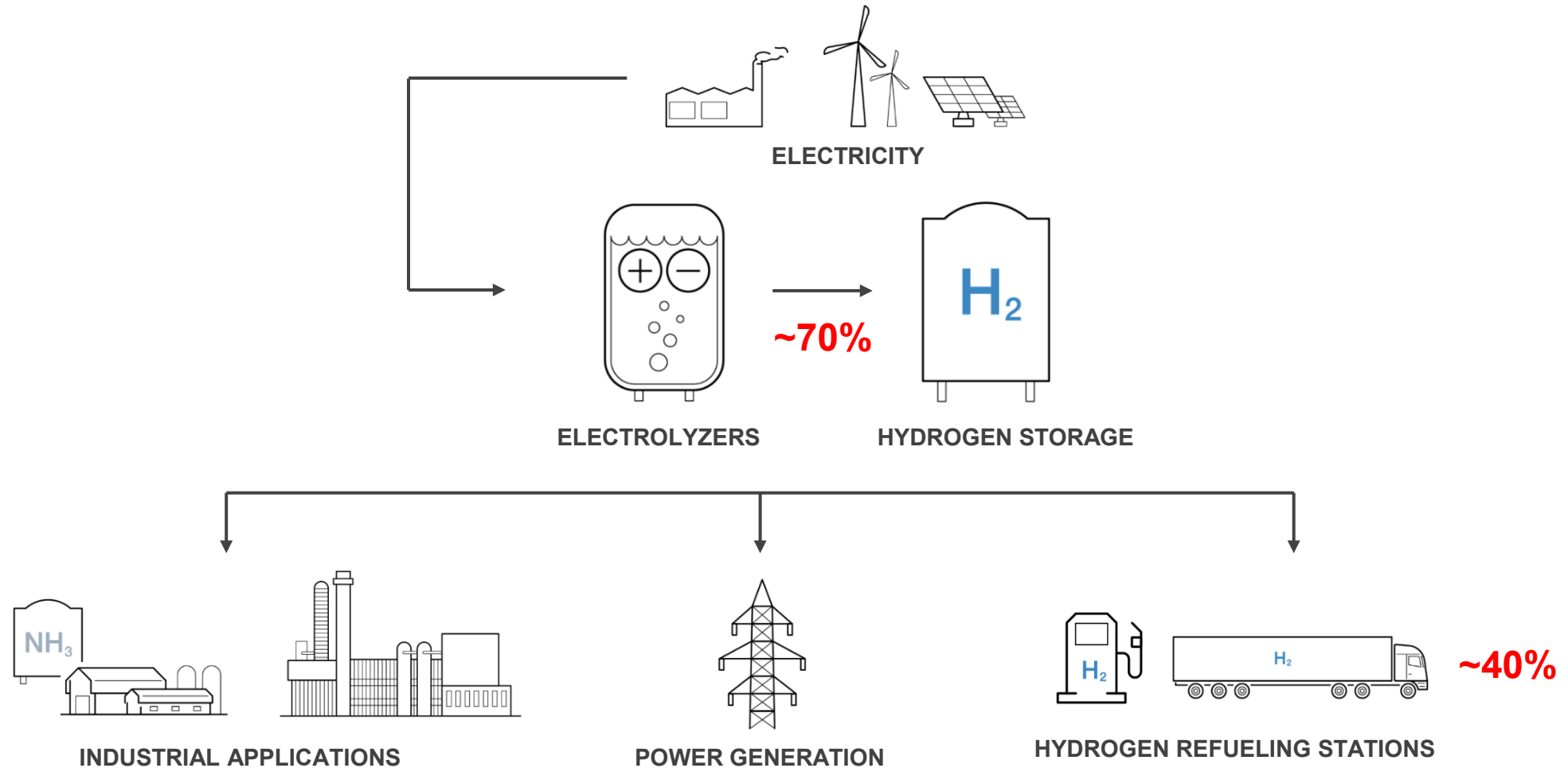


Increase adoption
of fuel cell,
battery electric
and hybrids



Reduce GHGs from
internal combustion
engines

Decarbonizing the Hydrogen Energy Source



Transition to Hydrogen

DRIVERS & ENABLERS



Infrastructure



Economics



Customer
acceptance



Regulations/Incentives

Electrolyzer Platform Roadmap

WE KNOW HOW TO SCALE THE INDUSTRY'S MOST EFFICIENT PEM ELECTROLYSIS

FROM THE FIRST MEGAWATT STACK TO THE LARGEST PEM ELECTROLYZER IN THE WORLD – WE'RE READY TO SCALE TO 1GW



COMMERCIALY AVAILABLE TODAY

QUOTING FOR 2023 PRODUCTION

Fuel Cell Powertrain Improvements

- Fuel cell durability, efficiency, and cost

First automotive commercial product

- Low pressure stack technology



Meet commercial on highway requirements

- High pressure stack technology
- Metal BPP, improved MEA



Develop global platform that is designed for HD on highway, industrial market applications and is scalable

- Further stack improvements
- Max operating temp
- Durability



- Hydrogen storage on the vehicle

- System integration on the vehicle

- vehicle thermal management
- vehicle technology modularity
- Integration of e-Powertrain technology

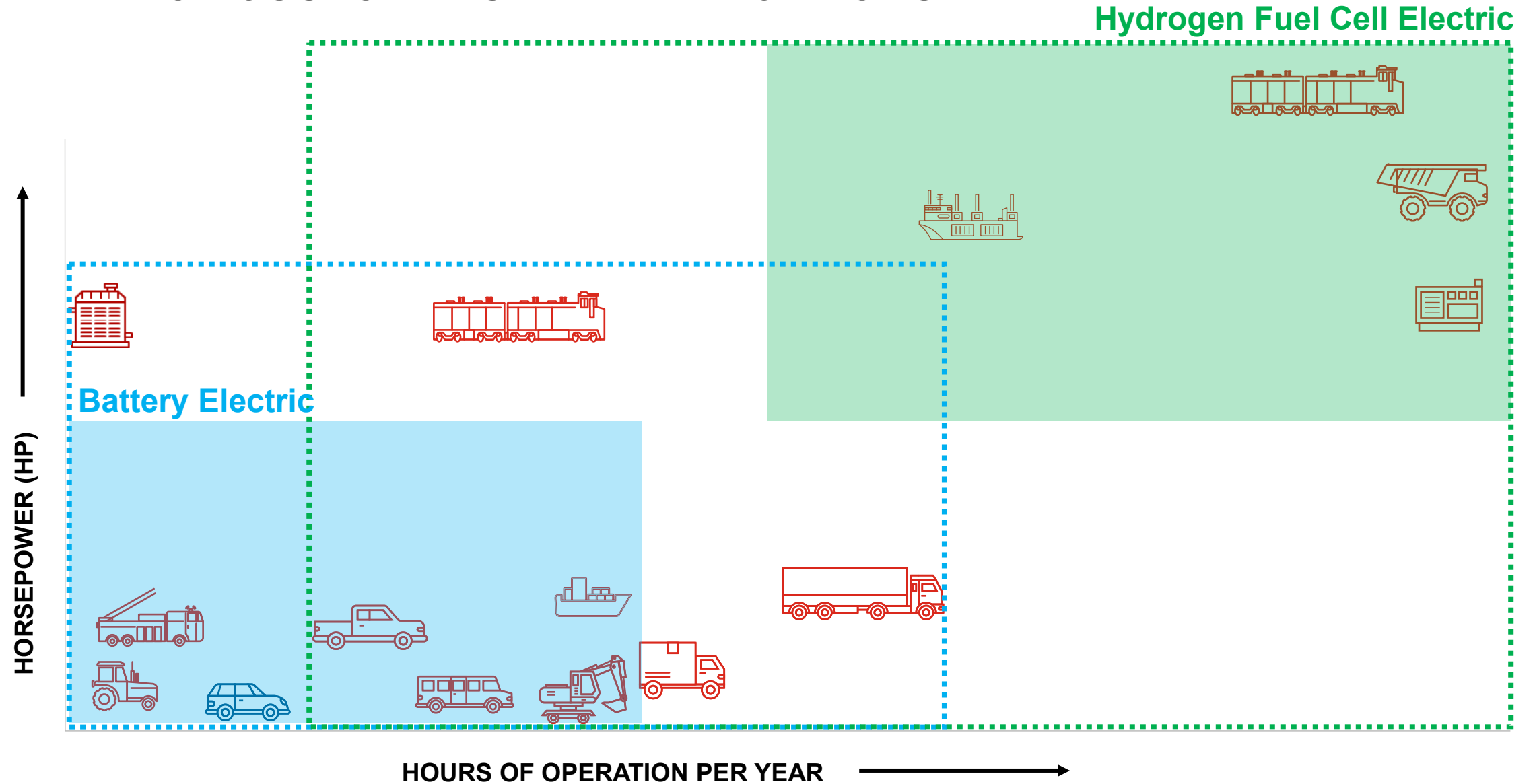


B6.7H HYDROGEN ENGINE

Sep 13, 2022 ■ Gross-Gerau, Germany

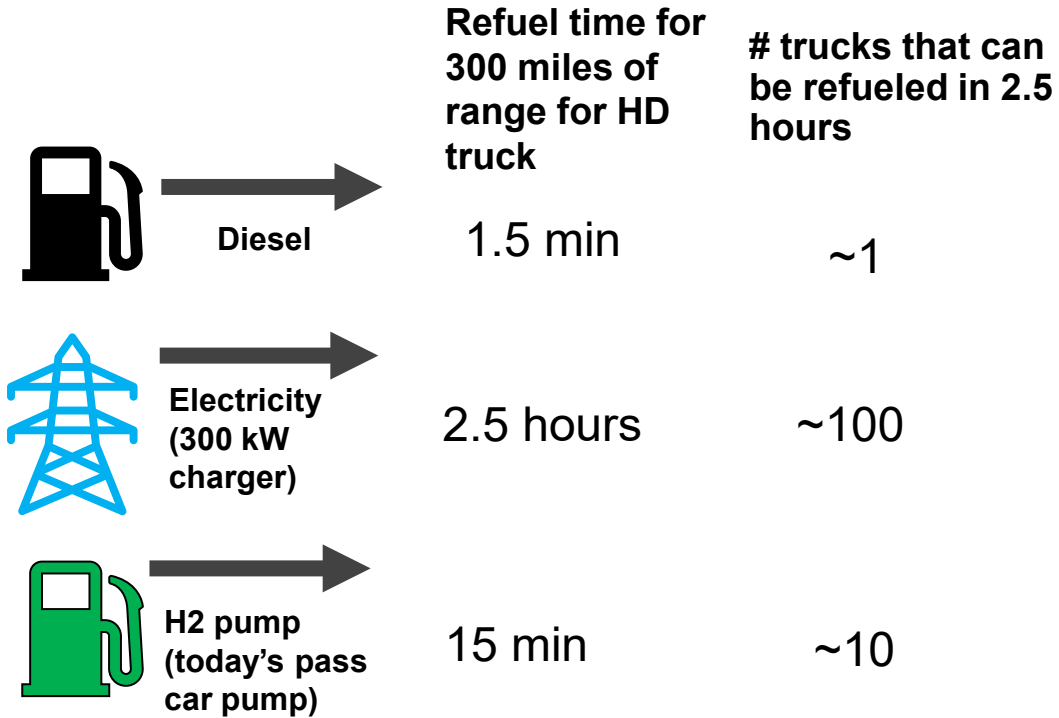


COMMERCIAL VEHICLE & INDUSTRIAL POWER INCLUDES A BROAD ARRAY OF CUSTOMERS AND APPLICATIONS



Hydrogen Highway: Range & Fast Refueling >> Utility & Flexibility

RANGE	Today	2030
BEV Truck	300	500
FC Truck	500	1000



Hydrogen: lower cost zero carbon energy storage

H2 storage system: \$20/kWh, Battery: \$100/kWh
Renewable energy storage / long term storage
More cost effective if duty cycles are variable



Hydrogen Fuel Cell Adoption in HDT

Near term

TCO breakeven with ICE's will be in the early 2030's—ACT/Sustainable Fleets will likely drive ZEV penetration in this decade

Choice between battery power vs hydrogen fuel cell power

battery cost vs fuel cell and hydrogen cost vs charging time

Future cost of diesel/NG operation could pull up TCO breakeven timing

Expect regional variation in adoption




H2 ICE may be a bridge solution

Longer Term






















































FCEV's will be an important platform in HDT

The development of FC technology, hydrogen infrastructure, low hydrogen cost, and regulations will impact timing

Powertrain Diversity – Truck Market

-  Displayed at the show
-  Developing/Researching, not in show display (Indicative)
-  Exists in current portfolio, not in show display

- All major players are diversifying their powertrain plays, but with varying degrees of in-house development vs. industry partnerships
- Along with ZEV development, most OEMs continue ICE R&D to carry in-house HD engine lines through next gen emissions regs (Euro VII, CARB24, EPA27)

Company	Diesel	Natural Gas	H2-ICE	Renewable Fuels	Hybrid	BEV	Fuel Cell
							
							
							
							
							
							
							
							
							
							
							

Summary

The transition to zero emissions commercial vehicles will be complex

Hydrogen is likely to have stronger adoption in HD Truck than other mobile segments

The TCO breakeven point for ZEV's with ICE's in HDT is likely in the early 2030's

Significant improvements in ZEV powertrains are ongoing

Modularity and scalability of powertrain options will impact cost and customer adoption

Regulations, incentives, and ESG initiatives will be impactful and create significant regional variations in the adoption of hydrogen fuel cell powertrains

