



WIVA P&G Knowledge Exchange on Hydrogen Trains

Hydrogen ICE in the Rail Sector – International Trends

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Climate Action, Environment,
Energy, Mobility,
Innovation and Technology



FFG
Promoting Innovation.





1. Introduction
2. Transformation - Challenges
3. Rail – Market Flashlights & ICE
4. Paths, Technologies and Solutions
5. Summary and Conclusion

01

INTRODUCTION

The Bosch Group

Company figures and business sectors

In 2023



91.6

billion euros
sales revenue



427,600

Bosch associates worldwide
at year-end (approx.)



4.6

billion euros EBIT
from operations



470

subsidiaries and regional
companies in more than
60 countries



Mobility Solutions
€ 56.3.3 bn
233,000 associates



Industrial Technology
€ 7.5 bn
34,000 associates



**Energy and Building
Technology**
€ 7.6 bn
34,000 associates



Consumer Goods
€ 19.9 bn
83,000 associates

The Bosch Group in Austria

Company figures and locations

In 2023



1.4

billion euros
sales revenue



3,200

Bosch associates
(1,400 R&D)



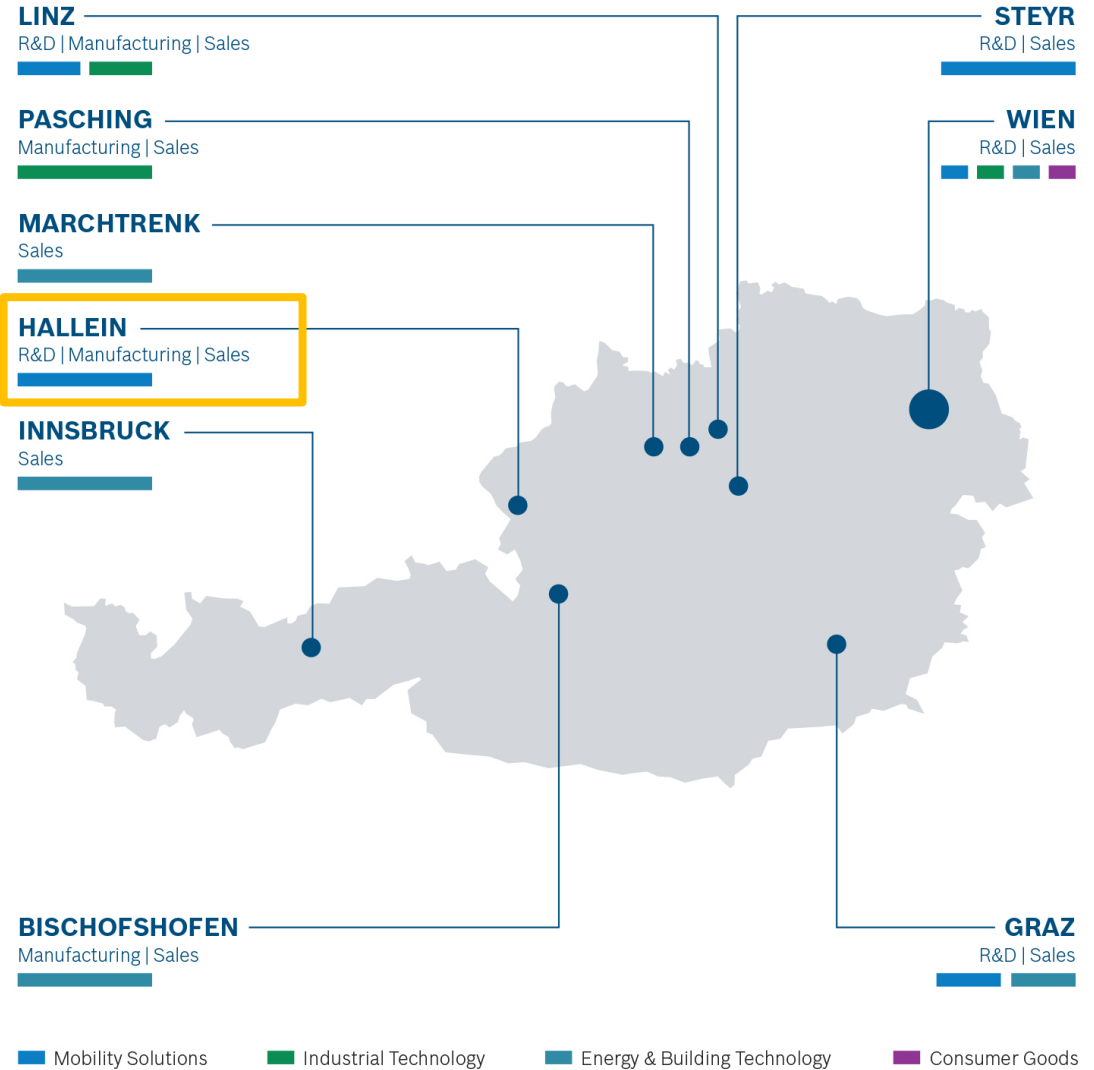
22

million euros
R&D H2 investment



4

development
competence center

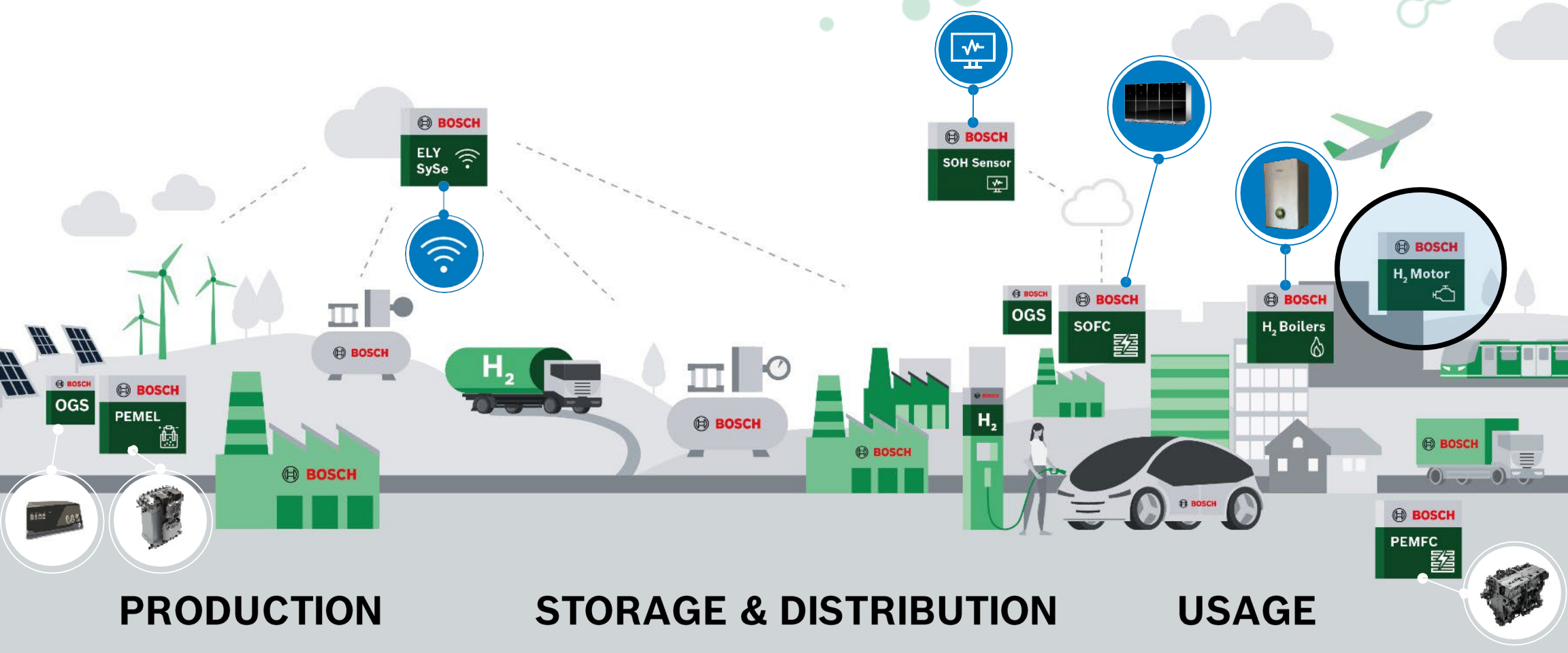


The Bosch Group in Hallein

Business Unit Large Engines | Headquarter Hallein & Plant 2



Bosch and the hydrogen economy



PRODUCTION

STORAGE & DISTRIBUTION

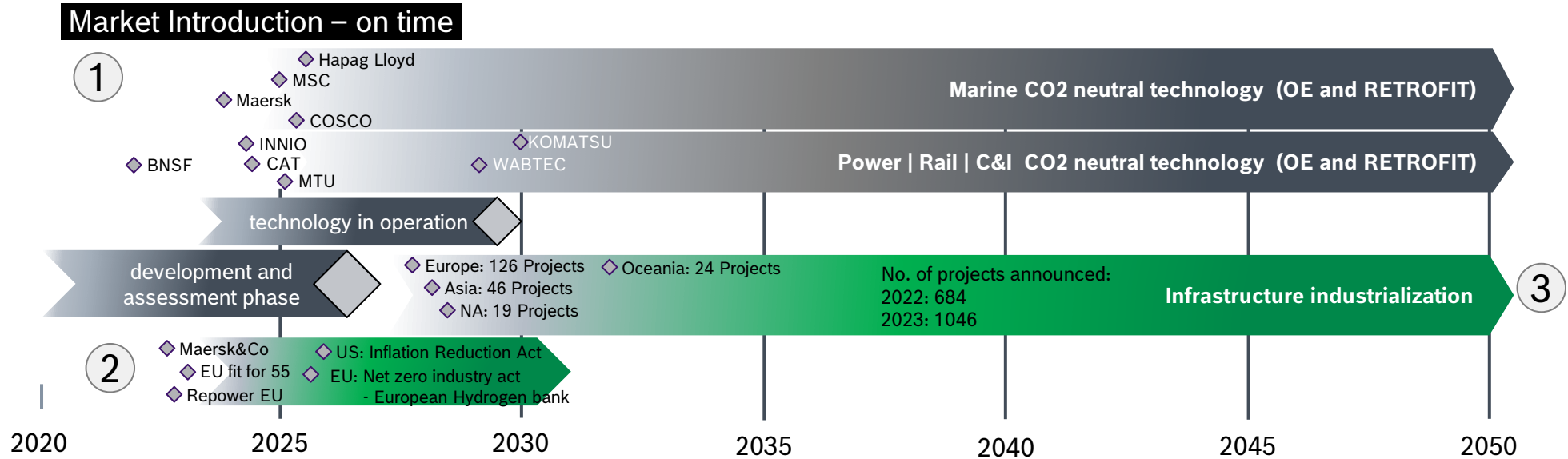
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02

TRANSFORMATION - CHALLENGES

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Transformation – Challenge

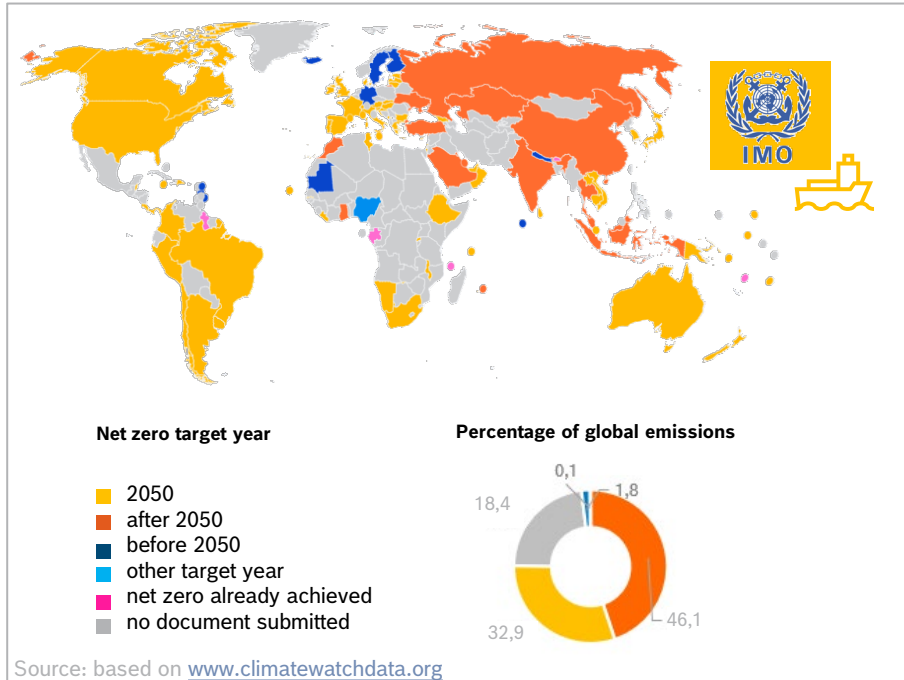


- ① Technology development initiated by lead market players
- ② Legislation framework progressing **BUT** not globally and with pending decisions
- ③ Fuel and Infrastructure with increasing efforts **BUT** pending financial decisions

- The decarbonization technologies are under development for OE and retrofit with multiple demonstrators during the assessment phase
- The industrialization depends strongly on the (local) available infrastructure

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Decarbonization – around the globe



North American Sustainability Goals on Carbon Intensity Reduction

Baseline 2019

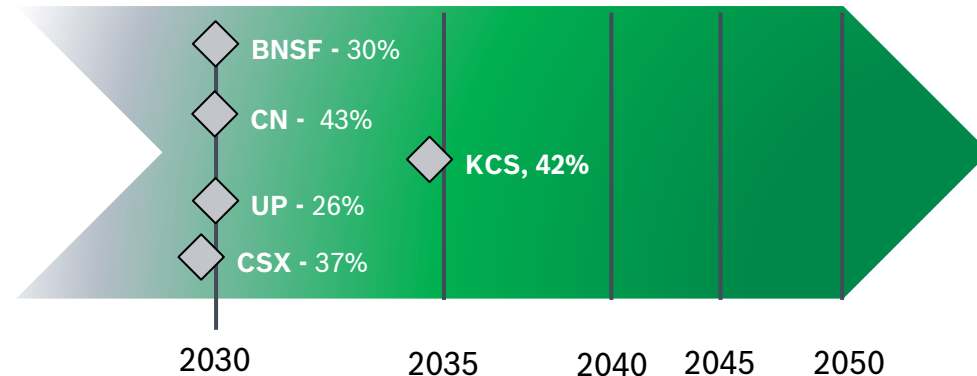
BNSF – Burlington Northern Santa Fe, LLC
 CN – Canadian National
 KCS – Kansas City Southern

Baseline 2014

CSX – CSX Transportation

Baseline 2018

UP – Union Pacific Railroad



- ~40% of ww LE applications (w/o IMO) not yet targeted in terms of CO2 reduction (net zero till 2050)
- Rail operators with ambitious targets around 2030 on the way to net zero till 2050

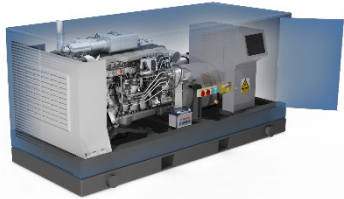
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RAIL – MARKET FLASHLIGHTS & ICE

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Four FIE Application Segments

POWER GENERATION



**Continuous, stand-by,
peaking power**

- Generator Sets
- Power Plants

RAILWAYS

Locomotives

- Mainline
- Shunting



LE: > 560kW

Annual New Builds

Approx. 73.000 in 2023



Vehicles/Machinery

- Construction Machines
- Mining Vehicles
- Oil & Gas mech. Drives

Propulsion / Auxiliary
(Ocean, coastal, inland river)

- Pleasure Boats
- Cruise liner
- Commercial Ships



**Installed Base
/ in Field**

> 1 mio. engines

**Age: up to 30 years and
more**

CONSTRUCTION & INDUSTRY

MARITIME

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Large Engines – HARSH CONDITIONS



Source: depositphotos

Criteria

- Fuel purity
- Air purity
- Durability
- Noise & Vibration
- Emissions
- Efficiency

**Majority of GHG/ Carbon output (>80%)
from Freight locomotive operations**

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RAIL – MARKET FLASHLIGHTS & ICE



Wabtec's goal, Santana said, is to “develop the next generation of zero-emission locomotives. Wabtec has a clear path to power new locomotives—and repower existing locomotives—with batteries, hydrogen internal combustion engines, and hydrogen fuel cells.” The Pittsburgh, Pa.-based company—which traces its roots to inventor George Westinghouse, whose automatic air brake was introduced in the pages of *Railway Age* in the 19th century—is **working with BNSF and the California Air Resources Board to test its battery-electric locomotive**, he testified.

Source: Wabtec

Fuel cells ordered for Canadian Pacific hydrogen locomotive

10 March 2021

CANADA: Ballard Power Systems is to supply the fuel cells for Canadian Pacific's hydrogen locomotive programme, which aims to develop North America's first hydrogen-powered main line freight locomotive by retrofitting fuel cells and a battery storage system to an existing diesel loco.



HVO100 for DB Cargo UK

In a first for the UK, hybrid cars built in the English Midlands will soon be carried to continental Europe via an eco-locomotive that runs on greener fuel made from used vegetable oil

[Read more](#)

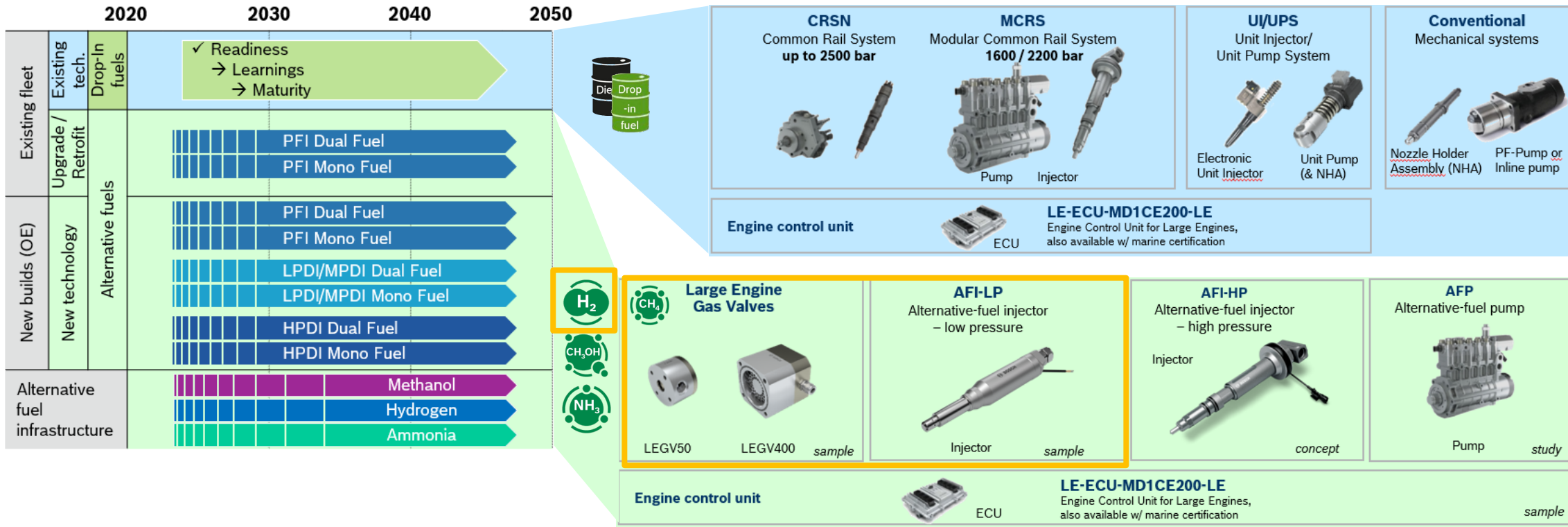


04

PATHS, TECHNOLOGIES and SOLUTIONS

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Decarbonization Paths and Solutions

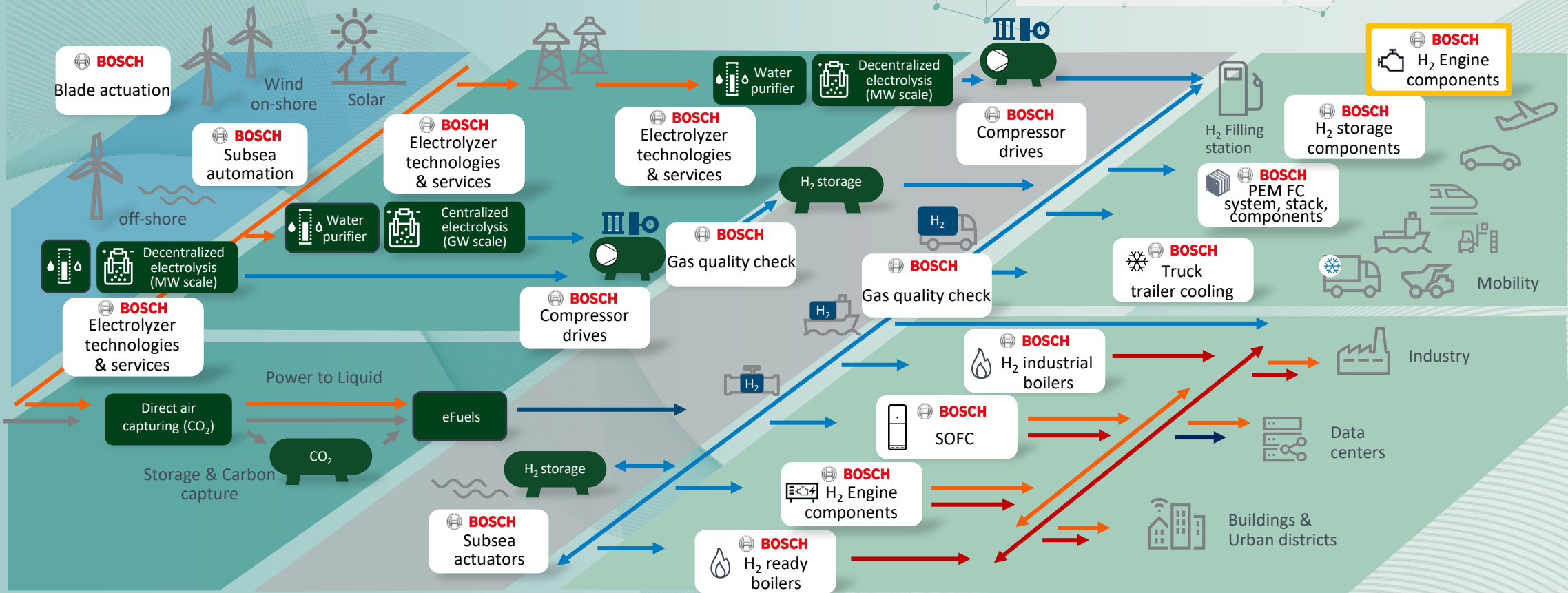


➤ The Bosch portfolio supports an immediate effective CO₂ reduction (drop-in fuels) and the paths to zero carbon (alternative fuels/new technologies) entirely

Hydrogen value chain



- Power generation
- H₂ production
- H₂ distribution / storage
- H₂ usage



— H₂ & derivatives — Electricity — Heat — Cooling — CO₂

PEM FC Polymer electrolyte fuel cell | SOFC Solid Oxide Fuel Cell | Source: RB H₂ map, version 10.07.22

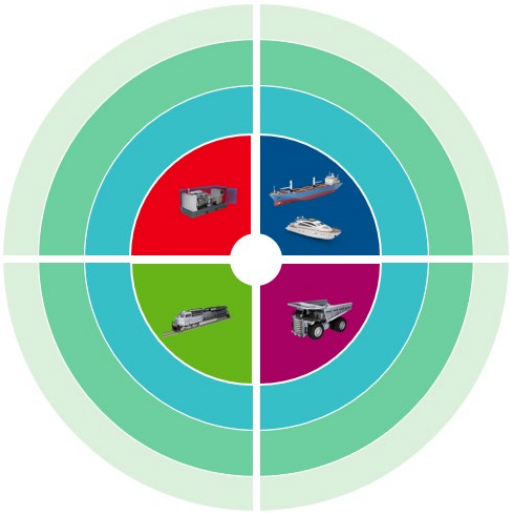


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SUMMARY & CONCLUSION

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SUMMARY & CONCLUSION



- The decarbonization has been started by the introduction of specified drop-in fuels
- The new technologies (PFI, LPDI, HPDI in combination with H₂, CH₃OH, NH₃) are under development
- Depending on the segment and the use case, different preferences are given
- Within the demonstrator/assessment phase a certain consolidation is expected
- The industrialization depends strongly on the available infrastructure
- Bosch focuses on PFI and LPDI (more favorable benefit/effort ratio)

WIVA P&G Knowledge Exchange on Hydrogen Trains
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Thank You for Your Attention

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