THE BOSCH HYDROGEN ECOSYSTEM:

TECHNOLOGIES FOR THE PRODUCTION AND USAGE OF HYDROGEN

BOSCH – MAGMA Advisory Council Meeting – December 12th, 2025

Matt Thorington – Engineering Manager, Hydrogen Electrolyzer Stacks

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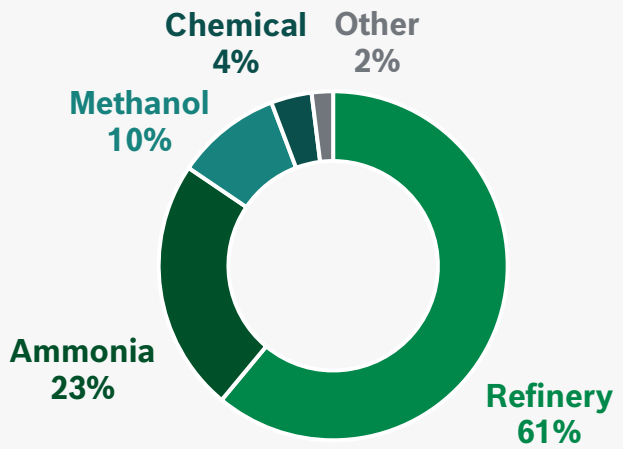
Local Hydrogen, Global Impact

Drivers for Electrolytic Hydrogen in NA – Distributed Demand

Hydrogen demand sectors in NA, representing ~16.7 Mt/a with ~99% from conventional H2 production



1 Mt = million tons

Data reference: Saoradh Enterprise Partners LLC

Strong & growing demand: *Today ~16.7 Mt/a (2025) with ~72% captive onsite production & ~28% merchant H_2. Demand projected to exceed 20 Mt/a by 2030.*

Sector-specific drivers: *Diverse use cases with sector-dependent economics driven by location, off-take demands, size, purity, and utilization.*

Distributed demand: *Numerous industrial and commercial users are widely distributed, with varied needs and limited access to centralized infrastructure.*

Growing fragmentation: *Demand fragmentation will increase as hydrogen adoption expands into new sectors and variable offtakes.*

Fit-for-purpose: *Optimizing fragmented demand requires hydrogen solutions sized to volume needs and tailored to demand profiles for best economics.*

Local-for-local advantages: *Distributed electrolyzers produce hydrogen at the point of use, avoiding costly transport while improving reliability and economics.*

Bosch H_2 portfolio brings in the maximum knowledge span

Production — **Storage & Distribution** — **Usage**

Water purifier

PEM electrolysis stack

Optical gas spectrometer

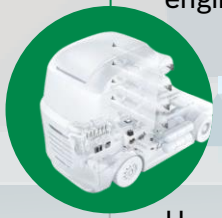
Compact gas compressor

Hydraulic compressor

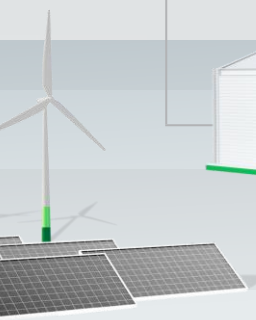
CryoPump

Universal steam boiler

Fuel cell engine



H_2 combustion engine



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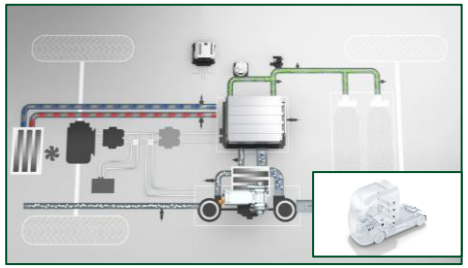
The Bosch Hydrogen Ecosystem
Hydrogen Technologies Overview



PEM Electrolysis Stack

- 1.25 MW maximum power input[1]
- Standardized design for scalability
- ~50 kWh/kg max. efficiency[1,2]
- 23 kg/h H_2 full-load output
- Digital services portfolio available for electrolysis system

Rexroth Cryopump

Stage 1
- Volumetric efficiency 99%
- Reliable performance
- Stay cool function for instant start

Stage 2
- Volumetric Efficiency 95-98%
- Continuous mass flow
- Rapid warm start

System
- Zero boil off during tests
- Direct filling (tube trailers)
- Turndown ratio

Fuel Cell Power Module (FCPM)

- Multiple options from 100 - 300kW
- >10 mil. miles on public roads
- Single set of BoP components lowers costs and integration efforts

H2 Storage System and Fuel Cell Components

- Tank valves & End plug
- Manifolds
- High Pressure Sensor
- Control modules & Software support
- Electric Air Compressor, Anode Recirculation Blower, Hydrogen Gas Injector and Air Valves
- Electrical and mechatronic components, incl. DC/DC, HV fans, inverters, and thermal management

Injection for Hydrogen Engines

- Direct injection system components
- Port injection system components
- On- or Off-Highway applications

1) Beginning of life; 2) At partial load

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Hybrion

PEM Electrolysis Stacks by Bosch

ASME BPVC & CSA/ANSI:B22734

1.25 MW
maximum power input [1)]

maximum efficiency [1),2)]

50 kWh
/kg H_2

23 kg/h
H_2 output at full load

> 32 bar
H_2 output pressure

All values are subject to development activities & provided on a non-reliant basis.

[1)] Beginning of life; [2)] At part load

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Providing optionality to established industrial system integrators

Leading PEM stack technology

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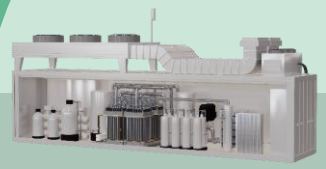
- *Global brand*
- *High credibility*

NEUMAN & ESSER
FEST
AKA Energy Systems
ANDRITZ
TECNICAS REUNIDAS
KYROS HYDROGEN SOLUTIONS



Pietro Fiorentini
HYTER NEW ENERGY ROUTES
Hygreen energy™
NIKKISO
IMI
H2B2 Electrolysis Technologies

End Uses

... to address needs of diverse off-takers

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The Bosch Hydrogen Ecosystem
NA Electrolyzer Project snapshot

BOSCH H2B Electrolysis Technologies

1.25 MW Electrolyzer for industrial application

- Michigan (Bosch HQ)
- 1 Bosch stack, containerized
- Permitts in place, construction ongoing
- Operation early 2026
- H2 for mobility R&D (fuel cells & H2ICE)

BOSCH AKA Energy Systems

1.25 MW Electrolyzer for R&D application

- PEI, Canada
- 1 Bosch stack, containerized
- System and site design in progress
- Operation 2026
- H2 for mobility R&D and refueling

In Development

15 MW Electrolyzer for mobility application, co-located with solar

- California, strategic site on I-5 corridor
- Containerized solution
- Front-end engineering
- Planned operation 2027
- H2 for mobility applications (refueling)
- Future extension beyond 15 MW

Integrating decentralized hydrogen production with distributed demands

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The Bosch Hydrogen Ecosystem

#H2 Landscape at Bosch Plant in Bamberg, Germany

BOSCH FEST

- Bosch Plant Bamberg, Germany
- 2 Bosch stacks, container-ized
- Operational
- H2 for mobility R&D (long-term fuel cell testing)

Reference: Bosch Press Release

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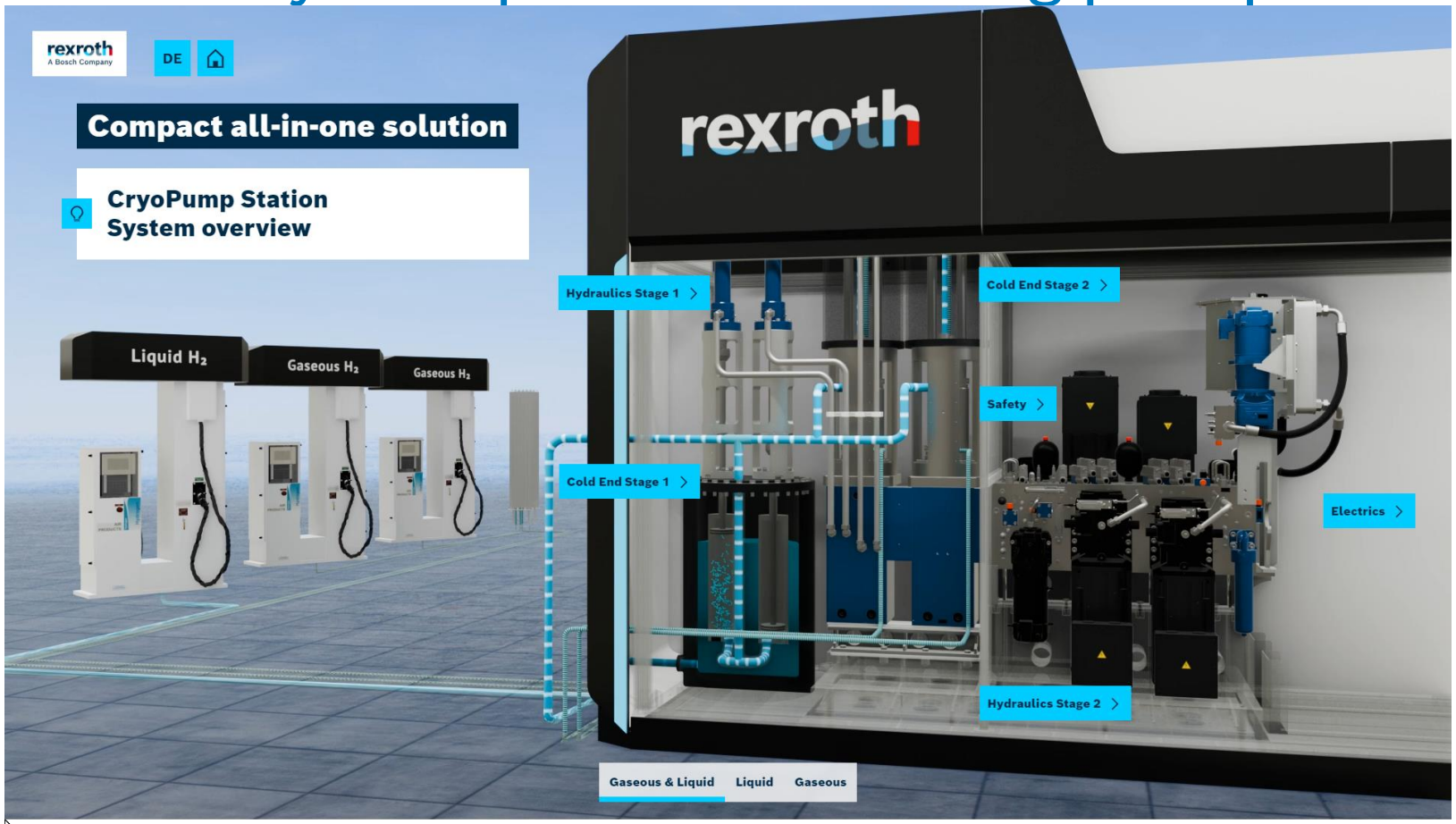
The Bosch Hydrogen Ecosystem

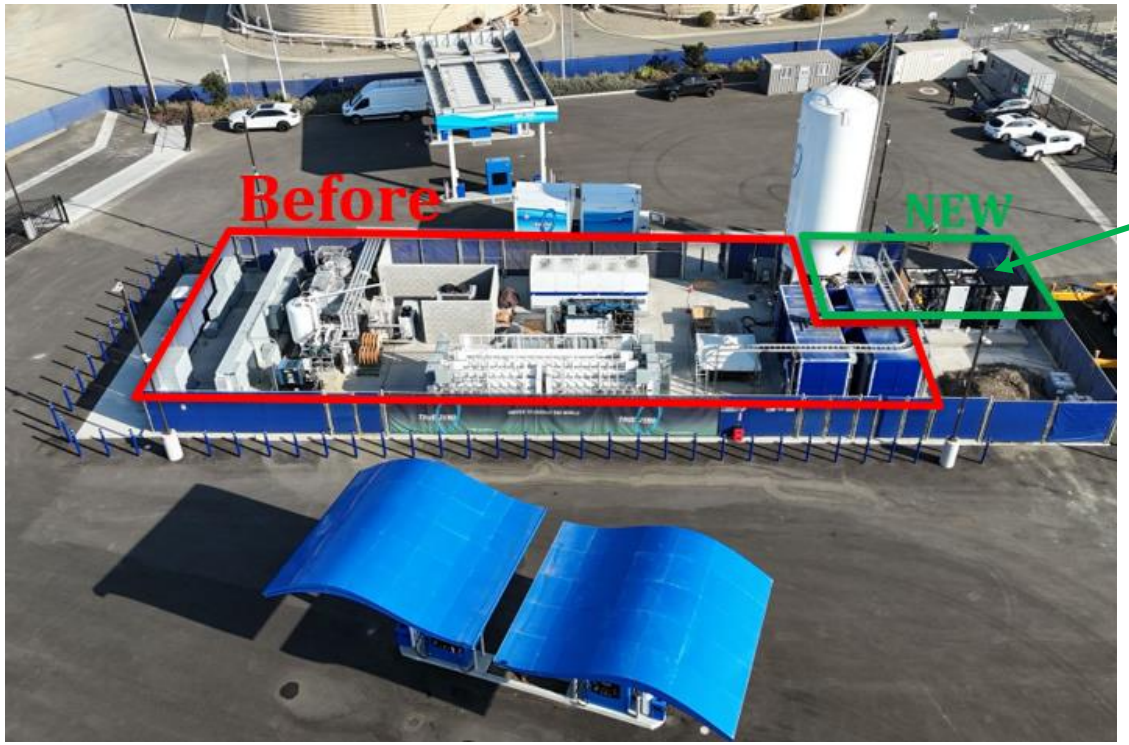
Rexroth CryoPump Station - Working principle

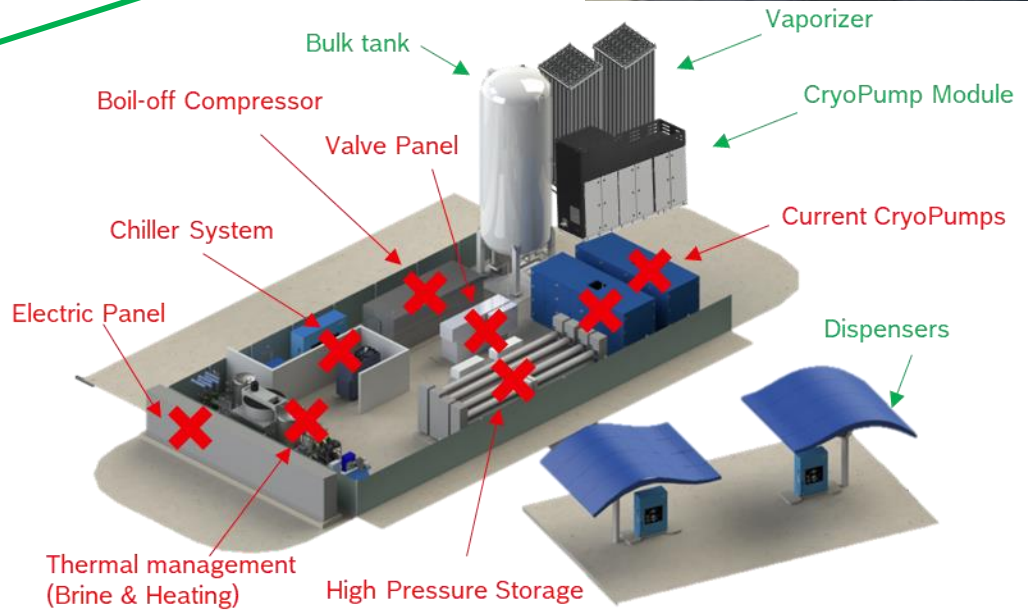


https://virtual-world.boschrexroth.com/cryopump-station/

The Bosch Hydrogen Ecosystem

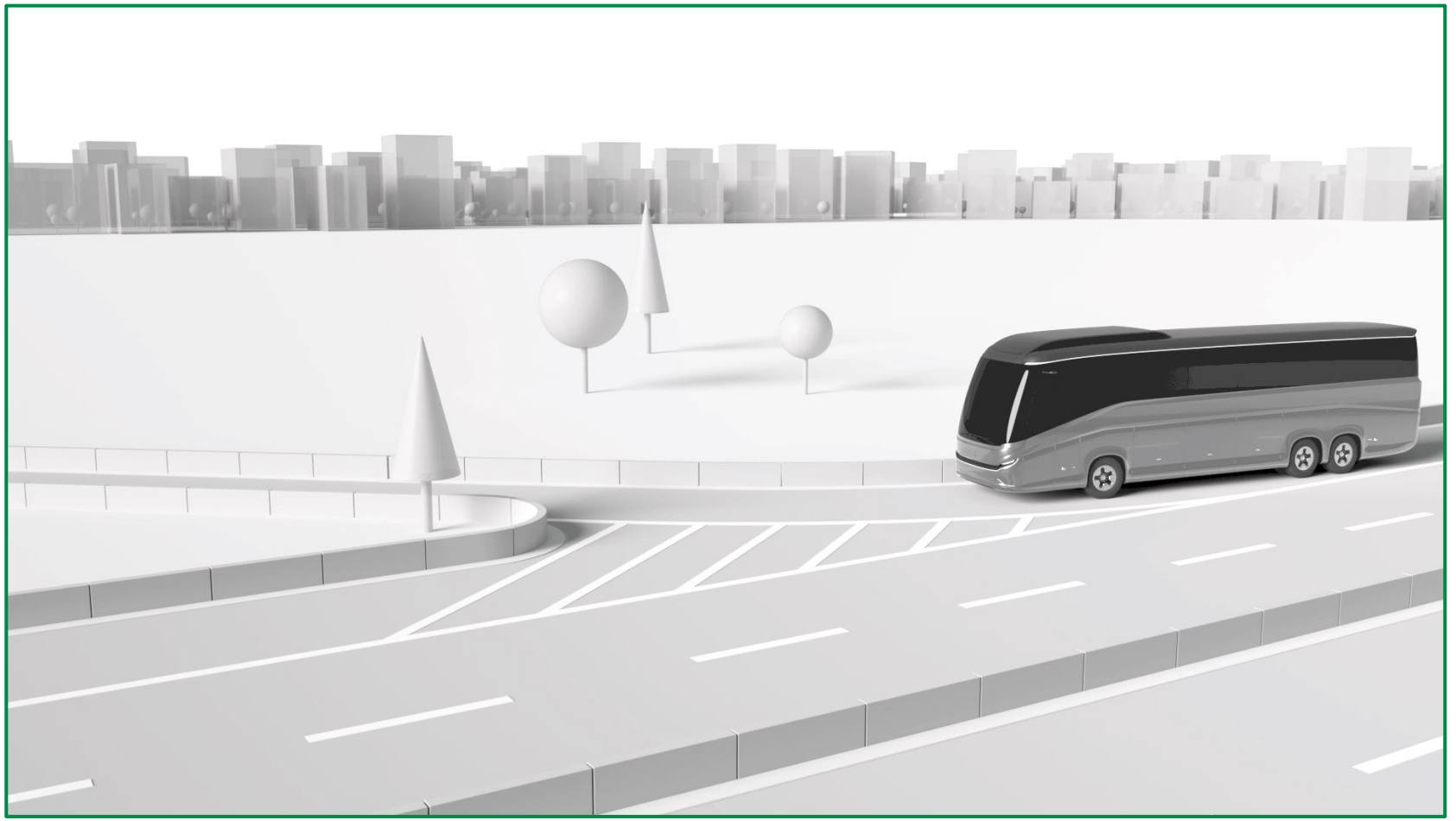
First Cryopump Reference Project – Oakland, CA





The Bosch Rexroth Cryopump reduces the complexity and footprint for a Liquid to Gaseous Station (or Liquid-Liquid), all the while increasing reliability (Items in red can be removed for a new station build)

The Bosch Hydrogen Ecosystem
Fuel Cell Solutions for Every Bus Application



Energy

Fuel cell power module compact 190

Highly integrated and compact system solution for fuel cell-electric medium-duty trucks, vocational vehicles, and intercity buses

One-stop fuel cell system

from a reliable partner with comprehensive automotive experience

Compact design

Highly integrated system solution for for easy integration in engine bay compartment

- Fuel cell power module with horizontal double stack and one set of fuel cell components
- Scope: stacks with anode and cathode submodules, power transfer unit incl. DC/DC, coolant pump, high-voltage heater and certified system controls (hard-/software)
- Stacks and major fuel cell components by Bosch, self-humidification, electric air compressor with turbine
- Reliability and safety according to automotive standards
- Automotive software interface (e.g. CAN communication and diagnosis)
- Applicable to medium-duty trucks, vocational vehicles, and intercity buses

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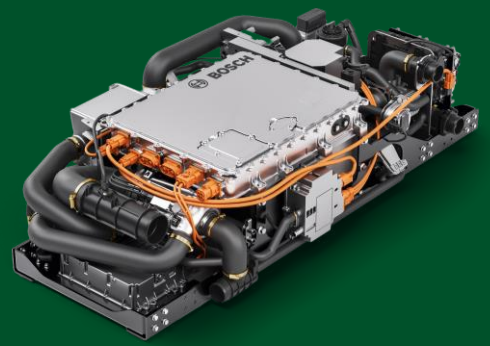
Energy

Fuel cell power module compact 100

Highly integrated and compact system solution for fuel cell-electric city buses



One-stop fuel cell system

from a reliable partner with comprehensive automotive experience

Compact design

Highly integrated system solution for easy installation in city bus rooftop applications

- Fuel cell power module with horizontal single stack and one set of fuel cell components
- Scope: stack with anode and cathode submodules, power transfer unit incl. DC/DC, coolant pump, high-voltage heater and certified system controls (hard-/software)
- Stack and major fuel cell components by Bosch, self-humidification, electric air compressor with turbine
- Reliability and safety according to automotive standards
- Automotive software interface (e.g. CAN communication and diagnosis)
- Applicable to 12-18 m city buses or similar applications

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Energy

Fuel cell power module compact 300

Highly integrated and compact system solution for fuel cell-electric heavy-duty long-haul trucks

One-stop fuel cell system

from a reliable partner with comprehensive automotive experience

Compact design

Highly integrated system solution for easy integration in fuel cell-electric commercial vehicles

- Fuel cell power module with horizontal double stack with one set of fuel cell components
- Scope: stack with anode and cathode submodules, power transfer unit incl. DC/DC, coolant pump, high-voltage heater and certified system controls (hard-/software)
- Stacks and major fuel cell components by Bosch, self-humidification, electric air compressor with turbine
- Reliability and safety according to automotive standards
- Automotive software interface (e.g. CAN communication and diagnosis)
- Applicable to heavy-duty long-haul trucks

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The Bosch Hydrogen Ecosystem

Hydrogen Engine (H2ICE/H2E) for CV Applications

CO_2 & Emissions

Direct CO_2 sources

~700 g/kWh

Diesel → > 99% → H_2 ≤ 2-5 g/kWh

No relevant influence on air quality

Same order of magnitude as fuel-cell or battery electric driven powertrains

Brussels 26. April 2024

HDV CO_2-regulation

Definition of ZEV:

BEV, FuelCell and H2E

Synergies

Production & assembling

- Established development and production processes
- Re-use of existing production facilities
- Use of existing service concept
- High resiliency against critical raw material- and global supply chain issues

Transformation speed

Activities worldwide

In Series dev.	*In acq.*	*Study*
In Series dev.	*In acq.*	*Study*
Increased # of Studies		
Study		

Major Markets

Europe & India

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The Bosch Hydrogen Ecosystem

What are currently the **biggest challenges** in the H2 market, business and projects?

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The Bosch Hydrogen Ecosystem

Ongoing activities for improved cost and performance

Cost

- Less precious materials
- Design optimizations
- Cost-effective production processes

Durability

- Design optimizations
- Optimization of electrochemical & material degradation & mechanical stability

Efficiency

- Voltage losses
- Faraday losses

WELCOME TO THE NEW H_2

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NEUMAN & ESSER
FEST
AKA Energy Systems
ANDRITZ
TECNICAS REUNIDAS
KYROS HYDROGEN SOLUTIONS

H2 Ready!

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HYTER NEW ENERGY ROUTES
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NIKKISO
IMI
H2B2 Electrolysis Technologies

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