FREUDENBERG
Fuel Cell e-Power Systems

Technical Expertise meets Power to Industrialize

Dr. Manfred Stefener
Managing Director

FREUDENBERG
INNOVATING TOGETHER

Technical Expertise meets Power to Industrialize

LONG-TERM EXPERIENCE

> 170 years History

HOLISTIC UNDERSTANDING

Material & Design Know-How

POWERFUL GLOBAL COMPANY

> 10 bn € Turnover

STRATEGIC FC COMMITMENT

Significant Budget

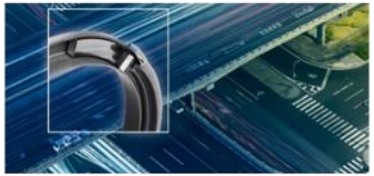
DEDICATED TO INNOVATION

~ 3.3 bn € Turnover

With products < 4 years

Freudenberg's business groups

Groups with fuel cell products since the 90's



Sealing Technologies €2.3bn

Performance Materials €0.9bn

Filtration Technologies: €0.4bn

Vibracoustic €2.1bn

Home & Cleaning €0.9bn

Chemical Specialties €1.1bn

Oil&Gas Technologies: €0.1bn

Eagle Burgmann €0.8bn

Medical €0.2bn

Other Businesses: < €1 bn

Battery & Fuel Cell

New Business Group (04/2022)
Battery & Fuel Cell Systems (BFC)

Freudenberg & Fuel Cell:
A success story of product innovation since 1995

The company committed itself to Fuel Cells as sustainable and forward-looking technology at an early stage

Freudenberg Filtration Technologies

Freudenberg Sealing Technologies

Freudenberg Performance Materials

NO MAJOR FC sold in market today without significant Freudenberg content.
Complete transfer of this long-term expertise to our FC systems for heavy-duty applications

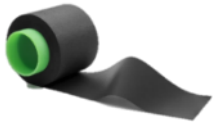
Large-scale industrialization of FC component GDL already realized – High volume supply in all market segments

- Materials designed to **meet all operative requirements** in hydrogen & direct methanol fuel cells
- Proprietary **nonwoven technologies** result in very high product quality
- **Fully industrialized** production lines meeting international and automotive **QM standards**

Just received the **IPCEI nomination ~180 m €**

Series Plant **Multi-GW-Level**

- "Elastic" GDL design with **smooth and secure** fit to membrane and superior contact to electrode
- **Flexible** product characteristics
- High volumetric power density due to **thin GDL** (<100 µm available)



- Homogenous and flawless GDL surface enables **easy processing** with higher catalyst utilization and longer MEA lifetimes
- Superior **mass transportation characteristics** allowing operation at higher current densities
- **Stack performance increase** by customized MPL coating development

HIGH VOLUME PRODUCTION on component level already realized within Freudenberg's global production footprint – Production capacities on Gigawatt-level in place

Freudenberg Combined Long-Term Component Experience
with targeted acquisitions to enter SYSTEM BUSINESS

BATTERY & FUEL CELL

TRUCK & BUS

RAIL & CONSTRUCTION

MARITIME

Fuel Cells designed for use **in heavy-duty system** with the highest **lifetime, quality and durability requirements** – Lifetime passenger car (5 - 8,000 h) vs. heavy-duty **(>35,000 h)**

Maximize Economies of Scale in Heavy-Duty Markets

MARITIME

METHANOL LNG HYDROGEN

TRUCK & BUS

HYDROGEN

Cruise
~60 MW

Yacht
~10 MW

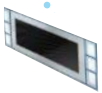
Truck
>100 kW

City Bus
>60 kW

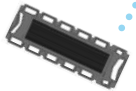
BoP +
Reformer +
Battery

Balance of Plant
(BoP) + Battery

MODULAR SCALABLE STACK
True Heavy-Duty



Integrated MEA



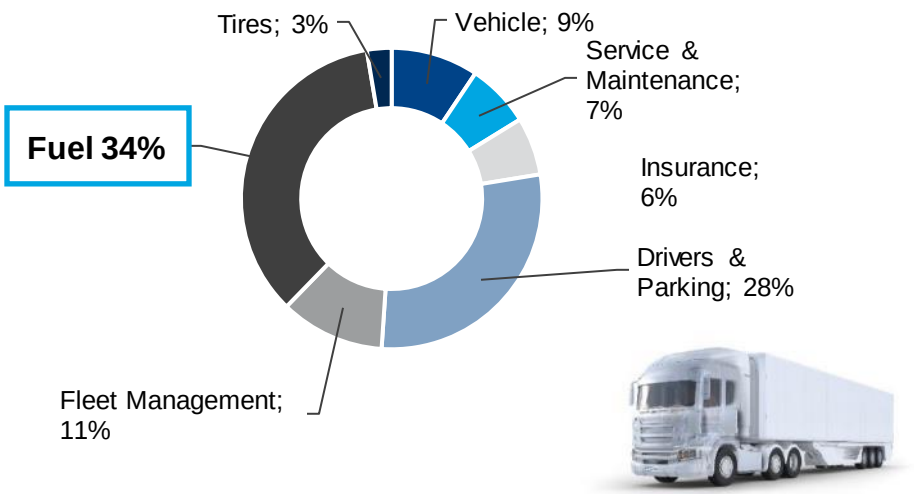
BPP

Heavy-duty dedicated **strategy of identical parts** combined with **deep vertical integration** for key components Fuel Cell unleash **maximum economies of scale**

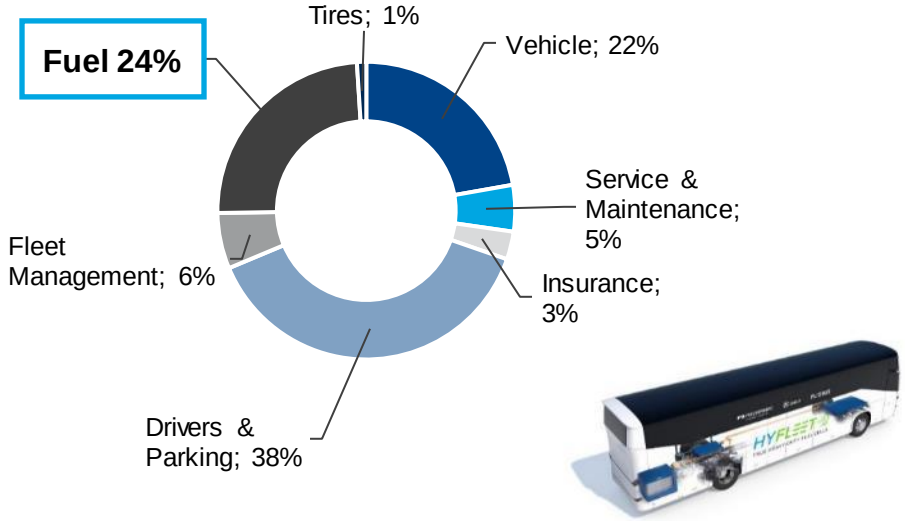
UNIQUE VERTICAL INTEGRATION

Total Cost of Ownership is the Key Criteria in Heavy-duty

TCO STRUCTURE TRUCK



TCO STRUCTURE COACH



EFFICIENCY → Fuel consumption, strongest leverage for Customer Value Add

Freudenberg targets true Heavy-duty designs
for best Total Cost of Ownership

TRUCK & BUS

Heavy-duty tailored

Lifetime target
> 35,000 hours

Deep Vertical Integration

Control Point for Technical Performance & Cost

Superior Efficiency for best OPEX

Efficiency target > 50 %
@ nominal power on system level[1]

Stack designed for
High Volume Production

Control Point for Quality & Cost

1 Consideration of complete FC-BoP including DCDC, Compressor, LT and HT cooling pumps

Example USPs: Proprietary catalyst production and a Multi-component approach for complete MEA7

UNIQUE VERTICAL INTE-GRATION ON CELL LEVEL

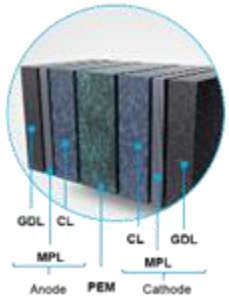
To drive cost, quality and performance

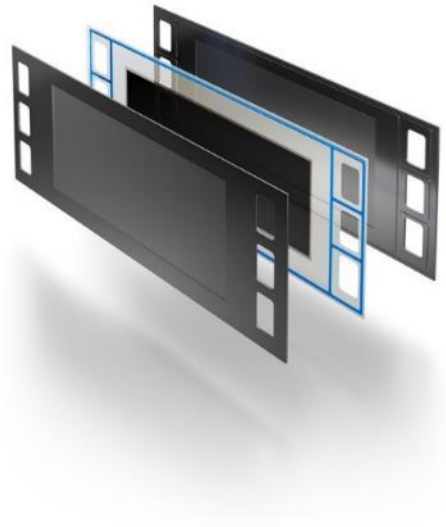
PROPRIETARY CATALYST PRODUCTION

Combining low-cost production with superior efficiency already on cell level

HEAVY-DUTY CELL CONFIGURATION

Uniform Cell Parameters for extremely prolongated degradation



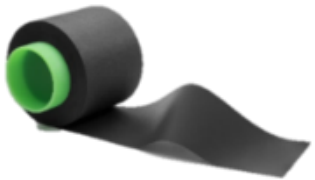


COMPLETE MEA7 – MULTI-COMPONENT PART

Reliable protection and integration of all MEA layers; no sophisticated assembly necessary

ROLL-TO-ROLL PROCESSES – COMPLETE MEA

Low production cost and easy scalability



GDL: Gas Diffusion Layer, **MPL:** Micro Porous Layer,
CL: Catalyst Layer, **PEM:** Proton Exchange Membrane

MAJORITY OF INDUSTRY focuses on system configuration and stack assembly, but deep vertical integration and industrialization ability in electrochemistry will drive future competition

HyFleet – A holistic approach from true heavy-duty technology development to large-scale vehicle deployments

HYFLEET
TRUE HEAVY-DUTY FUEL CELLS

Phase 01
<2024

HyPerform
Technology development
“True heavy-duty”

LIFETIME & EFFICIENCY FOR BEST TCO

Phase 02
2024 – 2025

HyCoach
Large-scale technology demonstration

FLEET DEMONSTRATION >50 COACHES

Phase 03
2026 – 2030

HyScale
International scale up

COMPLETE FLEET TRANSITION

FLIXBUS ZF FREUDENBERG
INNOVATING TOGETHER

Thank you for your attention!