



## FREUDENBERG e-Power Systems

### Maritime Fuel Cell Systems with integrated fuel reforming

October 10<sup>th</sup>, 2023

Dr. Manfred Stefener

# Who we are: A global technology champion with long-term focus

## Freudenberg Business Groups



**e-Power Systems**  
HD Battery & FC Systems



**Sealing Technologies**



**Vibracoustic**



**EagleBurgmann**



**Performance Materials**



**Medical**



**Home & Cleaning  
Solutions**



**Chemical Specialties**



**Oil & Gas Technologies**



**Filtration Technologies**



**Japan Vilene Company**

## Key Facts Freudenberg

**> €11.7bn**  
sales

**> 5%**  
R&D quota

**~ 60**  
countries

**> 50,000**  
employees

**> 50%**  
equity

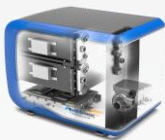
**> 170**  
years history

# Freudenberg Combined Long-Term Component Expertise

## Complemented by targeted acquisitions to enter FC system market

### Business Group e-Power Systems

#### Freudenberg Fuel Cell e-Power Systems



#### Freudenberg Battery Power Systems



### TRUCK & BUS



### MARITIME



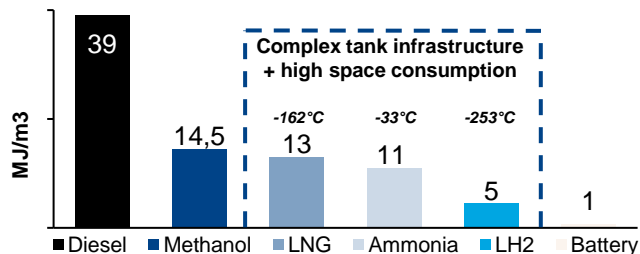
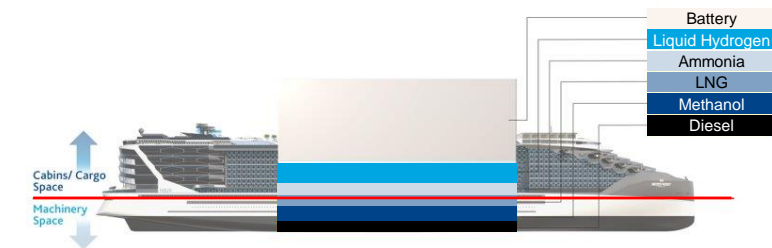
Fuel Cells designed for use  
**in heavy-duty systems**  
with the highest **lifetime**,  
**quality and durability**  
requirements

Lifetime heavy-duty system (**>35,000 h**) vs.  
passenger car (5 - 8,000 h)

# Target Market Maritime

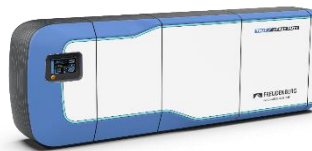
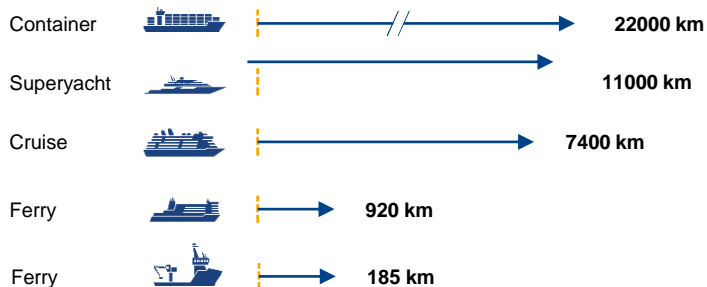
Pure hydrogen as energy storage is no option for most maritime segments

## STORAGE SIZE REQUIRED TO ACHIEVE SAME RANGE



Green Methanol has best usable space ratio in maritime

## RANGE REQUIREMENTS



Fuel Cell Systems with integrated fuel reforming meet maritime range requirements & best TCO

# Strong partnership with power to industrialize in large-scale

## Project HyCruisE

Development of a large-scale PEM fuel cell system with integrated fuel reforming for the LNG/Syngas fuel type in the power class 500 kW.



### Electronic Module

Electrical Infrastructure  
+ Control System /  
Safety

### Fuel Cell Modules

Stacks + Balance of Plant  
Components



*Illustrative image*

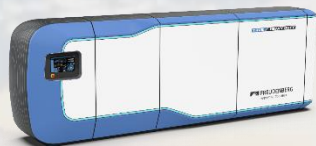
### Hydrogen Supply Module

- Media Interfaces
- Fuel Reformer



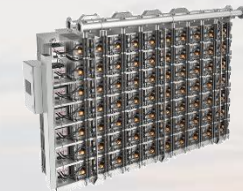
# The Future is happening

## Large-scale demonstration project within a strong consortium



**4 MW** Freudenberg Fuel  
Cell - **LNG 500 System**

**1.6 MWh** Freudenberg  
**Batterie System**



Royal  
Caribbean  
Group

**SILVER SEA – Evolution Class**  
First ship class with  
carbon-neutral hotel load

**2027+**

**CO<sub>2</sub> neutral  
vessels**

**Powered by Fuel Cell  
and Batteries only**



2024

2025

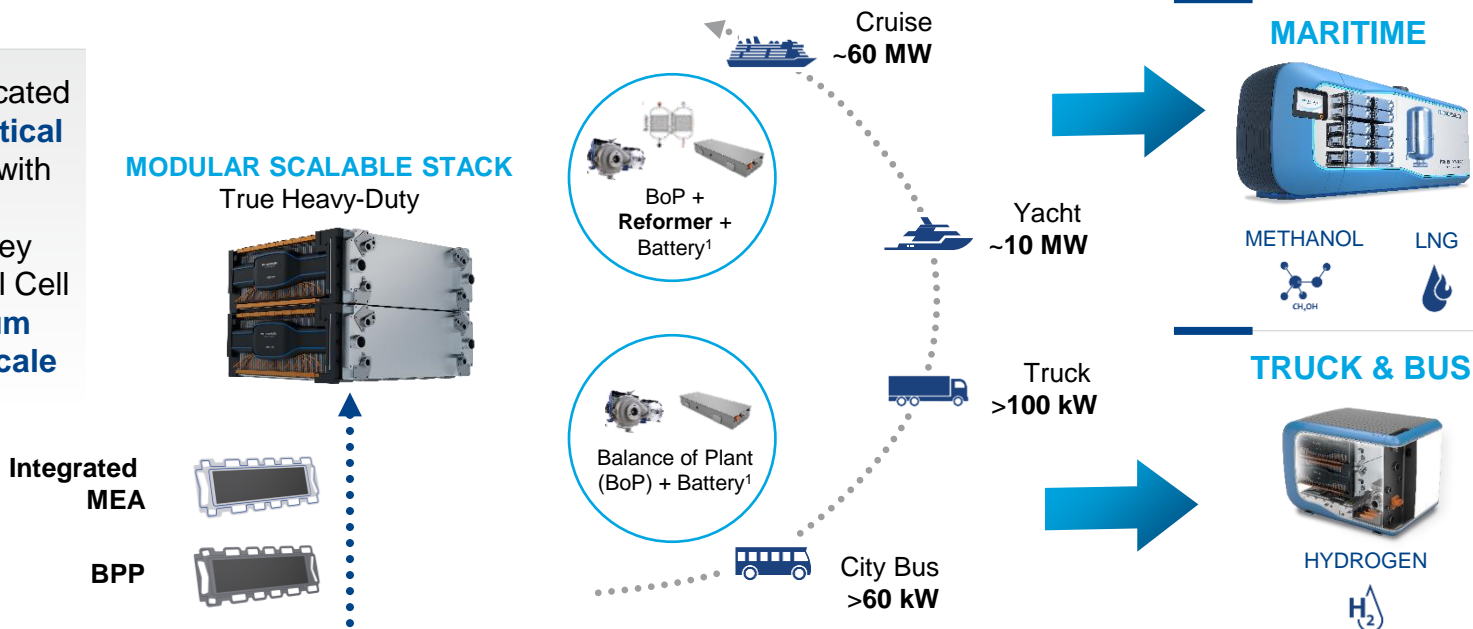
2026

2027

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# Maximize Economies of Scale in Heavy-Duty Markets

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



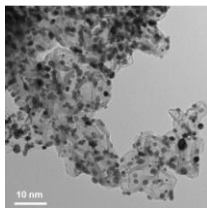
FEPS lifetime and efficiency optimized technology optimized for various heavy-duty segments like deep-sea vessels

# Key Success Factors for True Heavy-Duty Fuel Cells

## Freudenberg USPs

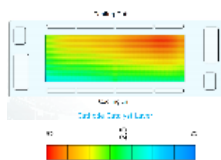
### PROPRIETARY CATALYST PRODUCTION

Significantly better degradation results than leading market players  
35.000 - 50.000 h lifetime expected



### STACK DESIGN COMPETENCE FOR ADVANCED LIFETIME

Temperature range <6K and extremely low pressure drop to achieve true heavy-duty lifetimes and meet **highest efficiency** targets



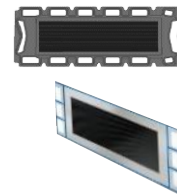
### CERTIFICATION AND REGULATION COMPETENCE

Maritime Safety Concept fully in line with current IGF codes.  
**Type approval already achieved for MeOH100**



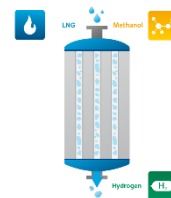
### INTEGRATED MEA AND HEAVY-DUTY BPP

Durable and low-cost cell design validated - testing of new "SMARTR" generation already started



### MARITIME TECHNOLOGY: INTEGRATED FUEL REFORMING

Efficient gas process proven:  
CO values <10 ppm  
Allows fuel flexibility for customers



### PROCESS INNOVATIONS TO REDUCE COST

Implemented **pilot manufacturing line with 60 MW/a**  
Including process innovation.  
Transition of patented manufacturing process into roll-to-roll process ongoing







Thank you for  
your attention!