Proton Motor Fuel Cell GmbH

Manfred Limbrunner

Director Sales & Marketing / Member of the Board

Fuel Cells · Power Systems

Proton Motor Power Systems PLC

Only European manufacturer of long life time PEM fuel cell stacks and fuel cell systems for high power applications

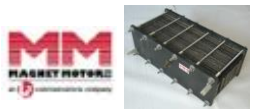
Proton Motor Fuel Cell GmbH:

Located:	Puchheim (Munich area)
CEO:	Dr. Faiz Nahab
Founded:	1998
Employees:	93
Space:	6.000 m^2 (development and production)

Proton Motor Power Systems PLC:

Located:	Newcastle upon Tyne (UK)
Chairman:	Mr. Helmut Gierse
Board:	Dr. Faiz Nahab (CEO PM) Mr. Roman Kotlarzewski (CFO PM) Mr. Sebastian Goldner (CTO/COO PM) Mr. Manfred Limbrunner (CSO PM)
Founded:	2006
WKN:	A0LC22 @ London Stock Exchange

Proton Motor Fuel Cell GmbH



Start development of Fuel Cell Technology

1994

Bayernbus set into operation

2000

Fuel Cell Ship “Alsterwasser” in operation

2008

Road approval Newton with HyRange®

2011

EPS-System BOS Application

2016

75 kVA Fuel Power plant Surf’n’Turf

2017

1998

Foundation Proton Motor Fuel Cell GmbH

2001

World first Fuel Cell Fork Lift

2009

World first Triple Hybrid City Bus

2012

EPS System installed in Bachhausen

2016

Presentation of FC REEV vehicle

2018

FC-EPS System at DB Netz AG

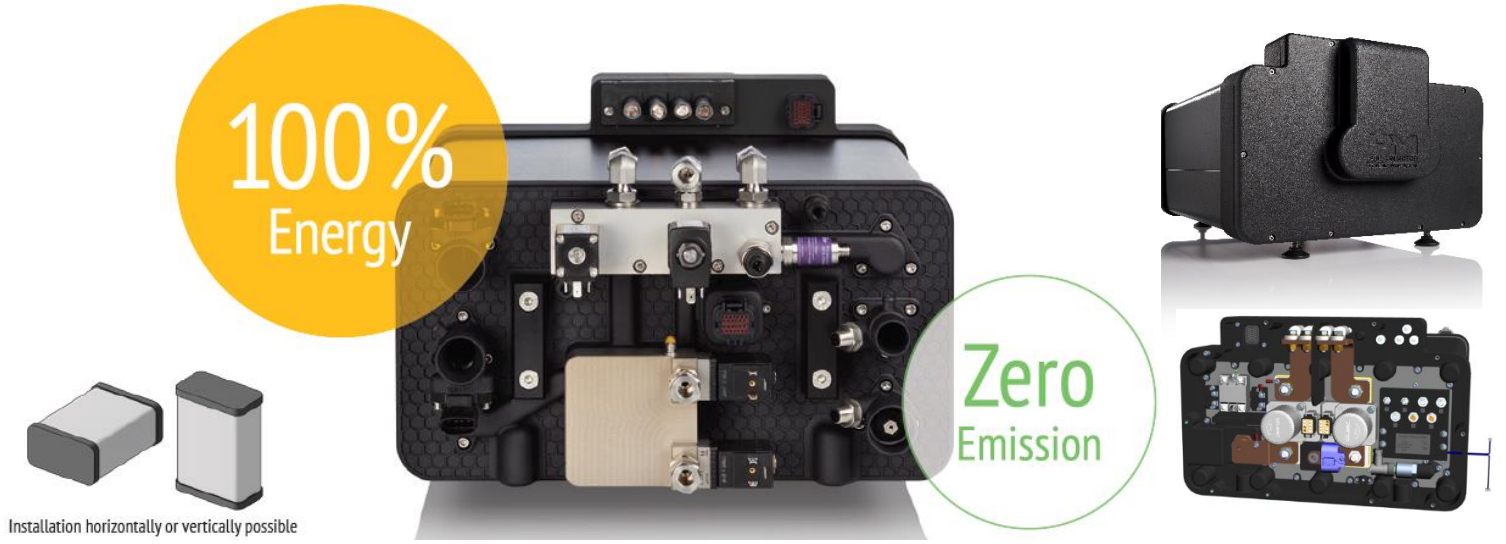
Types of Fuel Cells

FC Types	Fuel	Temp.	Pros	Cons
AFC Alkaline Fuel Cell	H2	≤ 80°C	• Dynamic operation • Start/Stop capability • High el. Efficiency • Emission free	• High H2 purity • High O2 purity • Low lifetime
PEFC Polymer Electrolyte Fuel Cell	H2	≤ 80°C	• Dynamic operation • Start/Stop capability • High el. Efficiency • High lifetime • Emission free	• High H2 purity
PAFC Phosphoric Acid Fuel Cell	Reformate	≤ 200°C	• Low H2 & O2 purity	• Low Dynamic operation • Start/stop capability • Low el. Efficiency • Low lifetime • Emissions
MCFC Molten Carbonate Fuel Cell	Reformate	≤ 650°C	• Low H2 & O2 purity	• Low Dynamic operation • Start/stop capability • Low el. Efficiency • Low lifetime • Emissions
SOFC Solid Oxide Fuel Cell	Reformate	≤ 1000°C	• Low H2 & O2 purity • High Lifetime • High el. efficiency	• Low Dynamic operation • Start/stop capability • Emissions

Hydrogen Storage Systems for PEFC Applications

On-Board H2 Storage Systems		Automotive		Rail	Maritime
		Passenger Cars	Utility Vehicles		
Compressed Gaseous Hydrogen (CGH)	350 bar		X	X	X
	700 bar	X			
Liquid Hydrogen (LH2)					X
Metal Hydride Storage					X
Liquid Organic Hydrogen Carrier (LOHC)		To be developed			
Ammonia		To be developed			

Modular Fuel Cell Stack & System Approach



Stationary

Automotive

Rail

Maritime

PM200 Stack Modules	PM400 Stack Modules
FC Power Range: 2,1…14,8 kW_{el} (2 kW steps)	FC Power Range: 14,2…71,0 kW_{el} (7 kW steps) 85…213 kW_{el} (20 kW steps) Cascadable into MW_{el} power range
Current range: 0…150 A	Current range: 0…500 A

Efficiency:	47…67%	Ambient Temp.:	-35 to +45 °C
Life time:	> 20.000 operating hours	H2 pressure:	3,5 / 8,0 bar_g
Protection class:	IP65	Conformity:	CE, EN 62282-2

Freeze storage and freeze start capable (since 2010)

No need for humidification

Liquid cooled

Modular System Approach for OEM Products











Package Components

H_2

Air

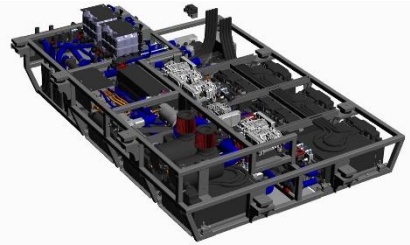
PM Stack Module inside

2–16 kW / 15–75 kW

Electricity

Cooling

Controls




Target Markets

- UPS / Emergency Power Supply
- Seasonal Energy Shift / Peak Shaving
- Grid Stabilisation / Energy Storage
- Power Supply Grid Independent

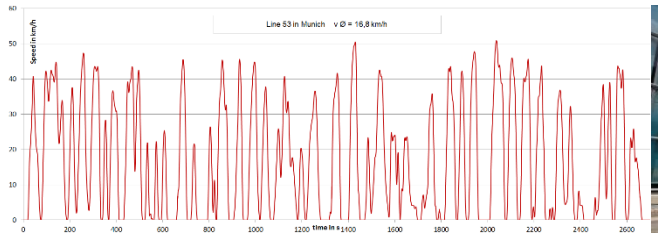
Stationary | **Automotive** | **Rail** | **Maritime**

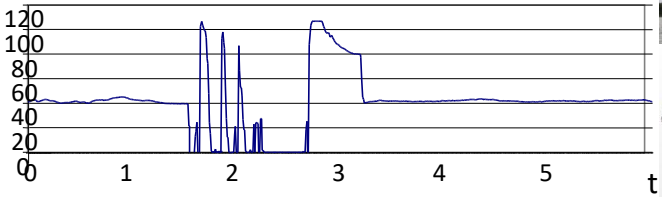
- Road Haulage
- Truck Fleet
- Passenger Transport
- Municipal Vehicles

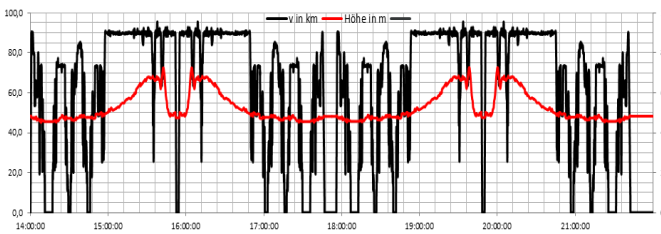
Fuel Cell Hybrid Concept

Demand of application defined through:

- Drive/Load Cycle
- Energy Autonomous Operation
- Stand By Time Between Operation
- Payload







Design & Dimensioning Principals:

Target: Refilling **NOT** Recharging

Peak Power and/or Breaking Power	→	Battery Size [kWh]
Average Power	→	Fuel Cell Size [kW_{el}]
Energy Autonomous Operation	→	H2-Storage Size [kg H2]

Definition within Proton Motor:

FC Range Extender: Fuel cell power less than average power of application
➔ refilling **AND** recharging

FC Hybrid: Fuel cell power higher than average power of application
➔ refilling **NO** recharging

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Reference Mobility Applications

Fuel Cells · Power Systems

Automotive

Etrucks europe

Application: Garbage Truck

FC Power: 43 kW

H2 Storage: 20/30 kg 350 bar

Battery: 136 kWh

Delivery: 6 Systems in 2020

Rail

LINSINGER RAIL MILLING TRAIN REVOLUTIONARY MG11 HYDROGEN

Application: Rail Milling Train

FC Power: 2 x 107 kW

H2 Storage: To be announced 350 bar

Battery: To be announced

Delivery: 1st Qu. 2021

Maritime

FINCANTIERI The sea ahead

Application: Marine Vessel

FC Power: 144 kW

H2 Storage: 50 kg Metal-Hydride

Battery: To be announced

Delivery: 1st/2nd Qu. 2021

References Stationary Applications

UPS / Emergency Power Supply (hydrogen supply)

UPS Telecom

Customer: DB Bahnbau

FC Power: 6 & 9 kW

UPS Road Tunnels

Customer: To be announced

FC Power: 23, 28, 36, 43 kW

Seasonal Energy Shift / Peak Shaving (decentralized hydrogen production)

Houses & Appartments

Projects: Hy2Green (I)

Brütten (CH)

FC Power: 9 kW

Housing Block

Customer: Vonovia

FC Power: 36 kW

References Stationary Applications

Grid Stabilisation / Peak Shaving (decentralized hydrogen production)

FC Power: 178kW
Voltage: 400 VAC (Grid dependent)
Customer: APEX
Location: Rostock (Germany)

Power Supply Grid Independent (hydrogen supply)

FC Power: 129 kW
Battery : 180 kWh
Voltage: 400 VAC (Grid independent)
Customer: Shell
Location: Munich (Germany)

Fully Automated Fuel Cell Stack Manufacturing

Status Quo

FC capacity 215 MW_{el}:

- 5.850 pcs. 37.0 FC Stacks
- 7.150 pcs. 30.0 Stacks

Increasing Market Demand

FC capacity 1.110 MW_{el}:

- 30.000 pcs. 37.0 FC Stacks
- 37.000 pcs. 30.0 FC Stacks

Increasing capacity and value at PM e. g.:

- Using roll material
- Sealing integrated
- Gluing integrated

100%
Energie

Zero
Emission

PM
Fuel Cells · Power Systems

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