

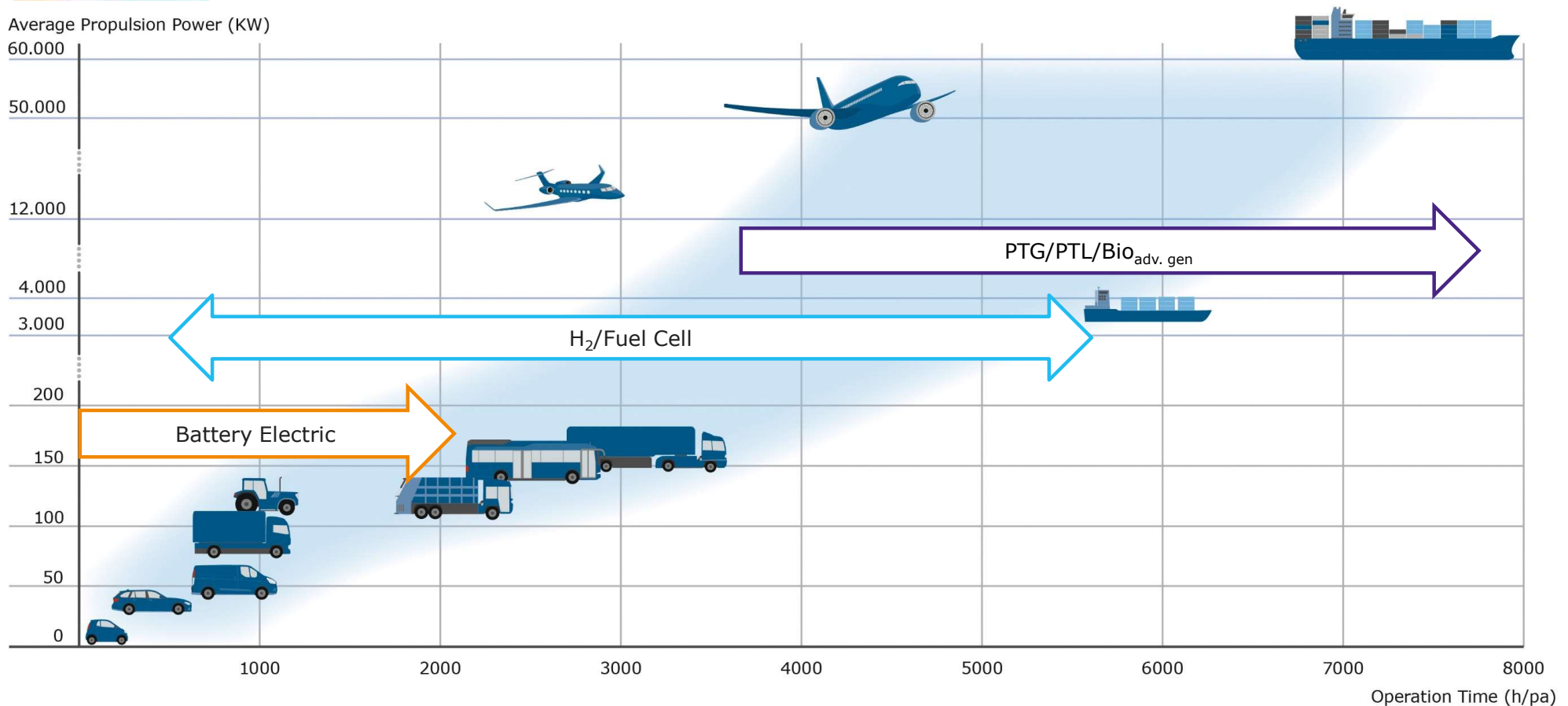


AVL PEM-Brennstoffzellenentwicklung für Straßenverkehr- und Schiffsanwendungen

ERFA Mobilität Wien 2022

Richard Schauperl

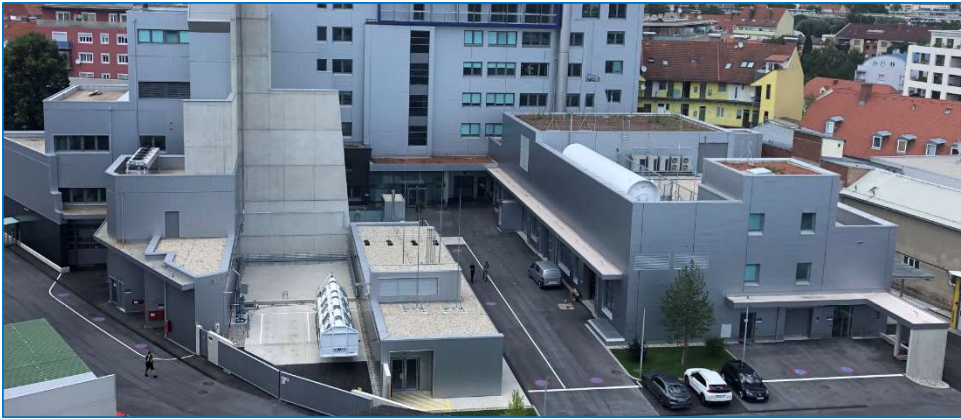
"Sustainable Fuel Map" for Transport Applications





AVL Fuel Cell

AVL Fuel Cell Global Footprint



Hydrogen & Fuel Cell Test & Development Center – Graz / Austria

- H₂ & fuel cell development since 2002
- ~500 engineers in engineering, testing & simulation
- 5 H₂ & Fuel Cell Tech-Centers:
 - Graz, AT PEM & SOC System
 - Vancouver, CA PEM Stack
 - Kecskemet, HU SOC System
 - Remscheid, DE SOC Integration & Testing
 - Warsaw, PL PEM Components & System



Electrolyzer Integration and Test Facility – Remscheid / Germany



Stack Test and Prototype Lab - Vancouver / Canada

AVL Solutions for H₂ Ecosystem Implementation



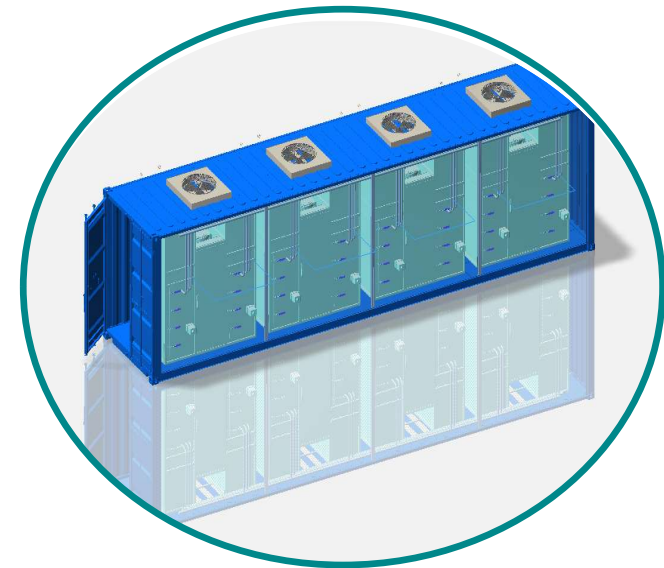
High-performance PEM Systems

- Passenger car
- Truck
- Bus
- LCV
- marine, rail, aviation



SOFC Decentral Power Generation

- Decentral power
- Marine APUs
- BEV Charging stations
- Power plants
- Data center, critical infrastructure
- Remote power

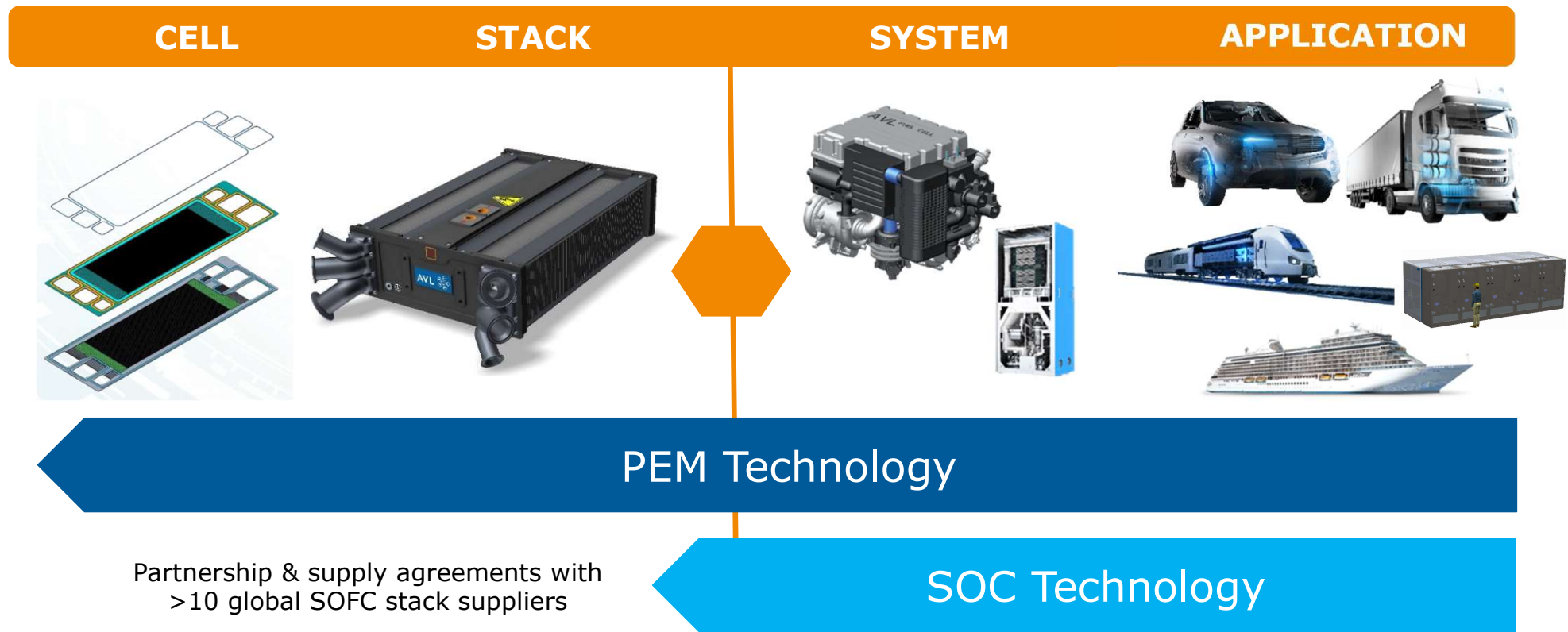


SOEC Hydrogen Production

- Hydrogen production
- eFuel production
- Hydrogen for industry
- Reversible electrolyzer/fuel cell systems

PEM...Polymer Electrolyte Membrane
SOFC...Solid Oxide Fuel Cell
SOEC...Solid Oxide Electrolysis Cell

AVL Fuel Cell Value Chain

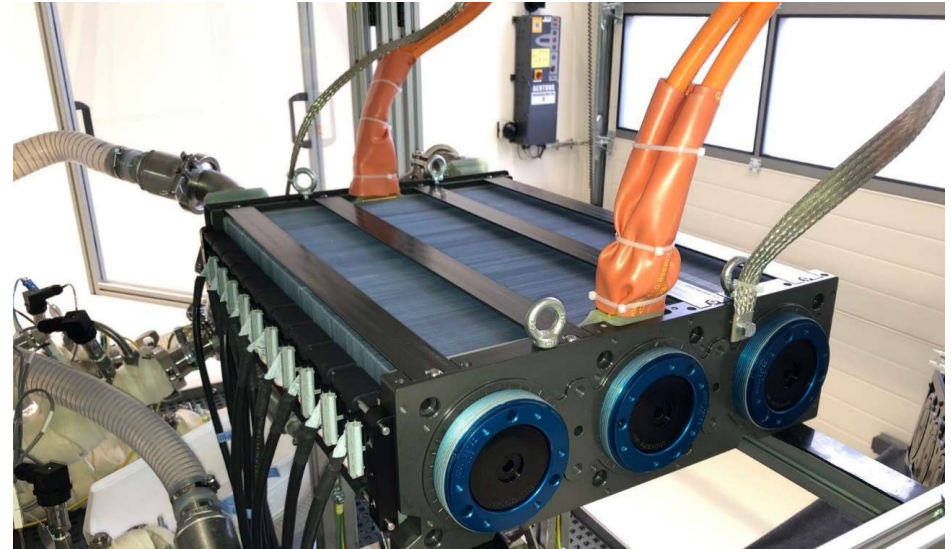
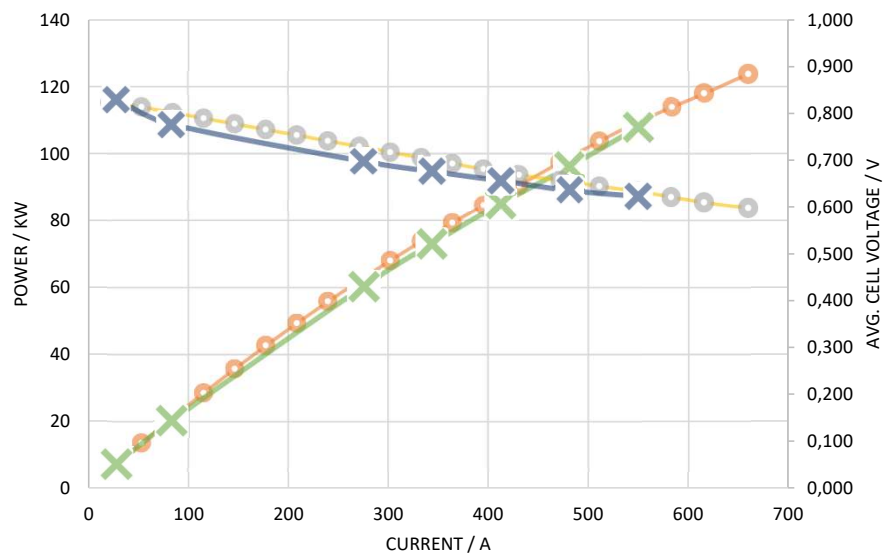




PEM Technology

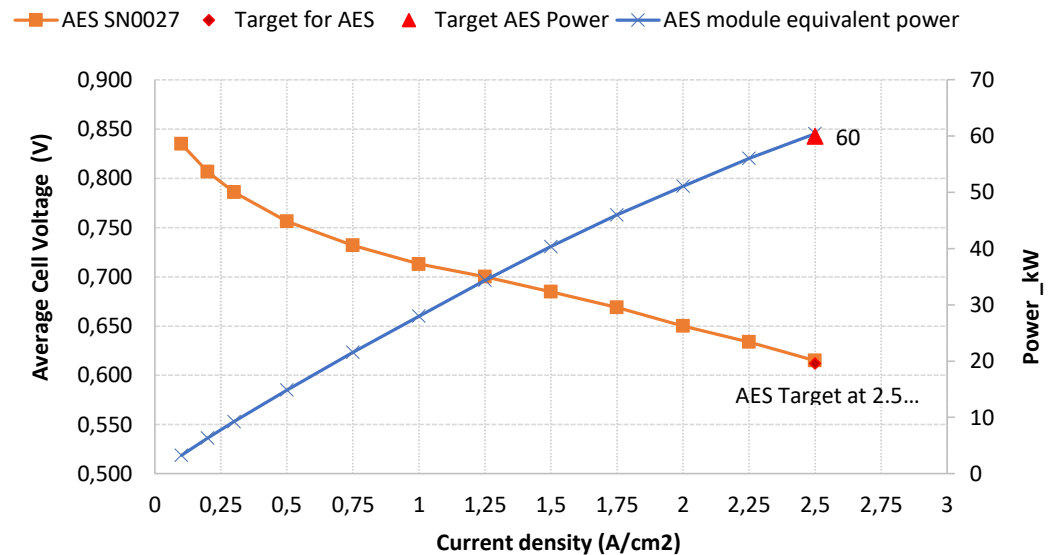
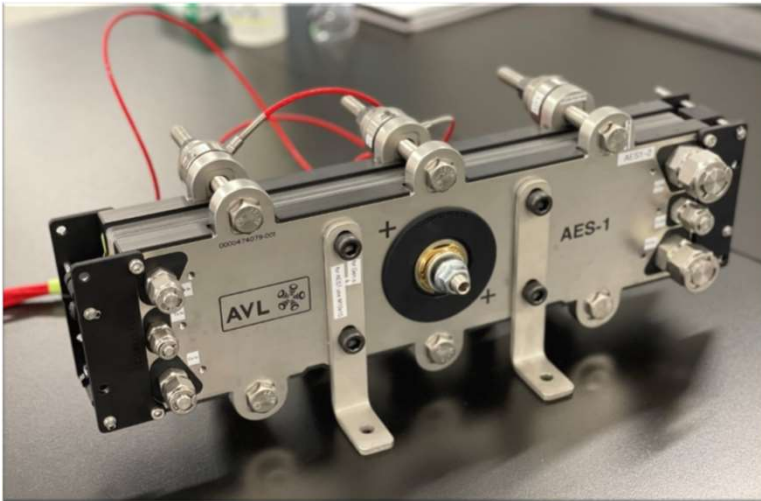
AVL PEM Stack Development

Comparison of Gen-0 stack
Simulation (Short Stack Basis) vs. End of Line
Test Results



Requirements		AVL Gen 0 Target	AVL Gen 0 Measured
Stack power @ 550 A	[kW]	109	113
Peak power	[kW]	125	138
Power density @ 0.6 V/cell	[kW/L]	~4	4.1

Next Generation Stack Development



Next Generation stack concept with >6kW/l demonstrated!

Applications for the AVL Gen-0/1 Fuel Cell Stack

- Range extender (~35 kW, 1 row, 45 cells)
- Automotive (~100 kW, 1 row, 330 cells)
- HD-Truck (~300 kW, 2 rows X 210 cells X 2 systems = 840 cells)
- Marine (~1.3 MW, 2 rows X 350 cells X 2 systems X 4 modules = 5600 cells)
- Many other applications possible (off-road vehicles, aerospace, rail,...)
- Because the Gen-0 is scalable, many different sizes and power levels are available to AVL customers



AVL Modular Fuel Cell System Concept

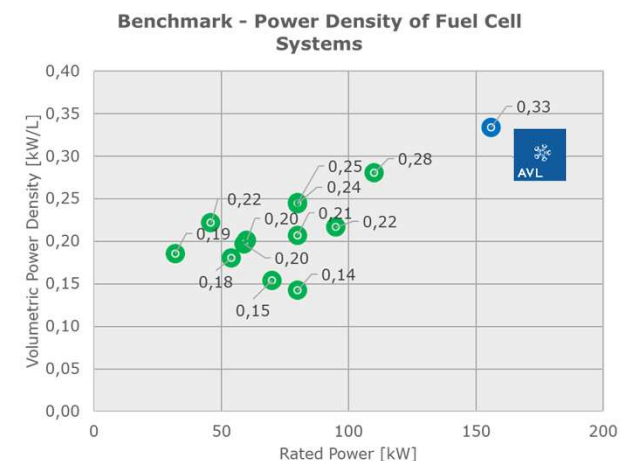
Fuel Cell Main Propulsion for LD, MD & HD Trucks



AVL Gen0 PEM Stack

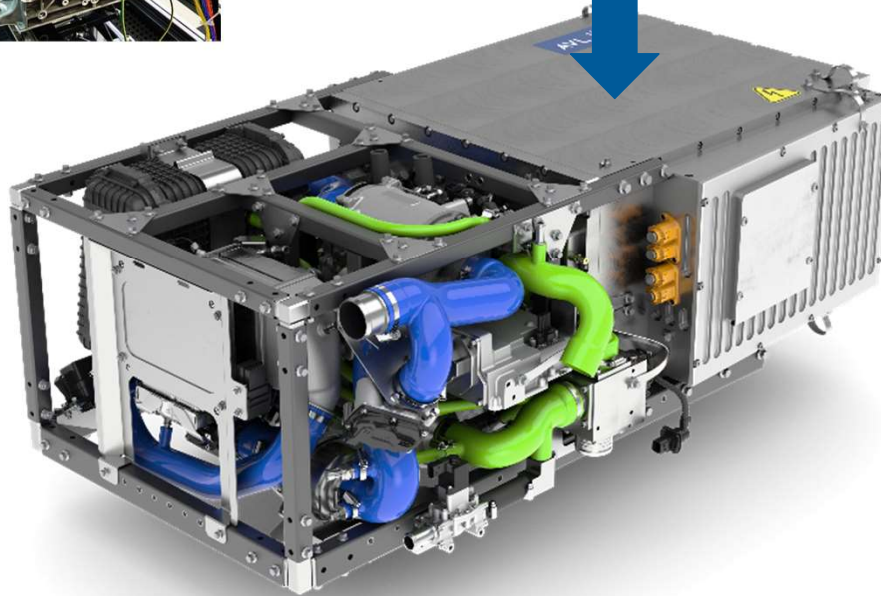


AVL 150kW HD Fuel Cell System



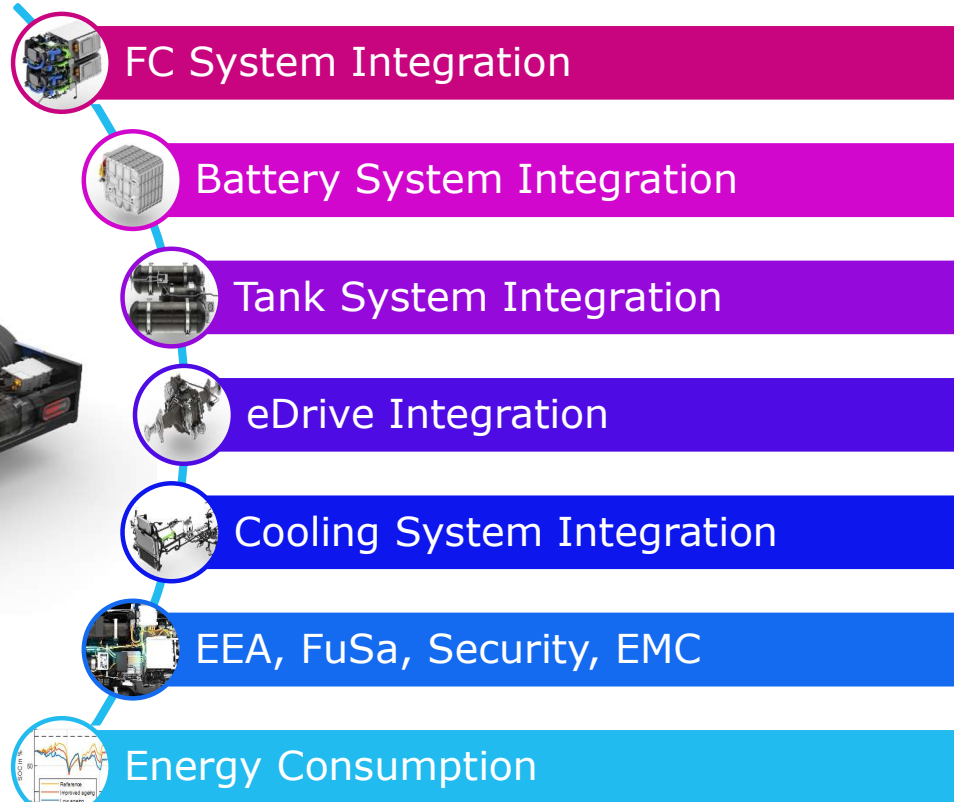
Highest Power Density PEM HD System in the World!

AVL System Technology based on TMC Stacks



- Combination of world-leading technologies:
 - PEM stacks from TMC
 - FCS design from AVL
- Unique power density & performance
- Stacks from TMC mass production allow leading cost position
- Specific requirements possible
- **Entering FCS production in 2 years with best-in-class cost and technology**

AVL Fuel Cell Technology Demonstrator Truck



+ Single Type Approval

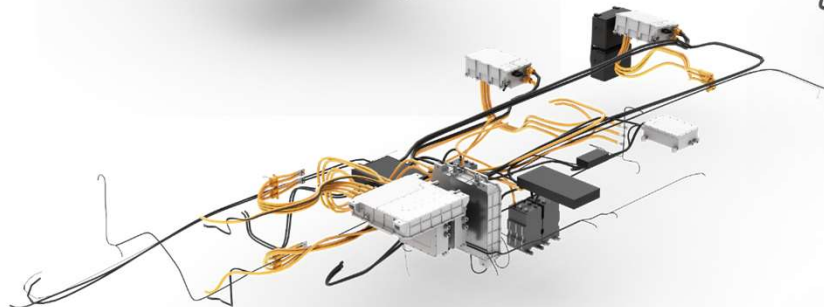
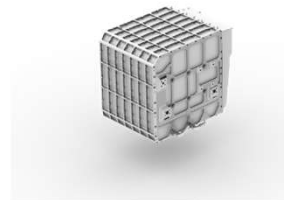
AVL Fuel Cell Technology Demonstrator Truck

Fuel Cell System

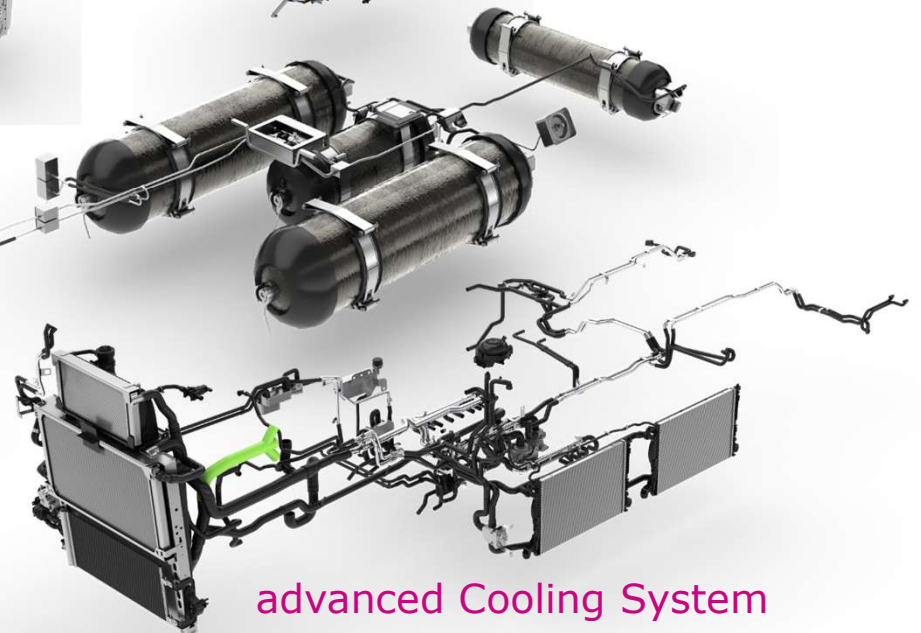
high power
Battery System

H₂ Tank System

Integrated high power e-Axle



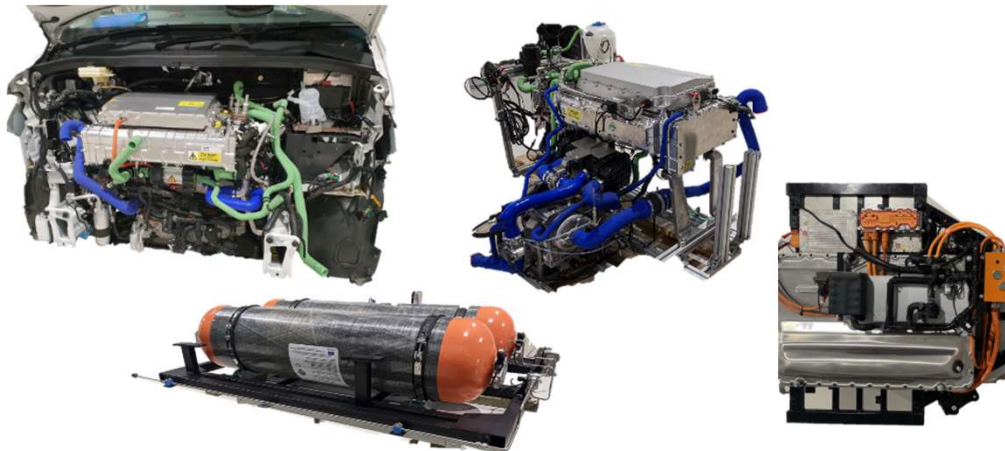
advanced E/E Architecture



advanced Cooling System

First Hydrogen Demo Vehicle Specification & Build

Customer Confidential Project – Full Design and Build (HW and SW) Commercial Demonstrator



Key achievements

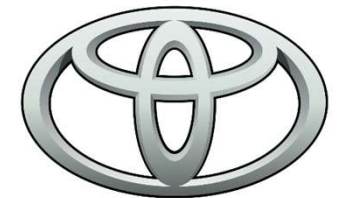
- Fully functional prototype MAN fuel-cell electric commercial vehicle road legal in UK
- Re-use of existing LCV FCEV AVL CRUISE™ M model to support First Hydrogen Project simulation
- Specification and design of FC system including high pressure H₂ system
- Fully automated FC system calibration on dedicated powertrain testbed using AVL CAMEO methodology
- Vehicle, Fuel Cell and Hydrogen storage controllers developed with seamless communication between all 3
- Vehicle conversion and functional safety verification, including HV electrical and H₂ fast fill process

Technical specifications

- Prototype battery electric VW MAN Donor Vehicle
- Fuel Cell stack (79kW), battery (13.8kWh) and c/o motor (100kW) to achieve required vehicle performance
- 700 Bar H₂ system with IR communication for fast fill
- Circa 10kg H₂ capacity



Fuel Cell Projects for Passenger Cars & LCV



TOYOTA

AVL is working with Toyota since 2018 on various fuel cell related topics



Strengthening Fuel Cell Development Efforts

Press Release: AVL Joins Collaborative Project to Develop Hydrogen-Powered Land Rover Defender Fuel Cell Prototype

**INEOS
Automotive**



AVL is the vehicle and powertrain integration partner for the FC Grenadier



AVL is developing fuel cell LCVs for FirstHydrogen based on Ballard stacks



Ford Motor Company and AVL Develop Fuel Cell Electric Commercial Vehicle Demonstrator

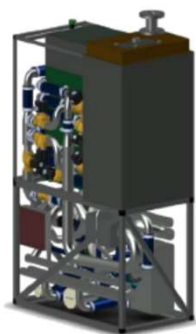
APC ARMD FCVGen1.0 - Fuel Cell Commercial Vehicle

TECO 2030 Marine PEM Fuel Cell System



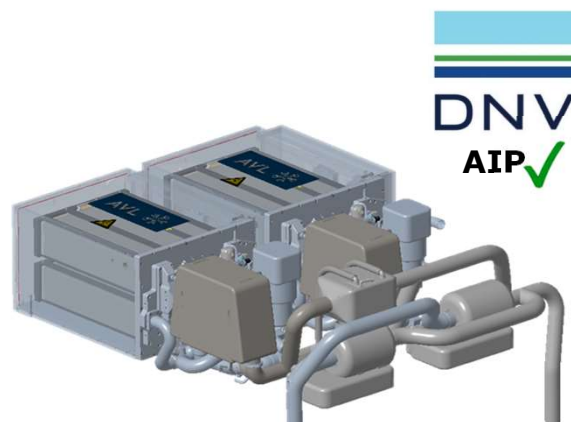
AVL Scope:

- TECO product based on AVL Gen0 stack platform
- Complete fuel cell system development till SOP
- Production engineering and setup of production line



FCM 400™

FC Module compartment



Project Scope 400kW FC Module
→ Scalable up to x MW



IPCEI Green Hydrogen @ the Blue Danube
supply frame agreement about 200MW fuel cells signed

325kW Marine Fuel Cell System

Development, Testing, Validation and Industrialization



Development of a 325kW net power marine fuel cell system

Marinization of the AVL Gen0 Stack Platform

Prototype Fuel Cell Stack and System built and testing

SOP software development
(operation, diagnosis, processes, safety)

Marine Fuel Cell System certification and in-ship validation

Industrialization of the TECO Fuel Cell Stack and System at the production facility in Narvik Norway

SOP 2023



SOFC Technology for Maritime

Ceres Power – AVL Cooperation



ceres

AVL

Ceres Power SOFC Stacks (1 to 5kW modules) will go into mass-production in 2021-2023 at Ceres licensees:



BOSCH

WEICHAI



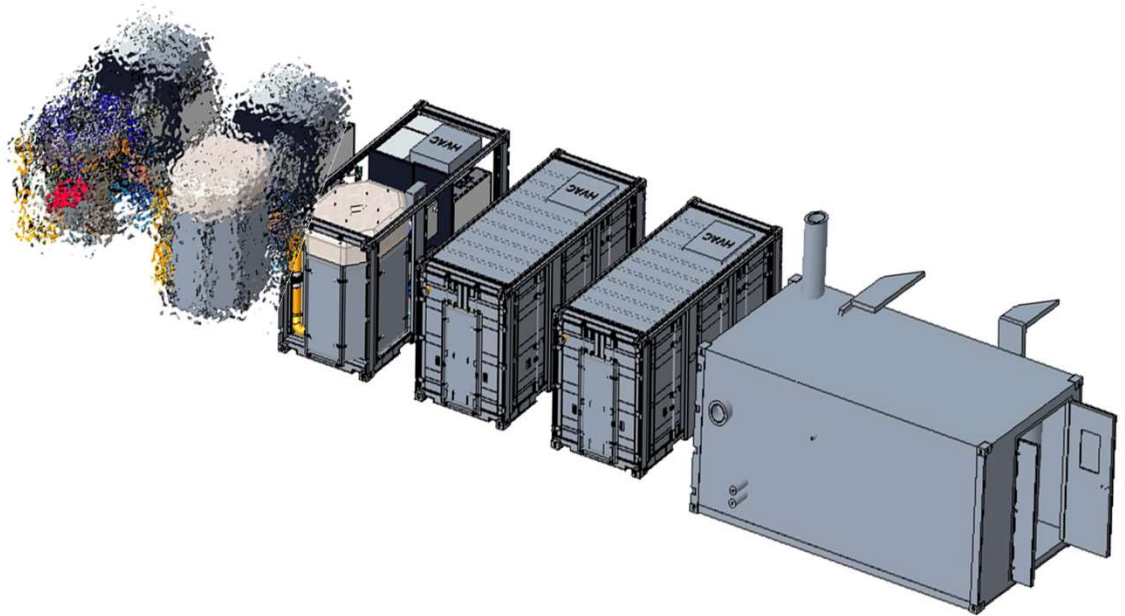
Benefits:

- Leading SOFC cell/stack technology in the market
- Lowest cost potential
- Very robust for mobile/portable applications

250kW SOFC – CNG/LPG dual fuel

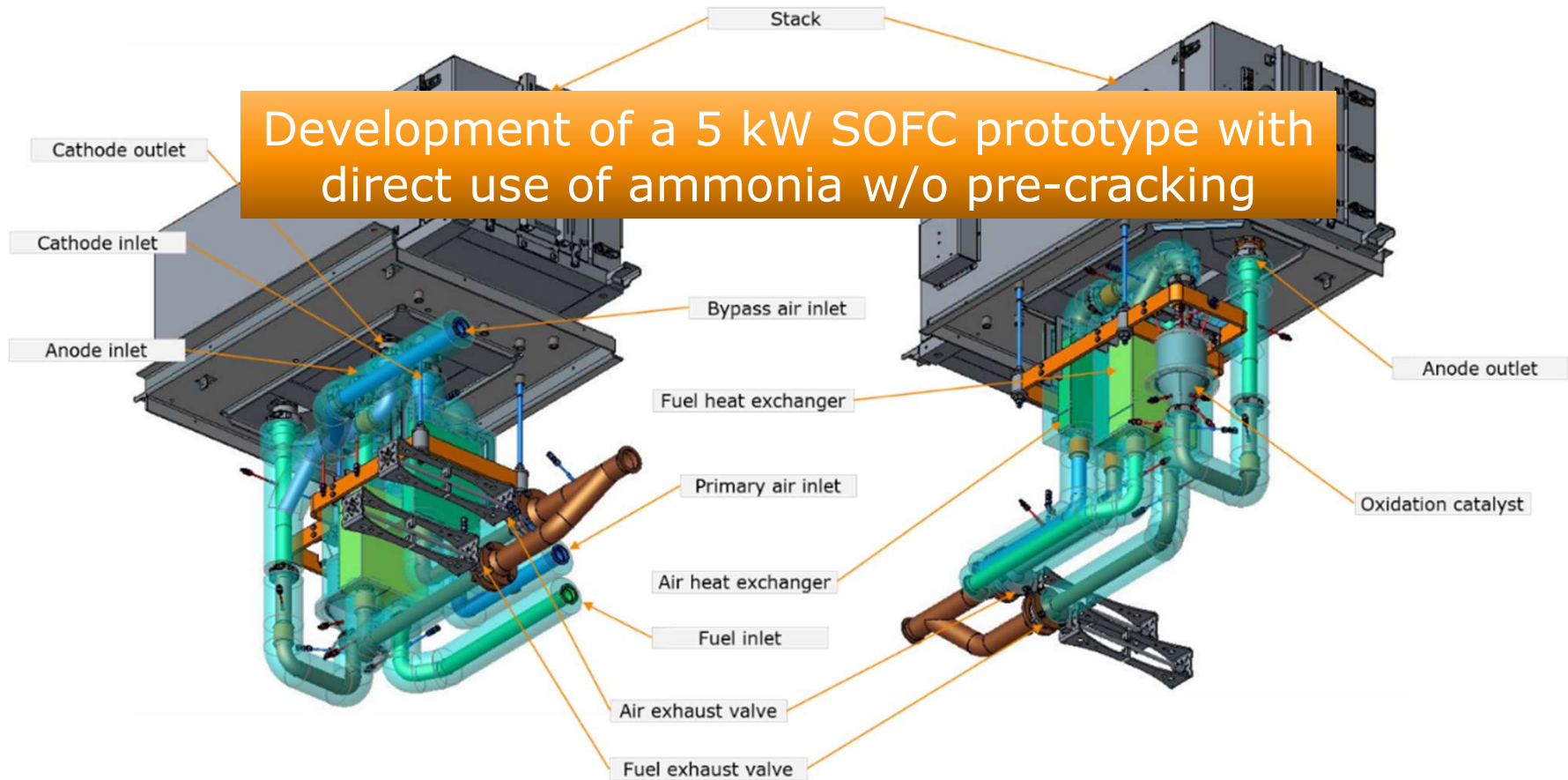


- **250kW SOFC PowerGen Product**
- SOP in 2024
- Stack technology from **ceres**
- ~60% efficiency BoL (NG, LPG, H₂ ready)
- Turnkey execution by AVL:
 - System layout, design & controls
 - assembly line planning & setup
- GenI prototypes to be tested in 2022
- 5x50kW modules



Ammonia powered SOFC

Development of a 5 kW SOFC prototype with direct use of ammonia w/o pre-cracking



Thank you



www.avl.com