

Disruptive pemfc stack with n**O**vel materia**L**s, **P**rocesses,
arch**H**itecture and optimized **I**Nterfaces

Overview of the DOLPHIN project:

(Joël PAUCHET, CEA, coordinator)



<https://www.dolphin-fc.eu/>
Joel.pauchet@cea.fr

Call year: 2018

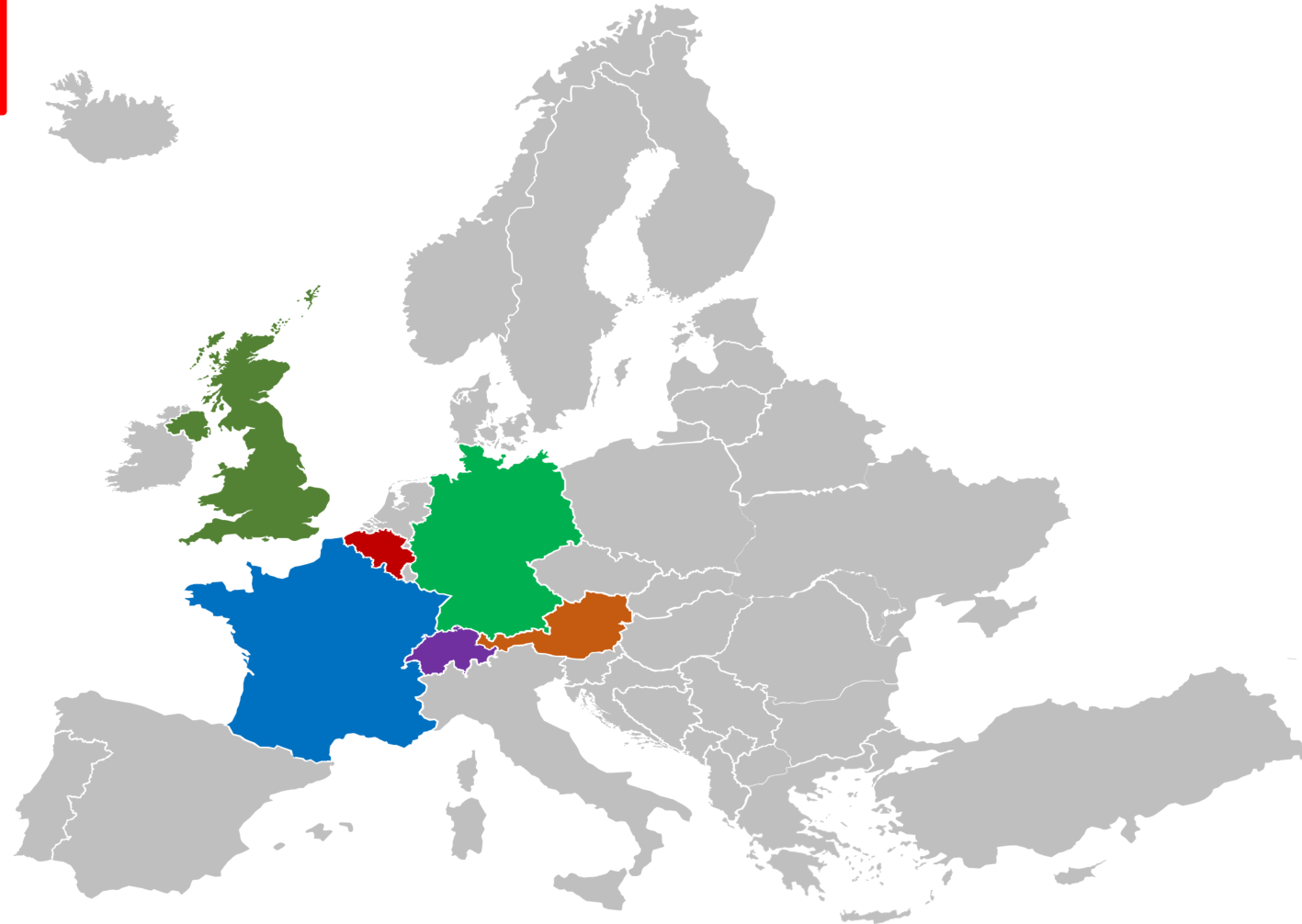
Call topic:
FCH-01-6

Game changer
fuel cell stack for
automotive
applications

Project dates: 01/01/2019 – 31/12/2023

FCH-JU max. contribution: 2 962 681 €
Partners contribution: 218 750 €

7 countries: 6 in Europe + USA
7 partners: 4 industries + 3 RTO

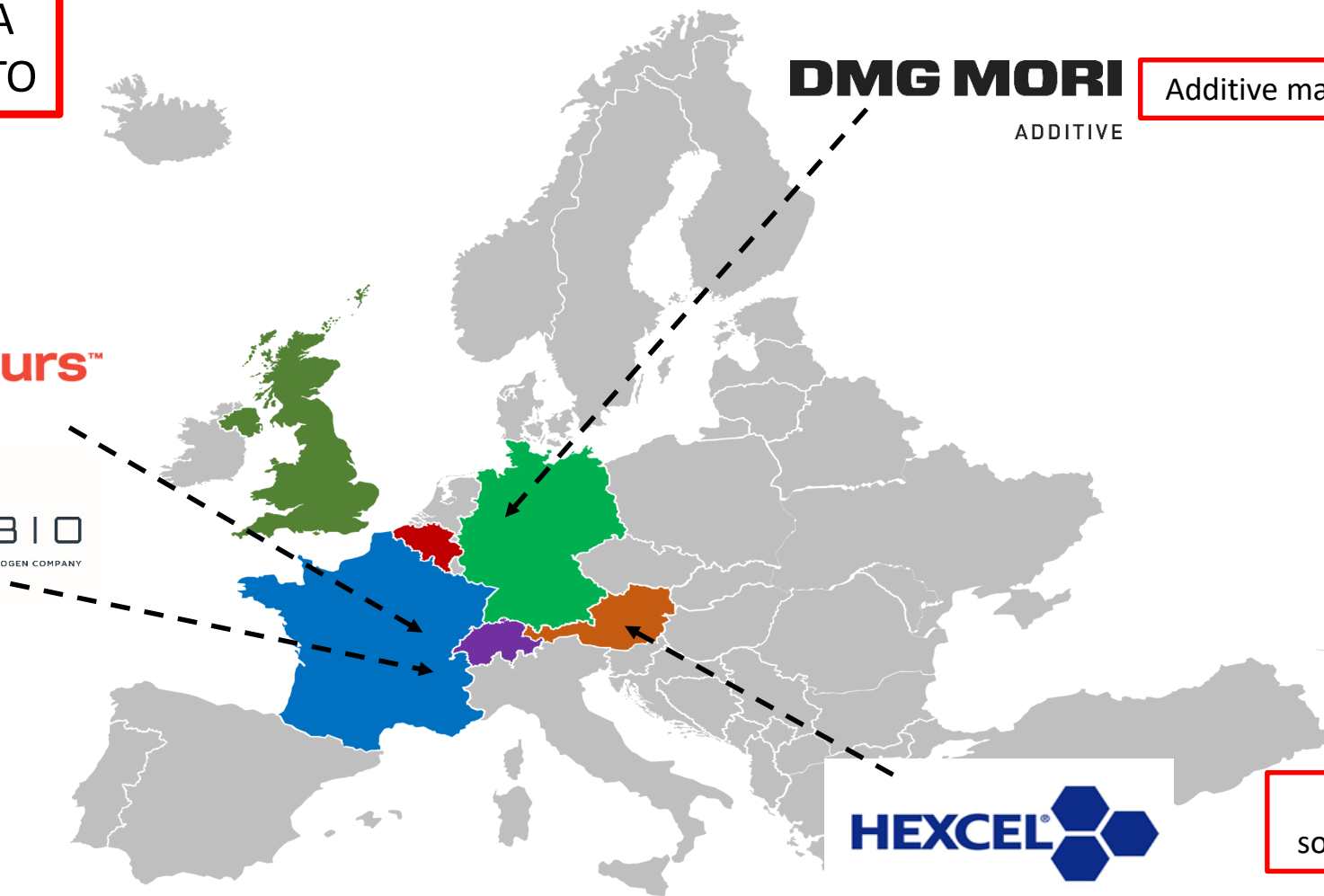


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Improved membrane
and ionomer



Requirements
Metallic-based solutions and process



DMG MORI
ADDITIVE

Additive manufacturing



Carbon-based
solutions and process

7 countries: 6 in Europe + USA
7 partners: 4 industries + 3 RTO

Graphene coating



DMG MORI
ADDITIVE

Additive manufacturing

Improved membrane
and ionomer



Modeling
Laser milling
Cell and stack tests



Requirements
Metallic-based solutions and process

Coordination
Modeling
Printing
Cell and stack tests



Carbon-based
solutions and process

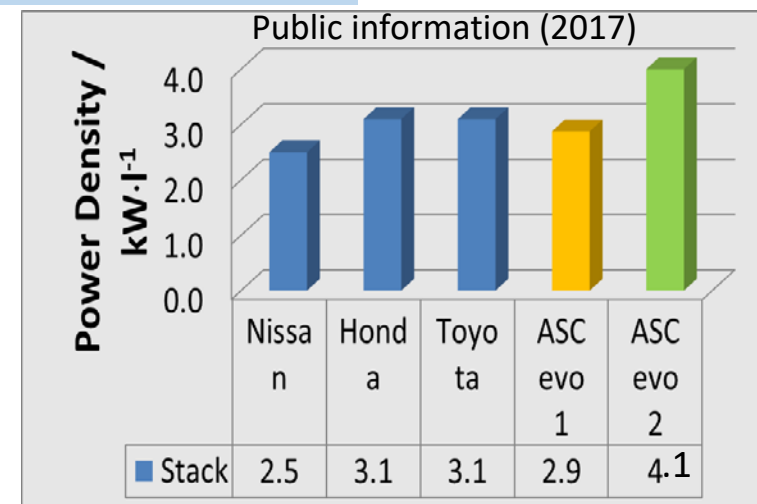
Main Objectives

Validate **disruptive technologies for 100 kW light-weight & compact fuel cell stack designs**, with high power density and enhanced durability (under automotive application conditions), and **compatible with large scale/mass production** of full power-stacks.

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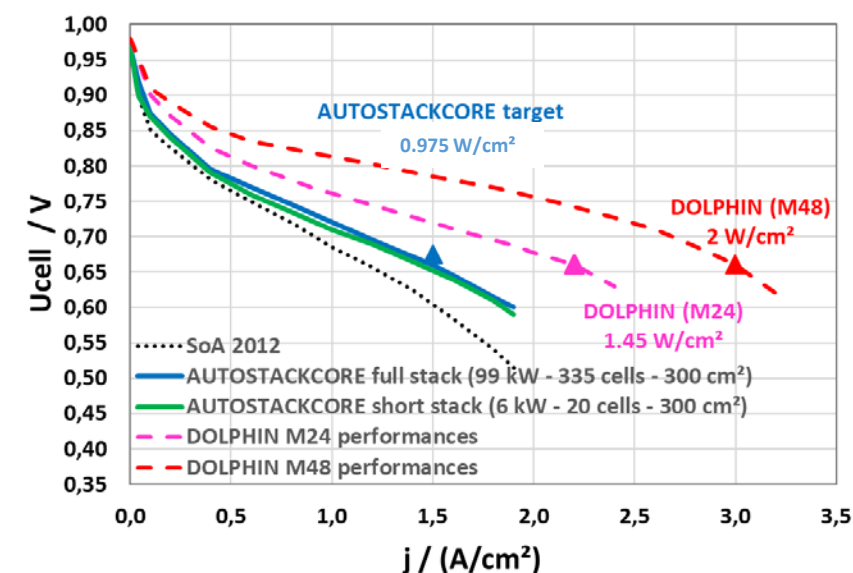
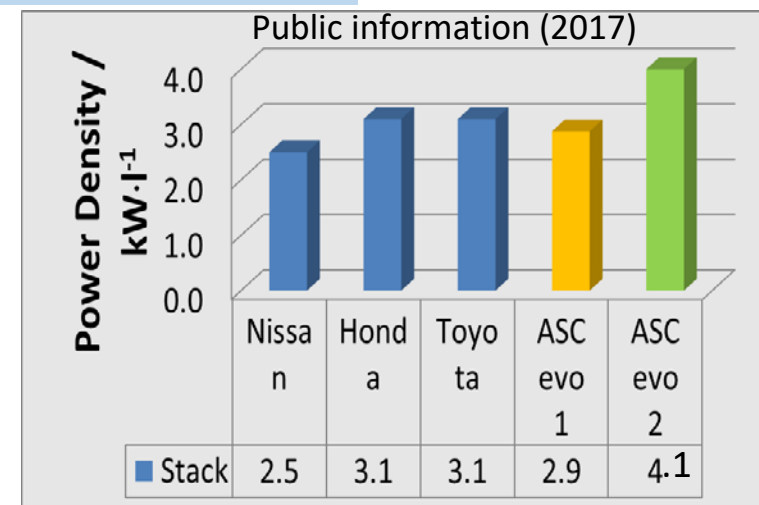
Main KPIs	Int. SoA 2017 (AutoStackCore)	DOLPHIN (~ FCH-JU 2024 targets)
Weight-specific power density (kW/kg) at nominal power	3.4	≥ 4.0 ($\geq +18\%$)
Volumetric power density (kW/l) at nominal power	4.1	≥ 5.0 ($\geq +25\%$)
Area-specific power density (W/cm ²) at 0.66 V (nominal conditions)	0,975	2.0 (+105%)
Cost (€/kW) at 100 000 units/year	36.8	< 20 (-45%)
Durability (hours)	3,500	6,000 (+70%)
Stack max operating temperature (°C)	95	105 (+10°C)



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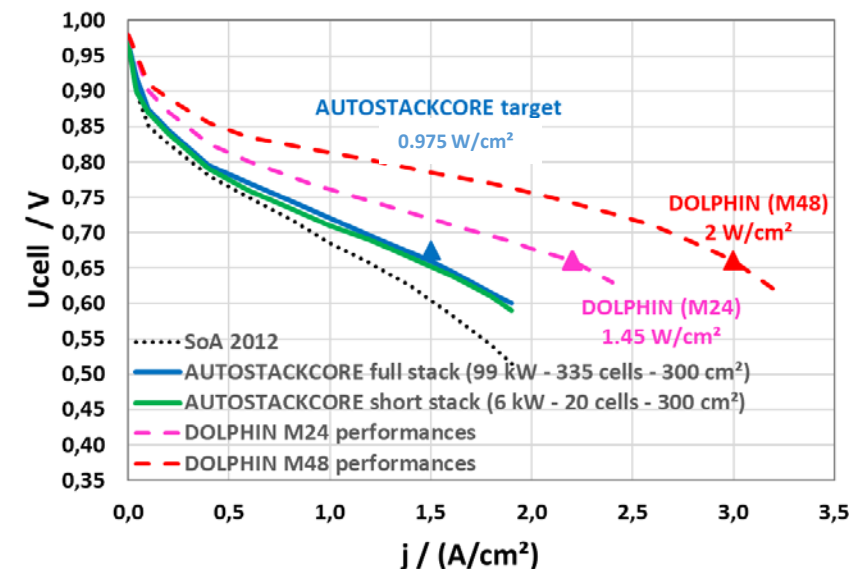
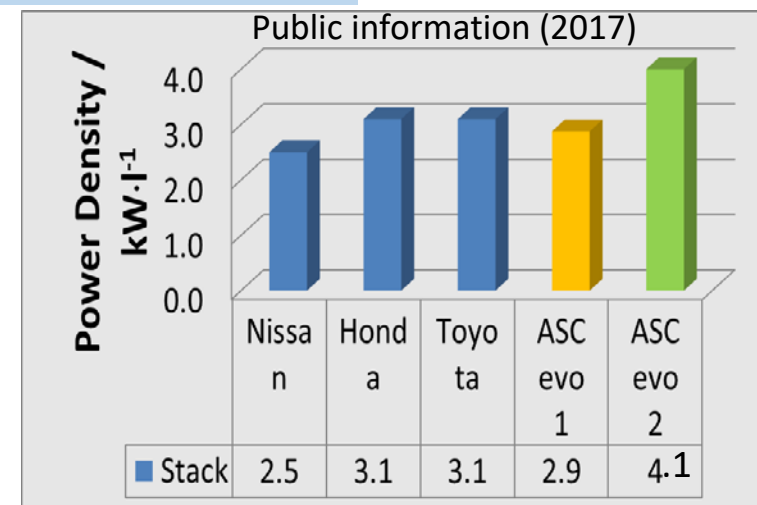


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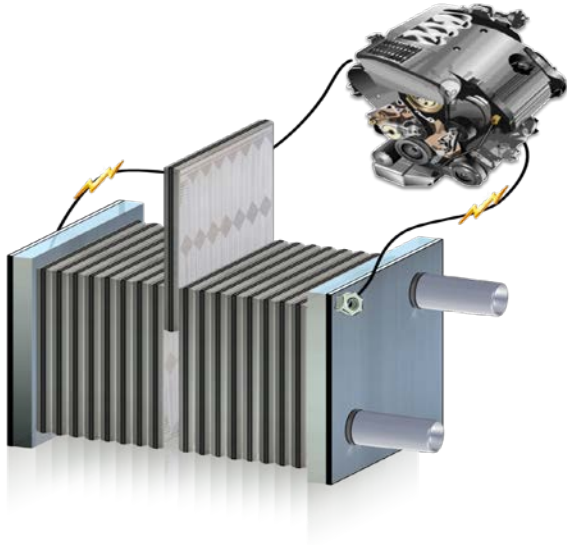
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Challenging!



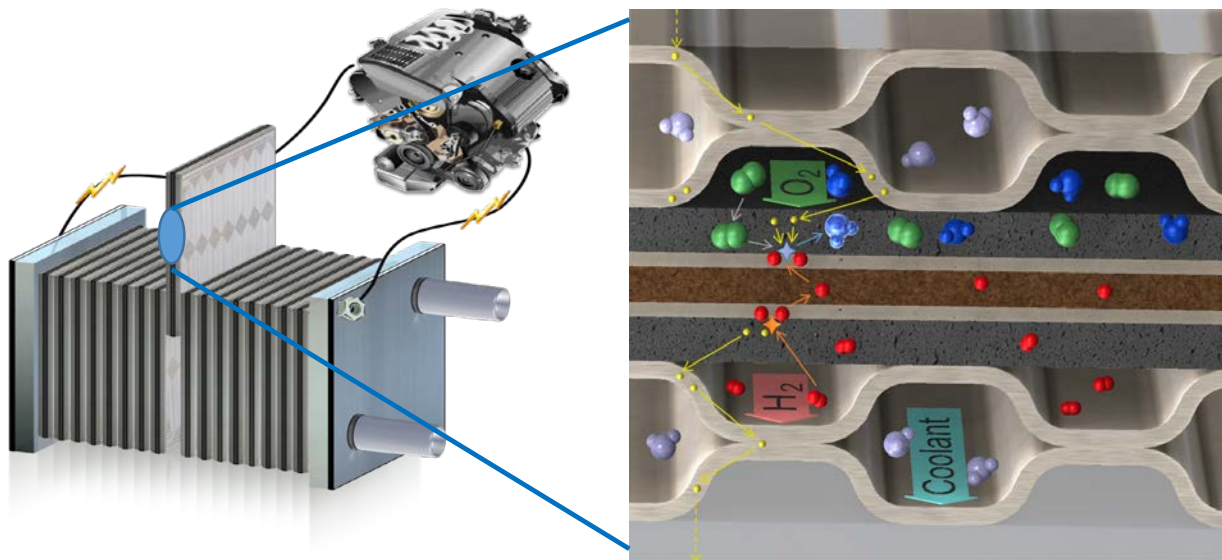
Technical Developments

5 kW demonstrator (CEA, ZSW)
with improved materials/processes



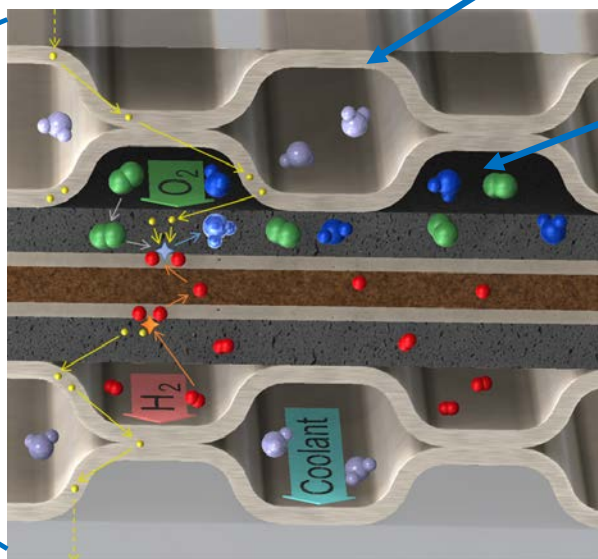
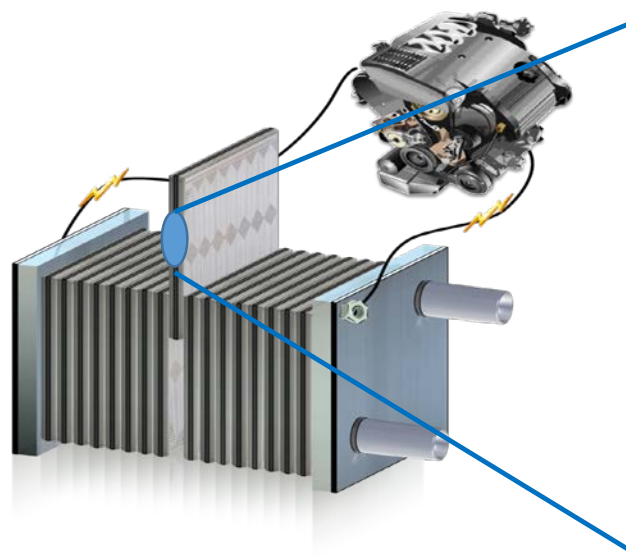
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Single Repeat Unit



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with improved materials/processes

Single Repeat Unit



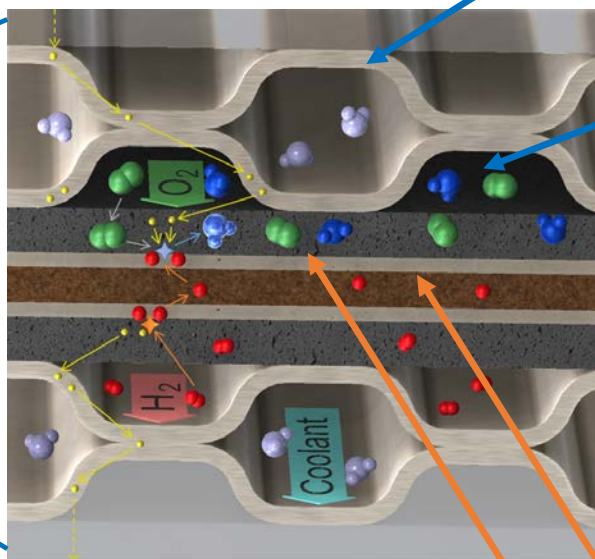
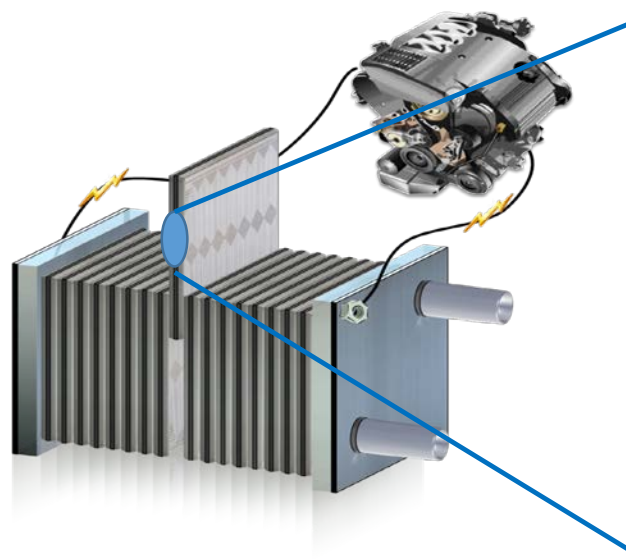
Thinner metallic plates (SYM)
Thinner carbon-based plates (HEXCEL)
Treatments of plates (SYM, CEA)

New (ZSW, CEA, SYM) Flow Field design
with downsized rib/channel pitch by
printing /machining (CEA), molding
(HEXCEL), stamping (SYM), additive
manufacturing (DMG-MORI), laser milling
(ZSW)

*Electrical and
Fluidics Core*

5 kW demonstrator (CEA, ZSW)
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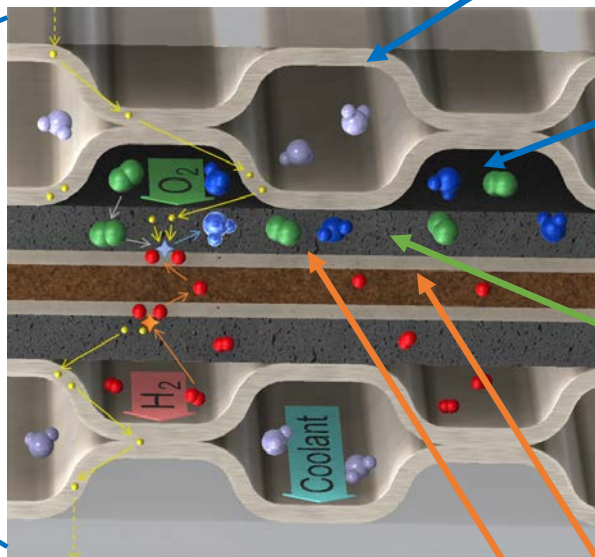
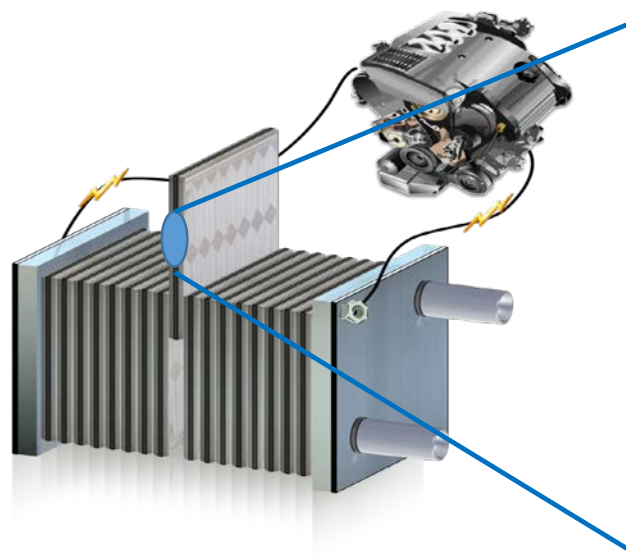
Thinner (<10 µm) or beyond PFSA
membrane (CHEM) with SLG coating (UoM)

3D textured cathode AL (CEA) with
improved ionomers (CHEM)

*Electrochemical
Core*

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Thin GDL substrate (HEXCEL), with MPL
and treatments (CEA)

Or remove GDM (ZSW, CEA)

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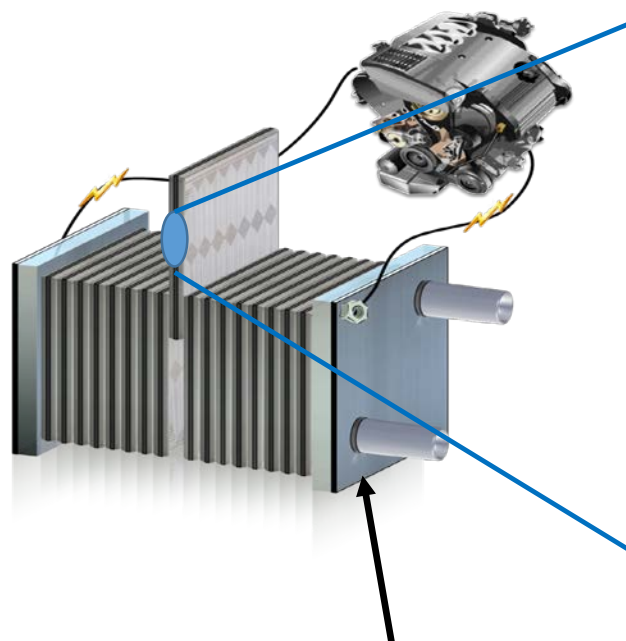
*Electrical and
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Interface

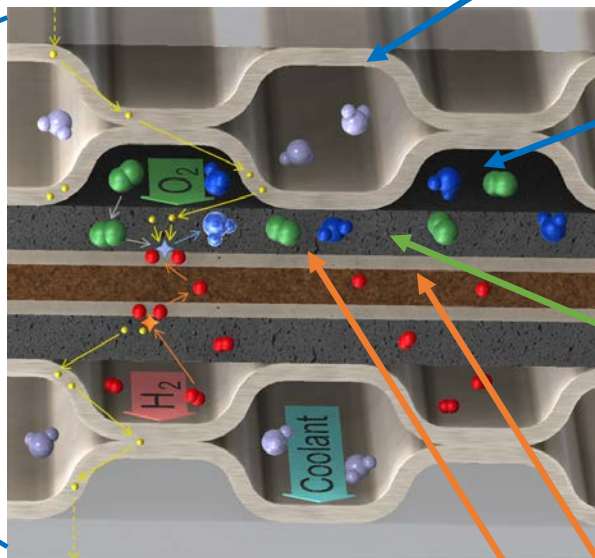
*Electrochemical
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5 kW demonstrator (CEA, ZSW)
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Single Repeat Unit



3D Lighter Integrated Terminal Plate
(composite, HEXCEL)



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*Electrical and
Fluidics Core*

Interface

*Electrochemical
Core*

A step by step approach

SPECIFICATION, MODELING & MANUFACTURING

Each partner

Performance screening

- EFC rib-channel
- EC core
- Diffusive transport structures
- Combinations EC/EFC

PLATFORM 1:
DIFFERENTIAL CELL TO MIMIC LOCAL CONDITIONS IN THE STACK

1.8 cm²

CEA

Performance screening

- EFC FF design
- EC core
- Combinations EC/EFC

PLATFORM 2 :
LARGER SCALE SINGLE CELL

100 cm²

ZSW, CEA

Performance/durability screening

- Cooling
- Gas distribution

PLATFORM 3:
SHORT STACK

100 cm²

CEA, ZSW

Performance/durability full assesment

- Novel Terminal Plates
- Select 1 or 2 architectures
- Cost assessment

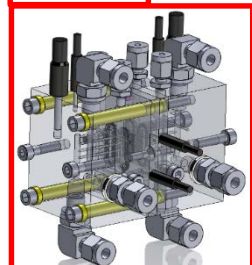
PLATFORM 4:
5 KW STACK

[150;200] cm²

CEA, ZSW

**DOLPHIN 100 kW stack
design & technologies**

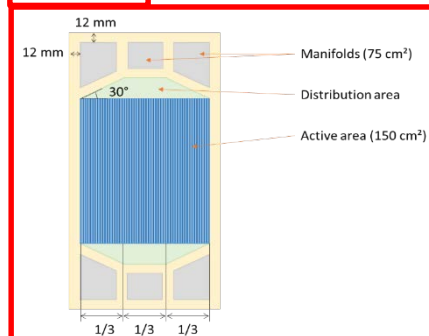
TP1



TP2 - TP3



TP4



A step by step approach

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Today

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LARGER SCALE SINGLE CELL

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ZSW, CEA

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SHORT STACK

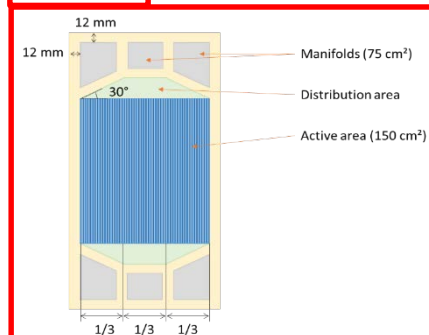
100 cm²

CEA, ZSW

TP2 - TP3



TP4



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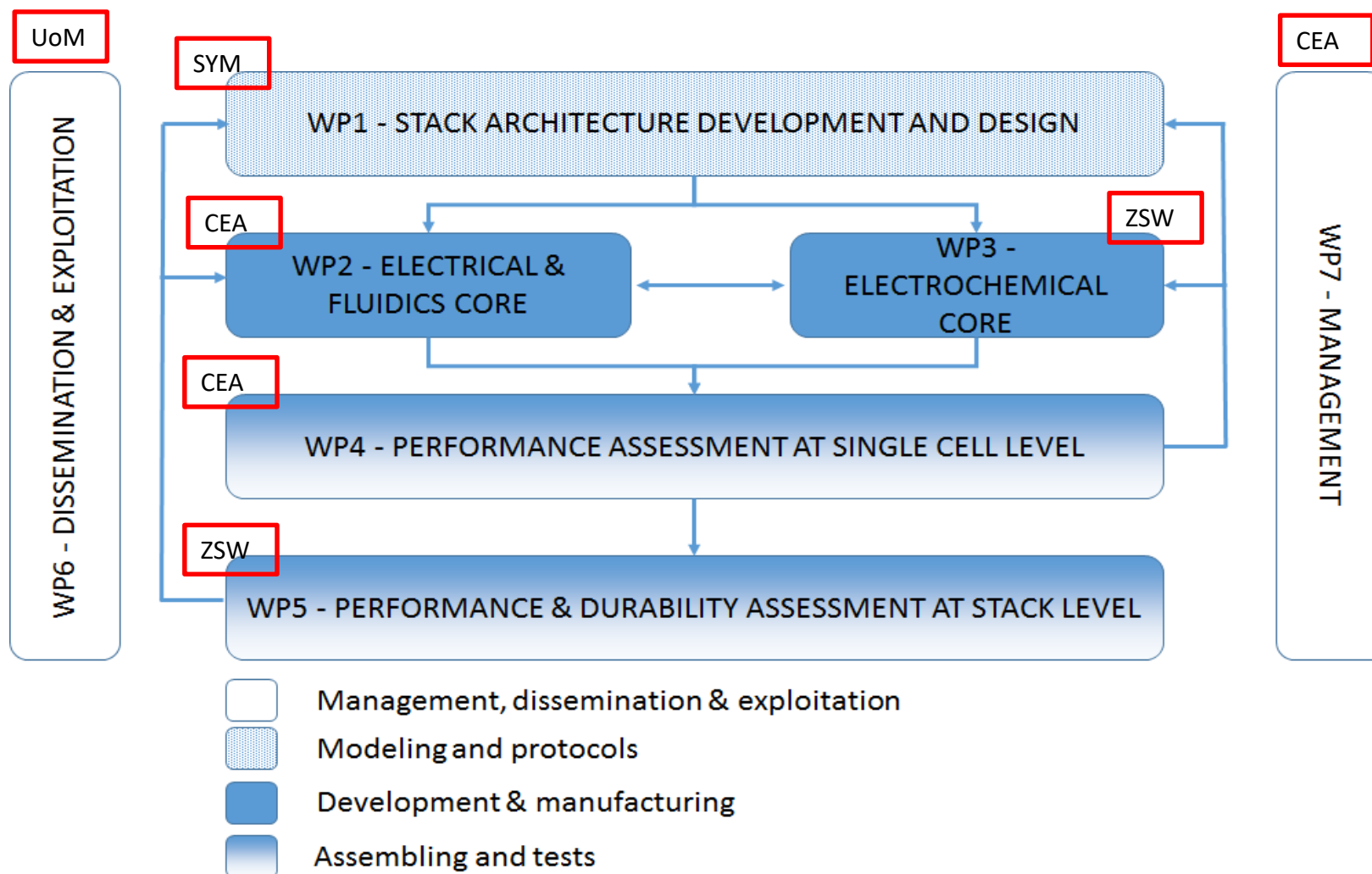
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CEA, ZSW

**DOLPHIN 100 kW stack
design & technologies**

Structure of the project



Short presentation of the partners

CEA-LITEN: from components to applications

CEA-LITEN

Thermal Systems



On board Systems



H2 technologies



PEMFC

Ink formulation, characterization



MEA manufacturing and assembly

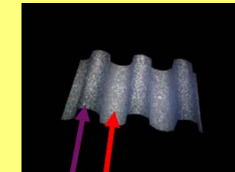


Performance/durability tests

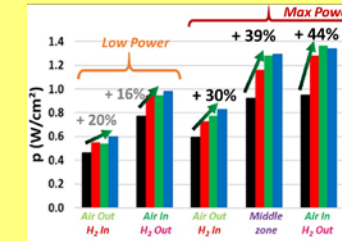


DOLPHIN

Rib-channel downsizing

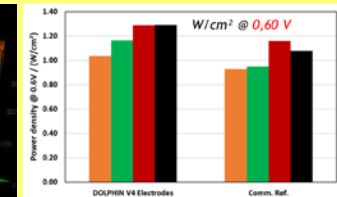
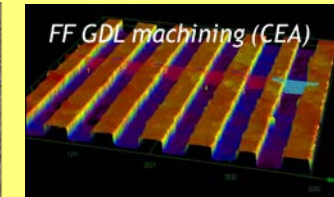
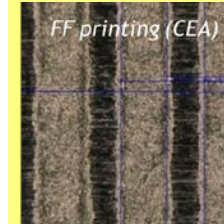


Rib/channel pitch

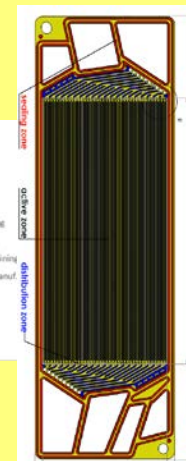
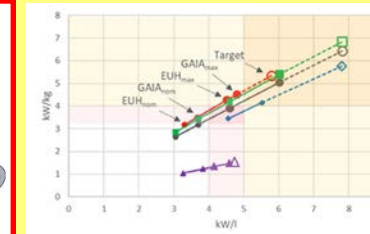
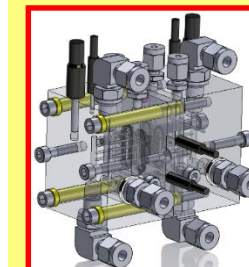


EFC, EC manufacturing

Electrodes



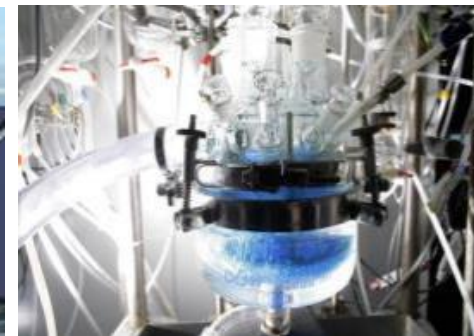
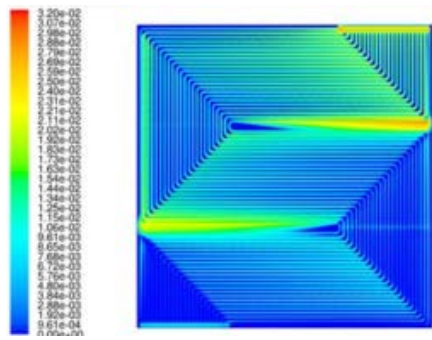
TP1, TP2, TP4 tests/analysis



A non-profit organization - 300 employees - 85% external funding

Applied Research & Development on New Energy Technologies:

- Batteries & Supercapacitors: materials, production technologies, systems, qualification
- Fuel Cells: technology, systems, production technologies, test-center
- Photovoltaic: thin film technologies (CIGS) & application systems
- Renewable Fuels: power-to-gas, biomass gasification
- Energy politics & economics, wind energy



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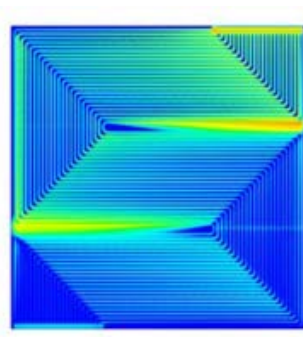
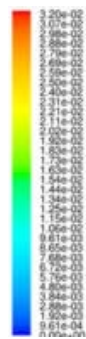
Applied Research & Development on New Energy Technologies

- Batteries & Sup
- Fuel Cells: techn
- Photovoltaic: th
- Renewable Fuel
- Energy politics &

ZSW Contributions to DOLPHIN:

- CFD modelling including all relevant processes
- Contribution to component, cell and stack designs
- Contribution to laser milling and additive manufacturing technology pathways
- MPL / protective diffusion layer development
- Contribution to single cell and stack assembly and testing

Qualification



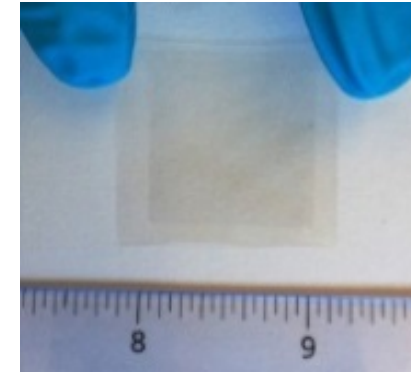
The University of Manchester



Public University in the UK
Member of the Russell Group of elite British research universities
Number of R&D personnel ~4,000
Turnover ~£100M

Contribution to Dolphin

Coating of proton conducting membrane with graphene



Aim: improve gas crossover, water management and membrane durability

Chemours participation in DOLPHIN

- CHEMOURS: A backward integrated chemistry company delivering membranes and dispersions
- Developed a 10 μm membrane, outperforming the 15 μm baseline membrane on durability and power density



Chemours is about Membranes and Dispersions
for PEM Fuel Cells and PEM Water Electrolyzers

- Tier-1 supplier, hydrogen solutions for light and heavy-duty vehicles
 - Fuel cell stack
 - Fuel cell system
 - Joint-venture with Schaeffler for bipolar plates manufacturing
 - New gigafactory in St Fons (Lyon) : 50 000 systems/year



INNOPLATE
A Schaeffler Symbio Hydrogen Company



- **Contribution to the project :**
 - WP1 leader :
 - Stack specification and design
 - ITP requirements
 - Assembling scheme and production protocols
 - Characterization protocols
 - Stamping technology assesment

HEXCEL (NYSE: HXL) – AT A GLANCE

- Leader in markets undergoing secular growth
- Broadest aerospace composite solution portfolio
- #1 in aerospace composites – by sales & production capacity
- 21 manufacturing sites | ~5,300 employees at FYE 2022
- High and numerous barriers to entry
- Culture of continuous improvement | Operational Excellence

Composite Lightweighting value proposition

- Stronger and lighter than metals
- Superior life cycle costs to metals
- Reduces fuel use and emissions for transportation applications
- Enables leading-edge product design

Markets

COMMERCIAL AEROSPACE

59%*

Wings, Fuselage
Secondary & Interior structures
Engines & Nacelles

SPACE & DEFENSE

29%*

Rotorcraft
Fixed Wing
Satellites & Launchers

INDUSTRIAL

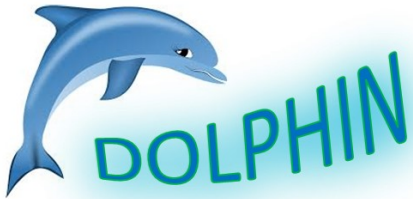
12%*

Automotive, Consumer Electronics,
Marine, Recreation & Wind Energy

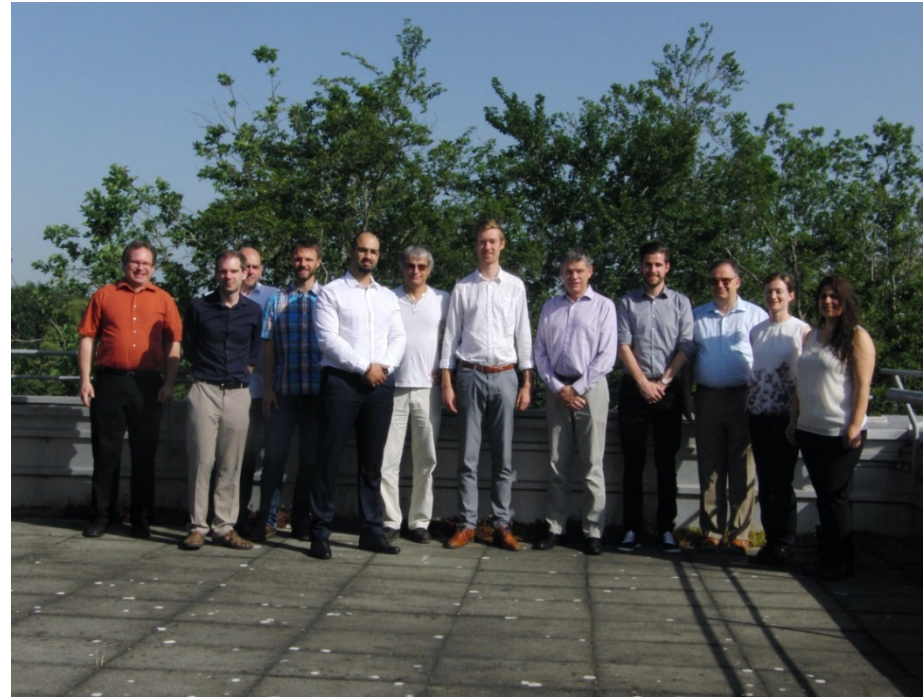
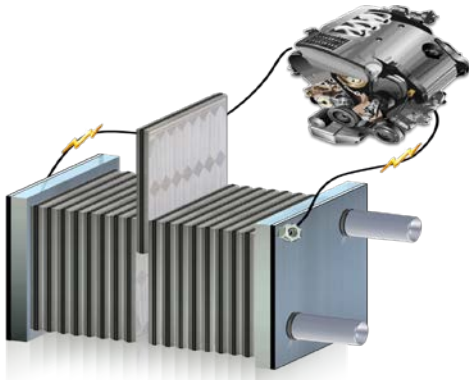
LTM SALES* | \$1.6 billion

* Last 12-months sales through Q1 2023

Thank you for your attention!



Disruptive pemfc stack with nOvel materials,
Processes, archItecture and optimized INTERfaces



The DOLPHIN project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No. 826204. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.

<https://www.dolphin-fc.eu/>
Joel.pauchet@cea.fr

