DOLPHIN

Disruptive pemfc stack with n**O**vel materia**L**s, **P**rocesses, arc**H**itecture and optimized **IN**terfaces

Overview of DOLPHIN: objectives and developments

(Joël PAUCHET, CEA, coordinator)

DOLPHIN Overview

Call year: 2018

Call topic:
FCH-01-6

Game changer fuel cell stack for automotive applications

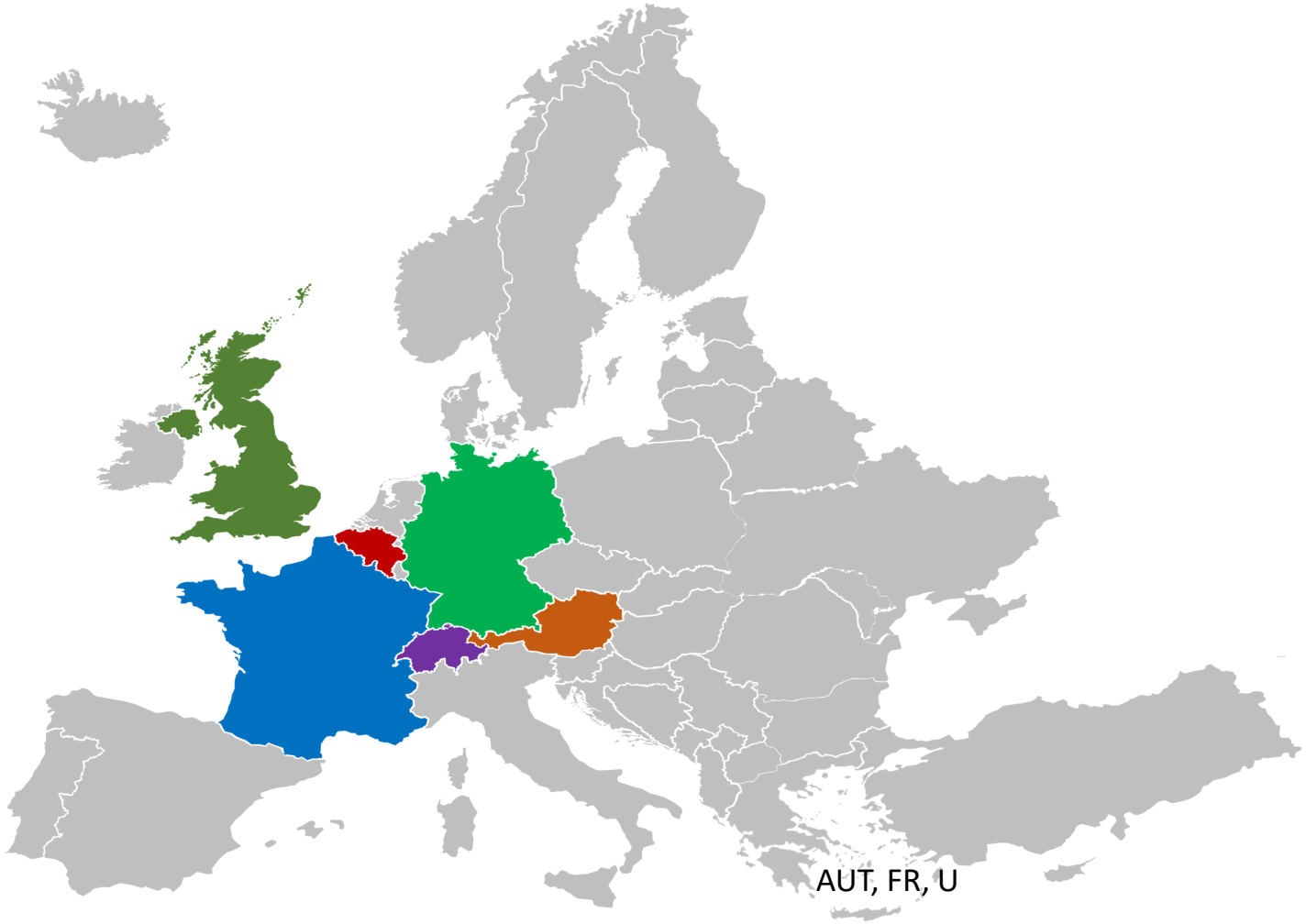
Project dates: 01/01/2019 – 31/12/2022

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

Overview of DOLPHIN

Consortium

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



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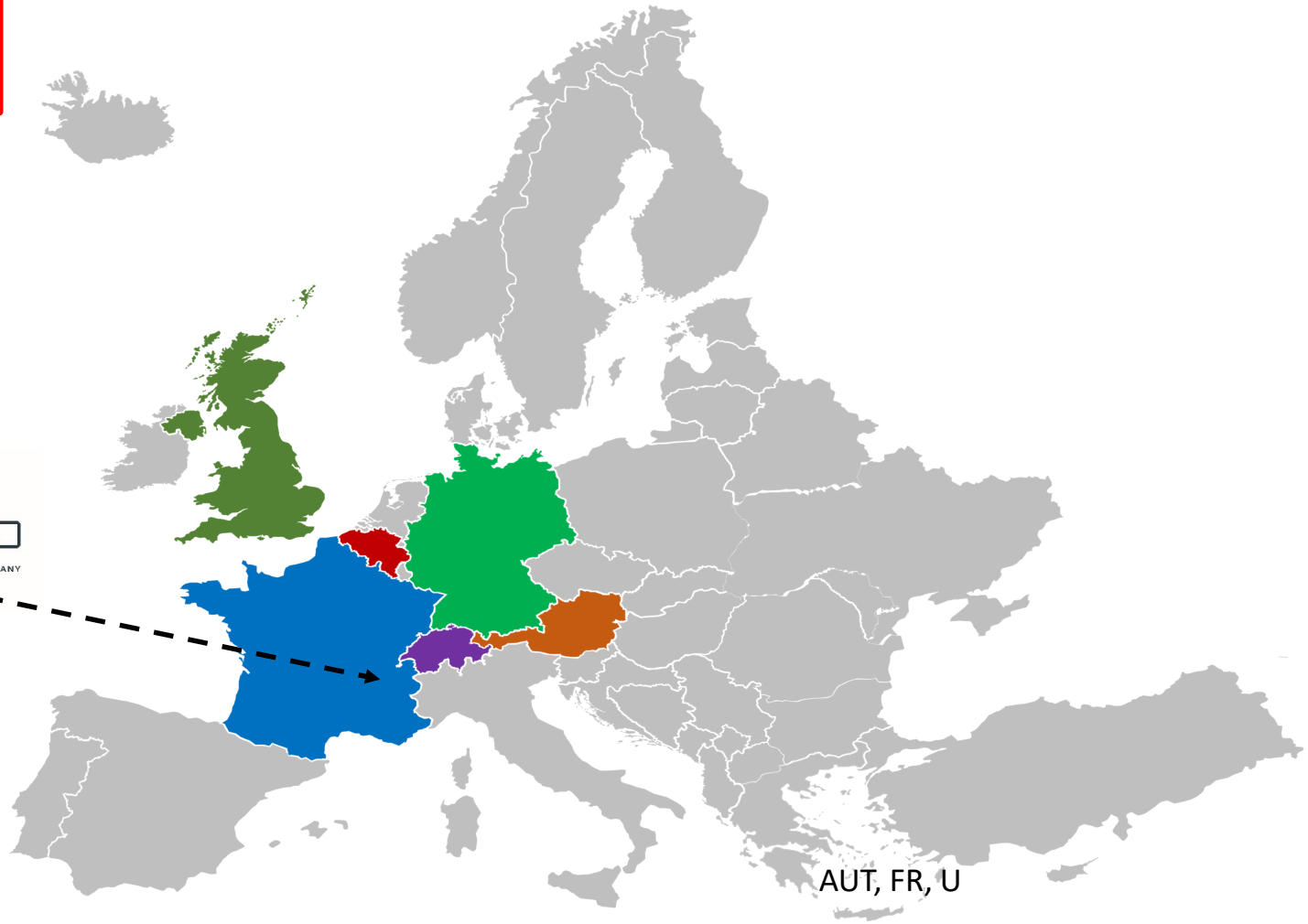

SYMBIO
A FAURECIA MICHELIN HYDROGEN COMPANY

Requirements
Metallic-based solutions and process

Overview of DOLPHIN

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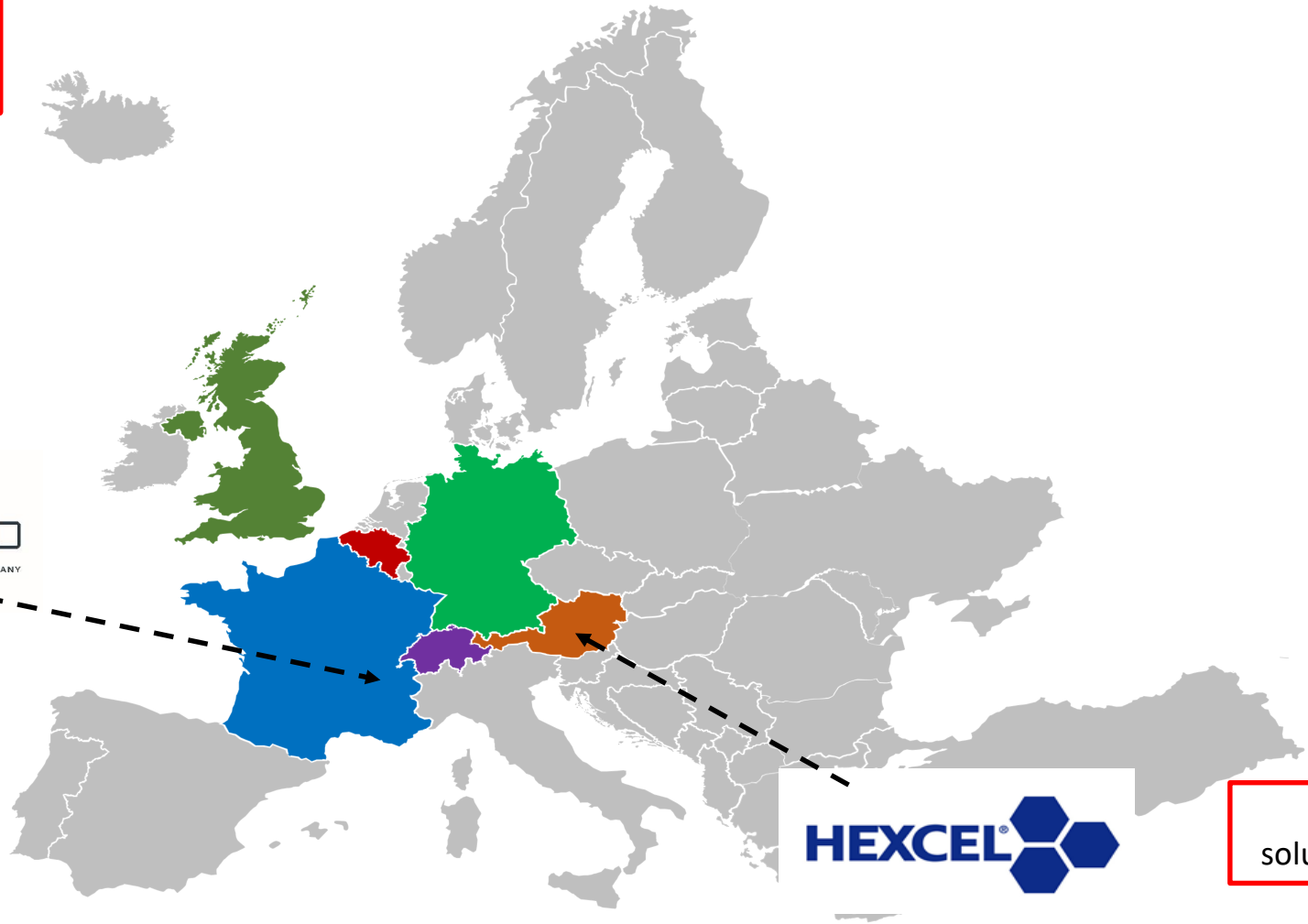

SYMBIO
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Requirements
Metallic-based solutions and process

HEXCEL

Carbon-based
solutions and process

Overview of DOLPHIN

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Improved membrane and ionomer

Chemours™

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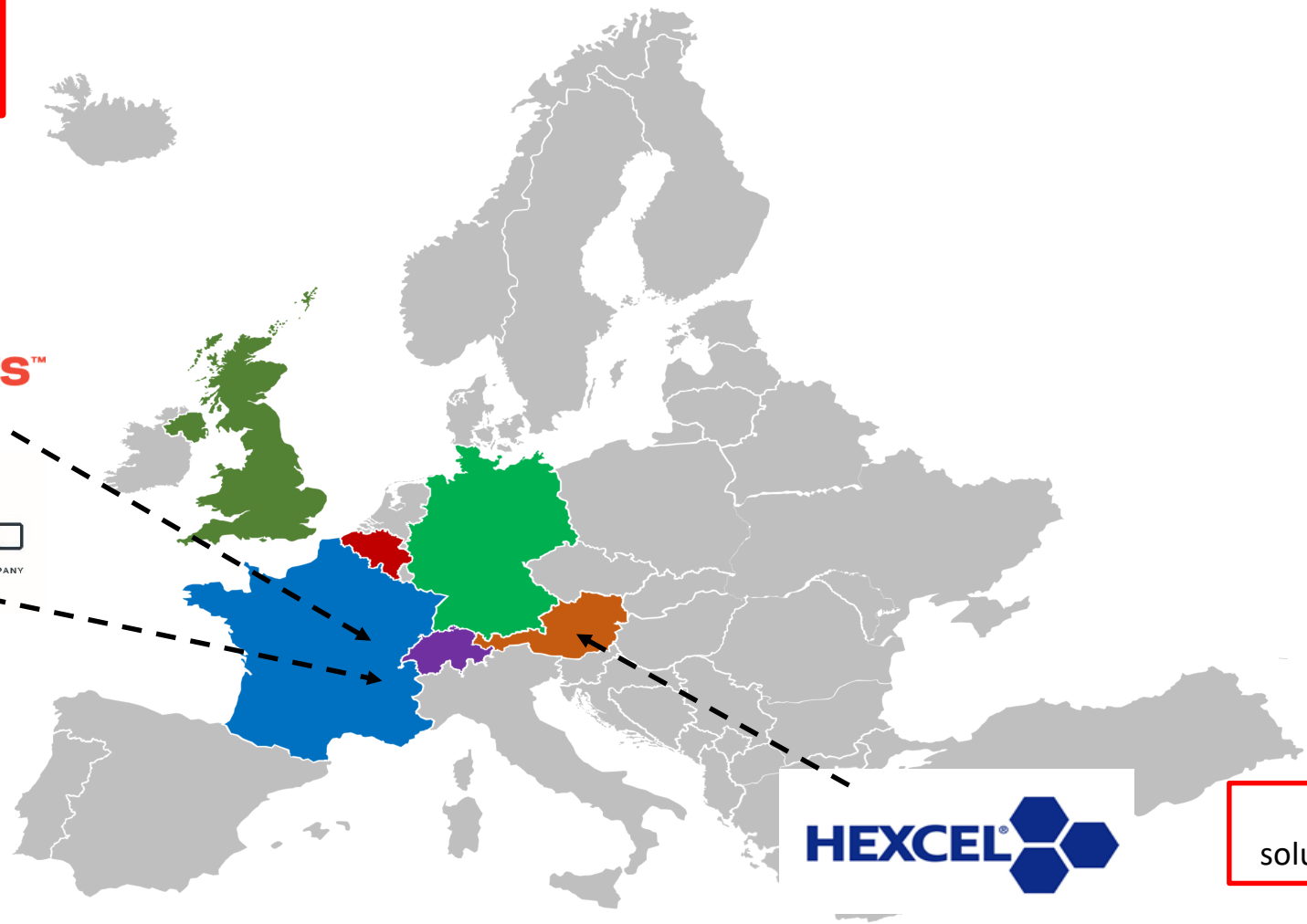
Requirements
Metallic-based solutions and process



HEXCEL

Carbon-based solutions and process

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DMG MORI ADDITIVE

Additive manufacturing

Improved membrane and ionomer

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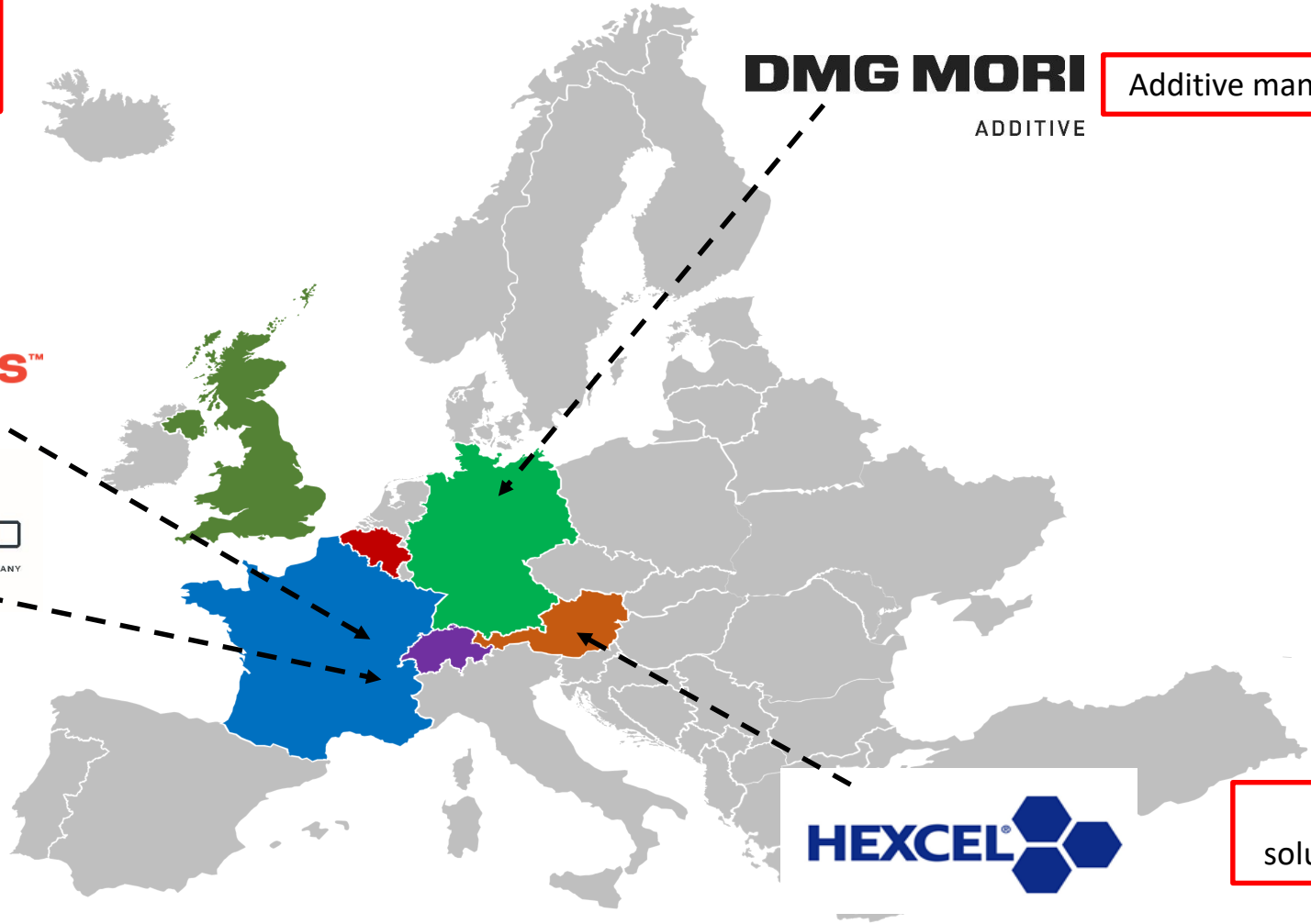

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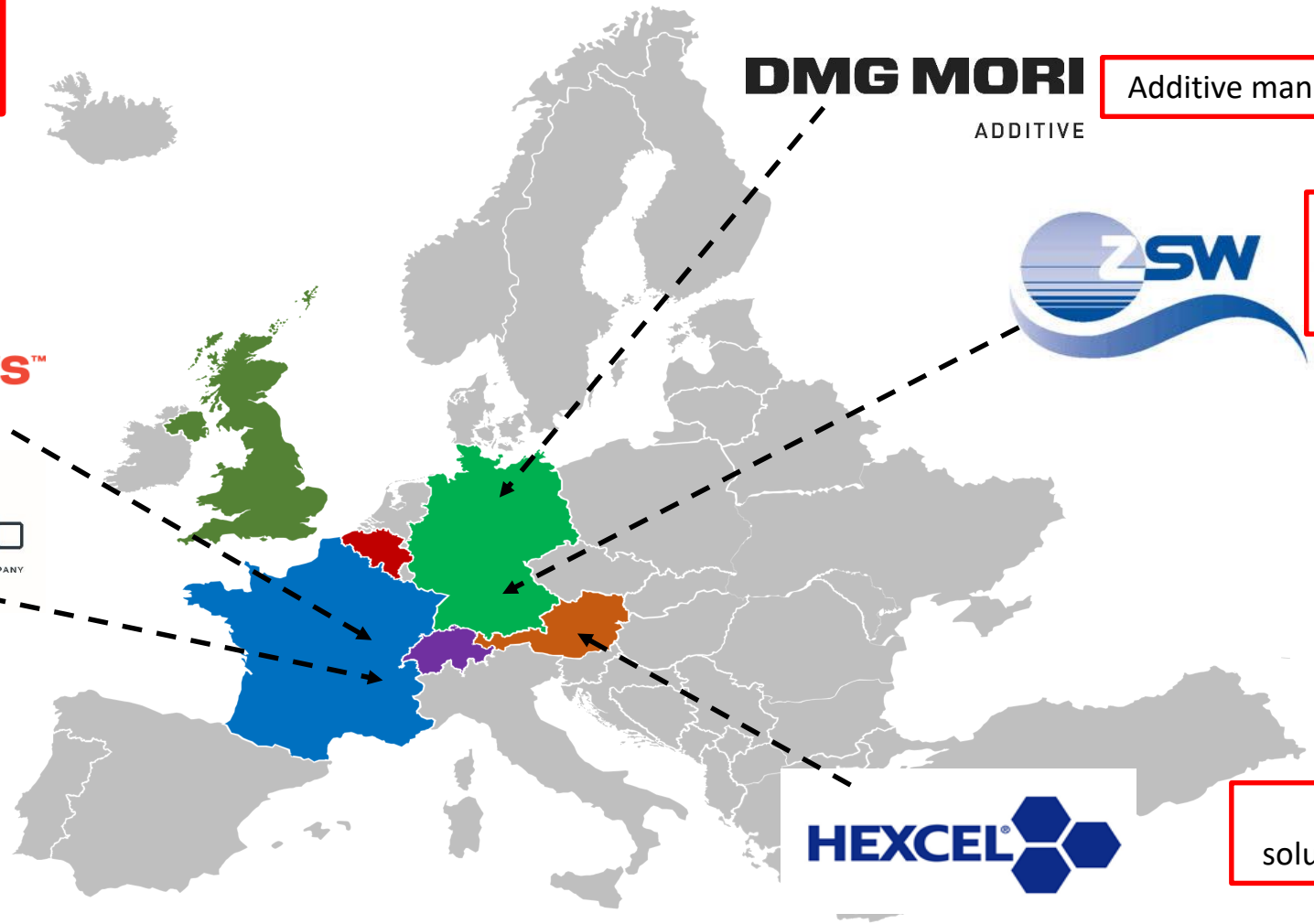
DMG MORI ADDITIVE — Additive manufacturing

Improved membrane and ionomer

Chemours™

ZSW — Modeling
Laser milling
Cell and stack tests



SYMBIO A FAURECIA MICHELIN HYDROGEN COMPANY

Requirements
Metallic-based solutions and process

HEXCEL — Carbon-based solutions and process

Overview of DOLPHIN

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Graphene coating

MANCHESTER 1824
The University of Manchester

DMG MORI ADDITIVE

Additive manufacturing

Improved membrane and ionomer

Chemours™

ZSW

Modeling
Laser milling
Cell and stack tests

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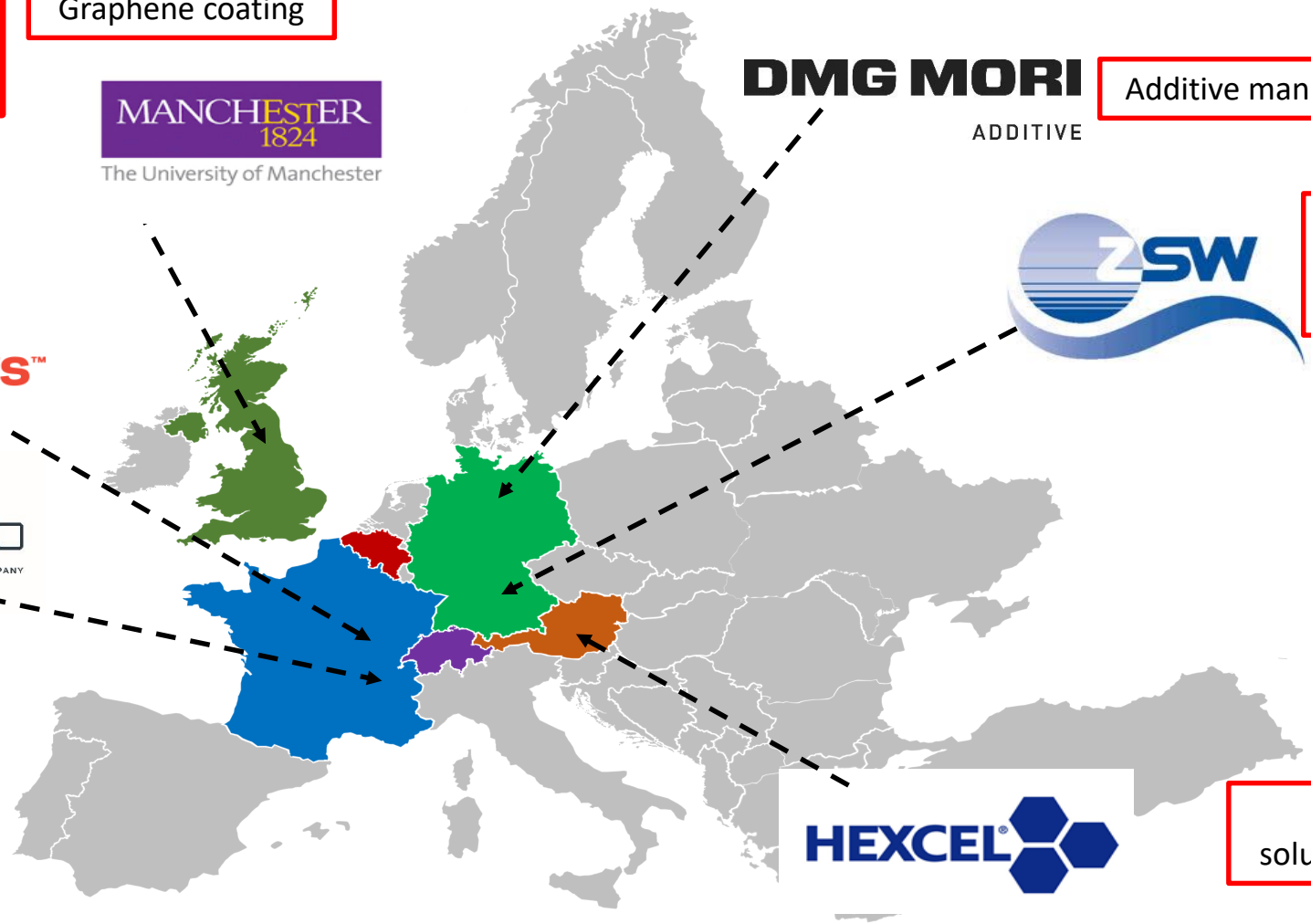

Requirements
Metallic-based solutions and process

HEXCEL

Carbon-based solutions and process

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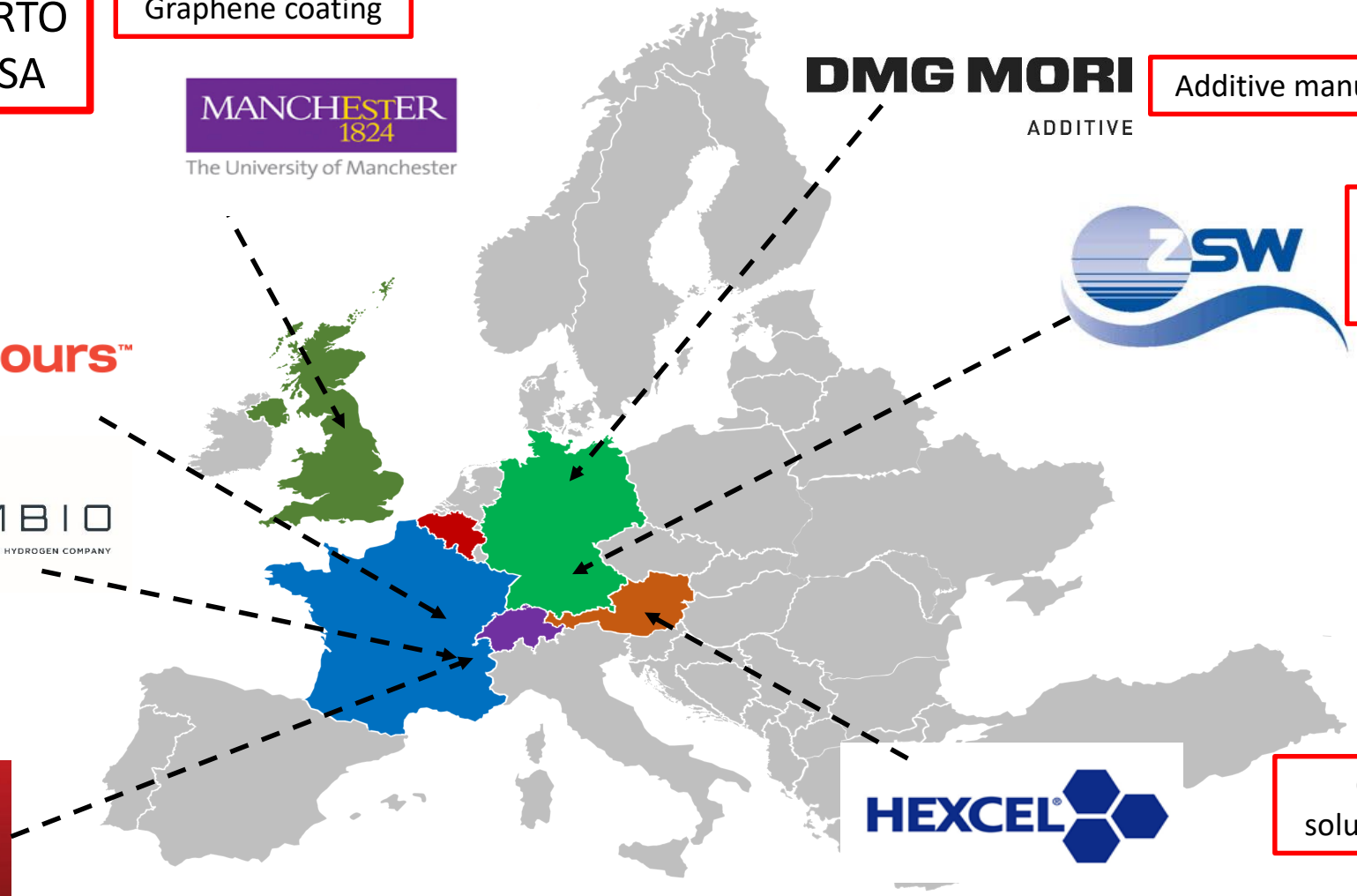

Requirements
Metallic-based solutions and process

Coordination
Modeling
Printing
Cell and stack tests

liten cea tech

HEXCEL

Carbon-based solutions and process

Overview of DOLPHIN

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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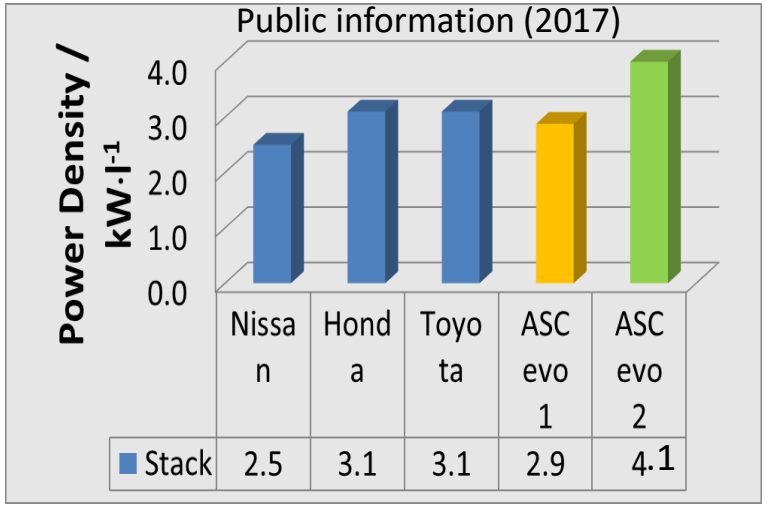

Main KPIs	Int. SoA 2017 (AutoStackCore)	DOLPHIN (~ FCH-JU 2024 targets)
Weight-specific power density (kW/kg) at nominal power	3.4	≥ 4.0 (≥ +18%)
Volumetric power density (kW/l) at nominal power	4.1	≥ 5.0 (≥ +25%)
Area-specific power density (W/cm²) at 0.66 V	1.13	2.0 (+75%)
Cost (€/kW) at 100 000 units/year	36.8	< 20 (-45%)
Durability (hours)	3,500	6,000 (+70%)
Stack max operating temperature (°C)	95	105 (+10°C)

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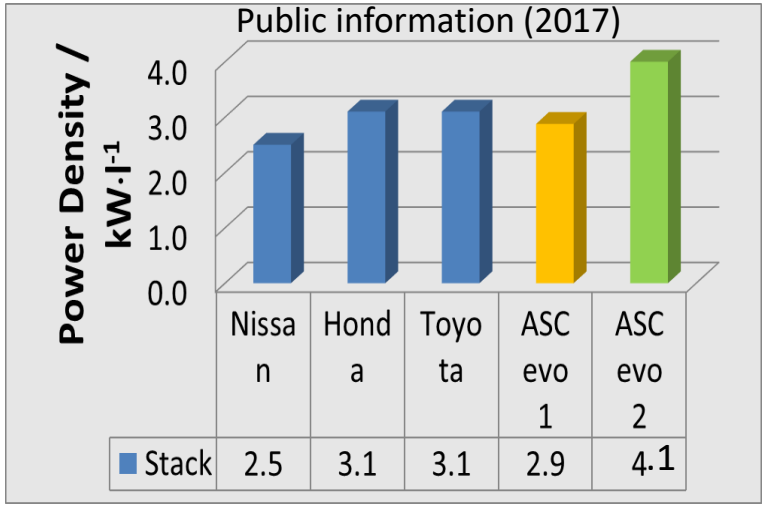

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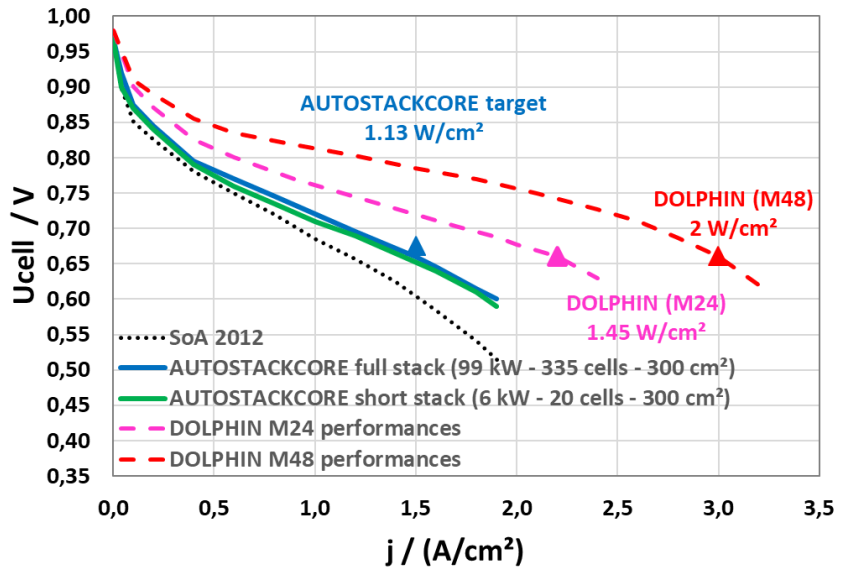

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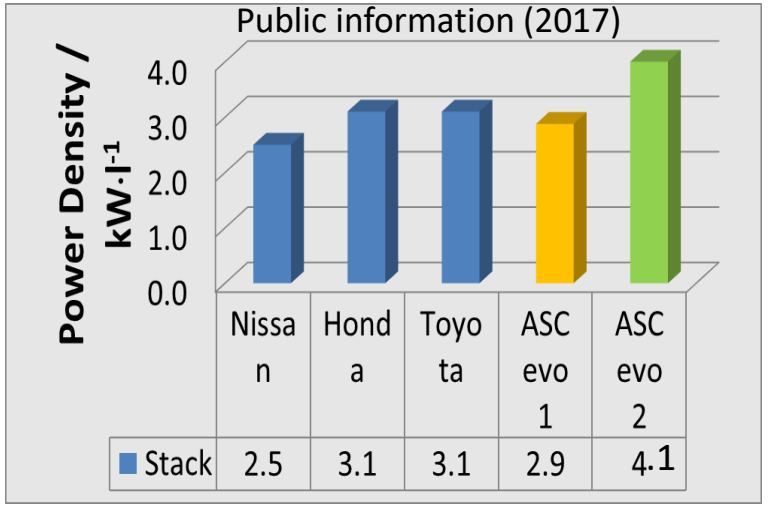

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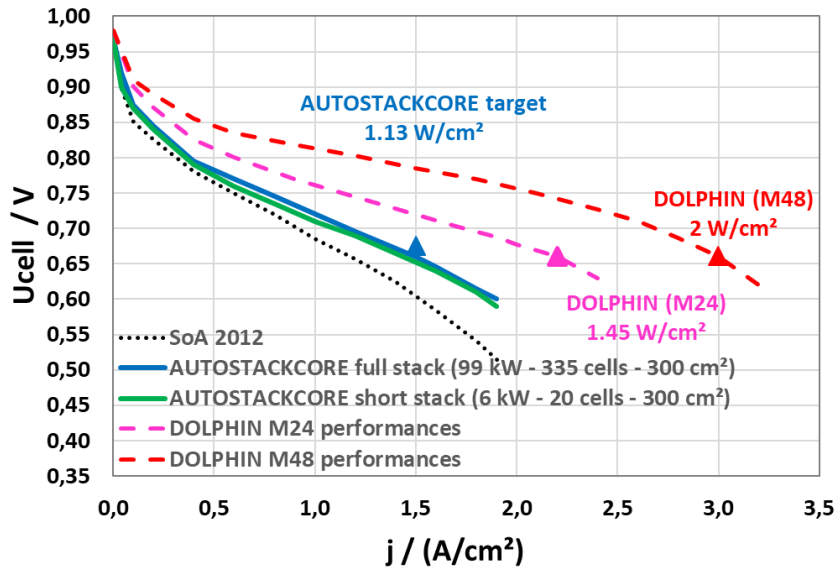
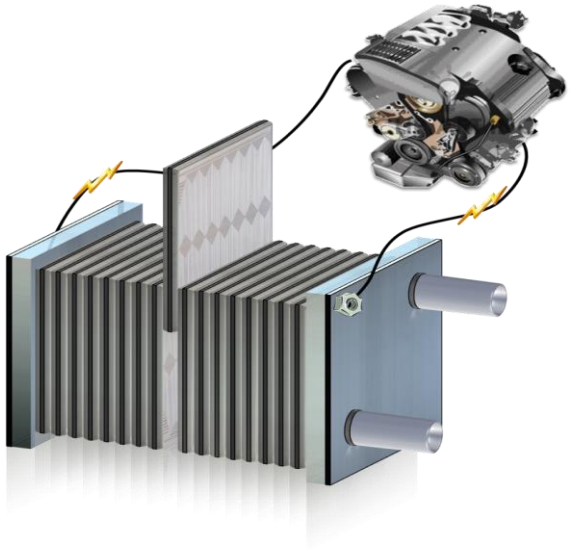


Challenging!

Overview of DOLPHIN

Technical Developments

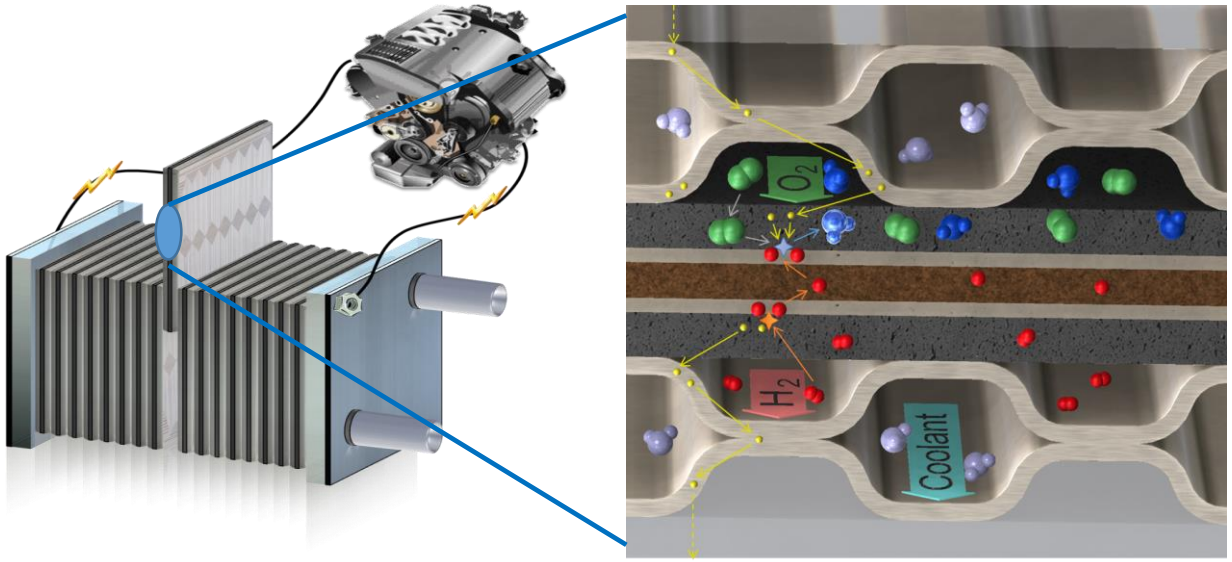
5 kW demonstrator (CEA, ZSW) with improved materials/processes



Technical Developments

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

Single Repeat Unit



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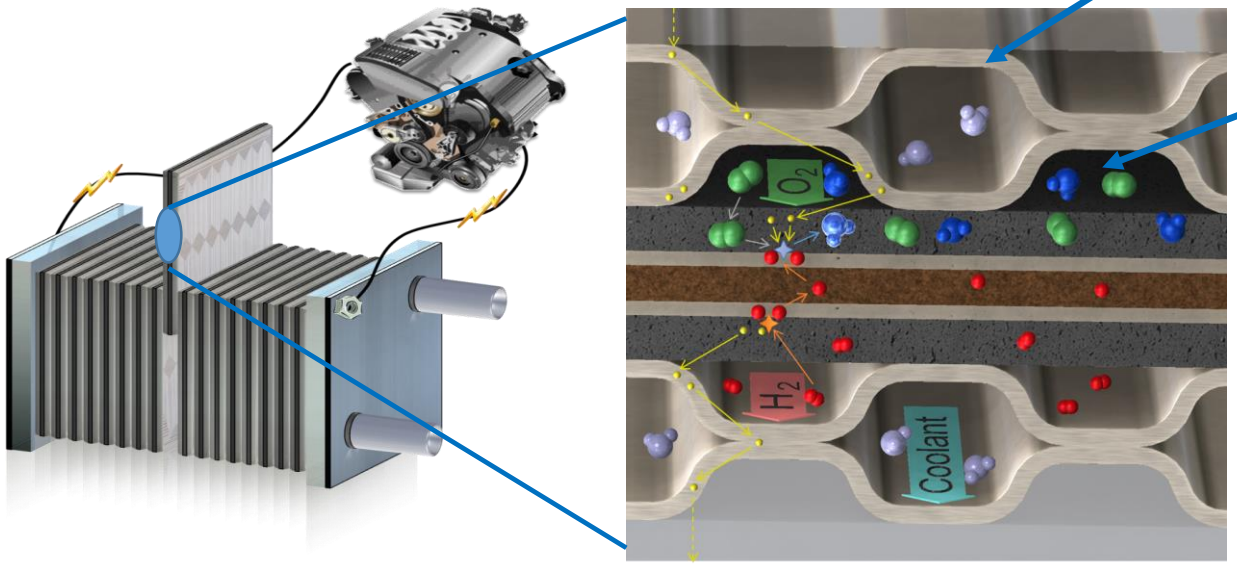

Thinner metallic plates (SYM)
Thinner carbon-based plates (HEXCEL)
Treatments of plates (SYM, CEA)

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

Electrical and Fluidics Core

Overview of DOLPHIN

Technical Developments

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

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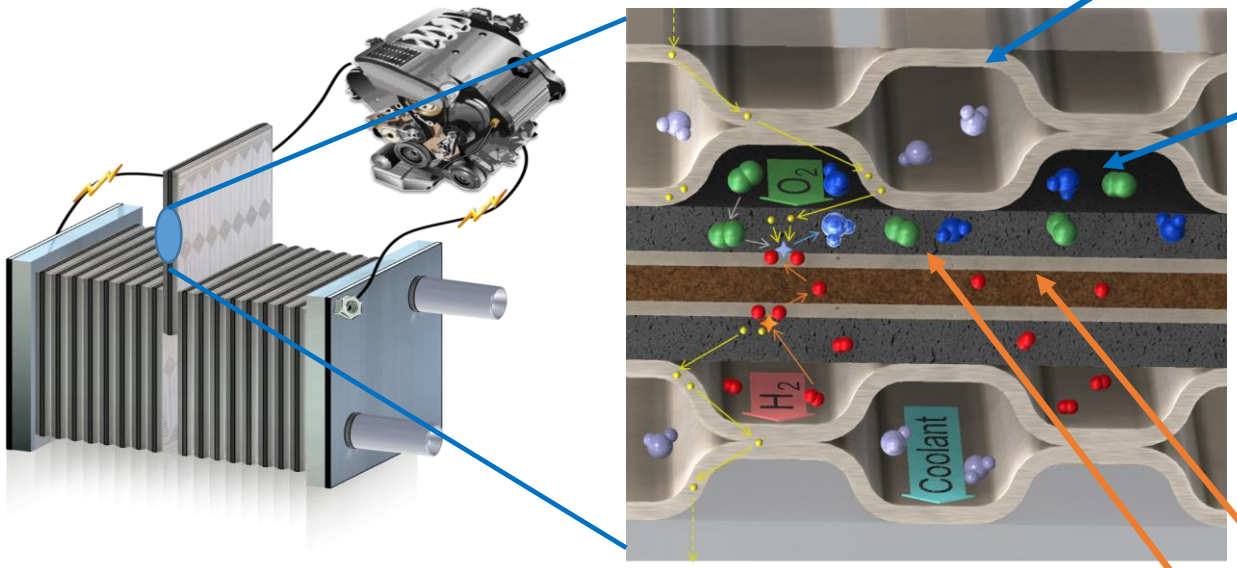

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Electrical and Fluidics Core

Thinner (<10 µm) or beyond PFSA membrane (CHEM) with SLG coating (UoM)

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

Electrochemical Core

Overview of DOLPHIN

Technical Developments

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

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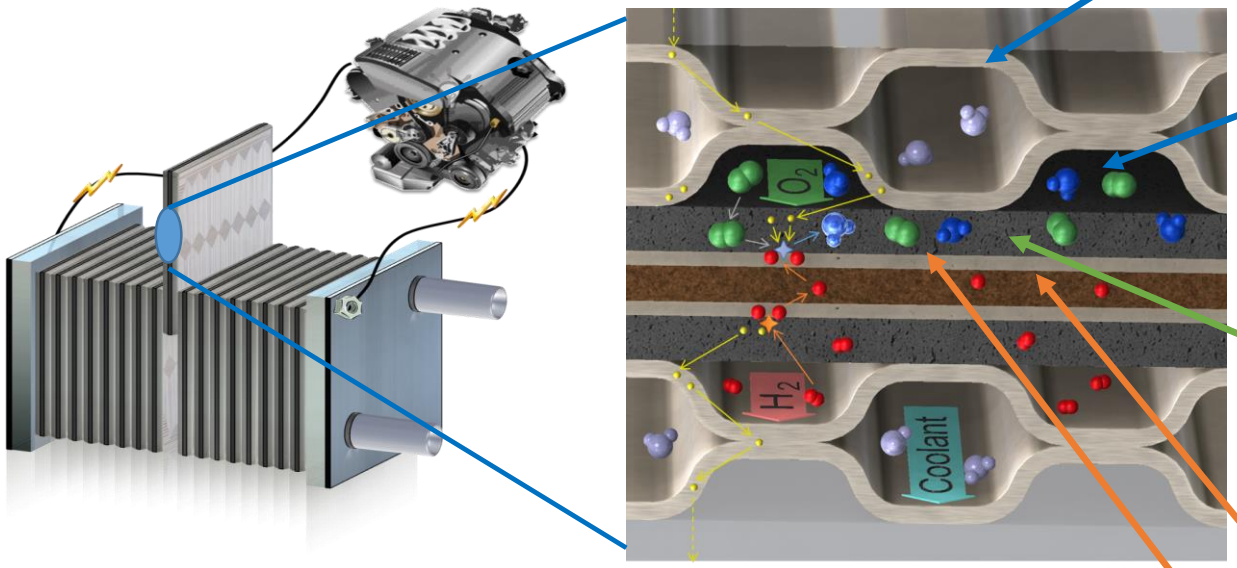

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Electrical and Fluidics Core

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

Or only MPL coated onto AL (ZSW, CEA)

Interface

Thinner (<10 µm) or beyond PFSA membrane (CHEM) with SLG coating (UoM)

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

Electrochemical Core

Overview of DOLPHIN

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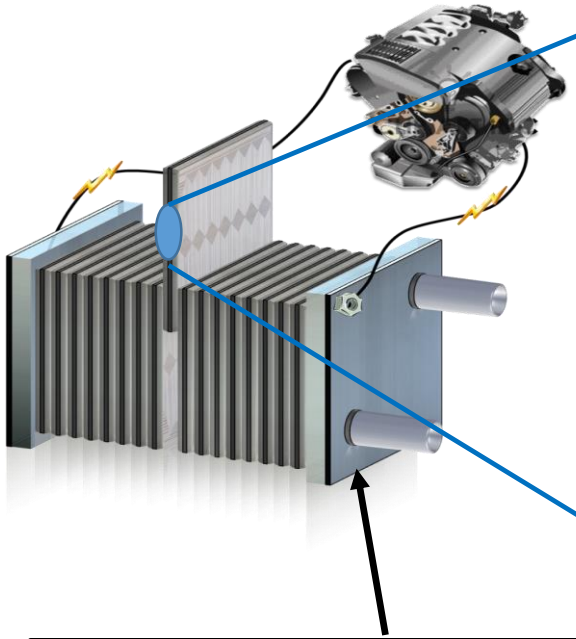
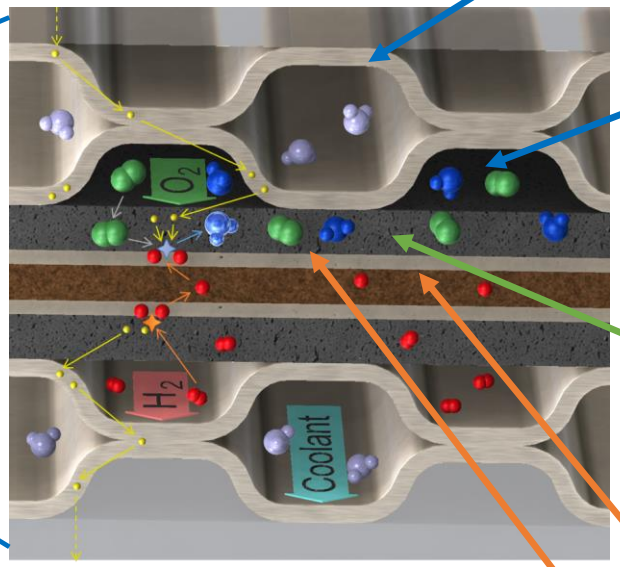


3D Lighter Integrated Terminal Plate (composite, HEXCEL)



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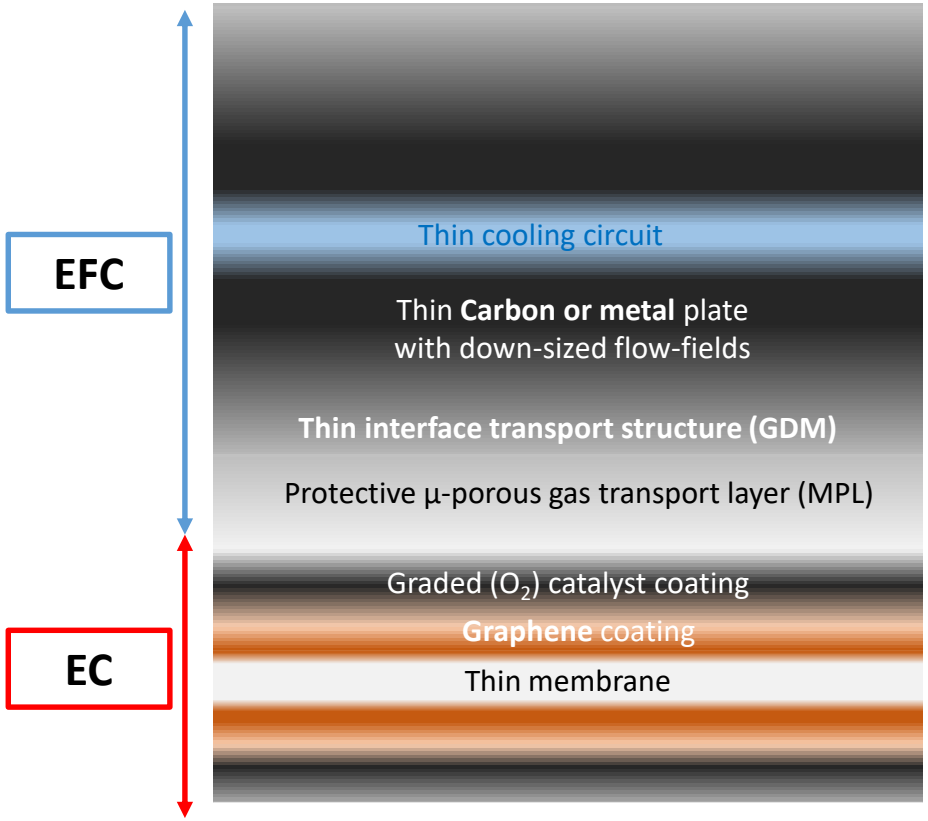
Electrochemical Core

Overview of DOLPHIN

Example of potential final designs

'Lower' risk approach : downsized components, alternative materials and processes, membrane protection



Overview of DOLPHIN

Example of potential final designs

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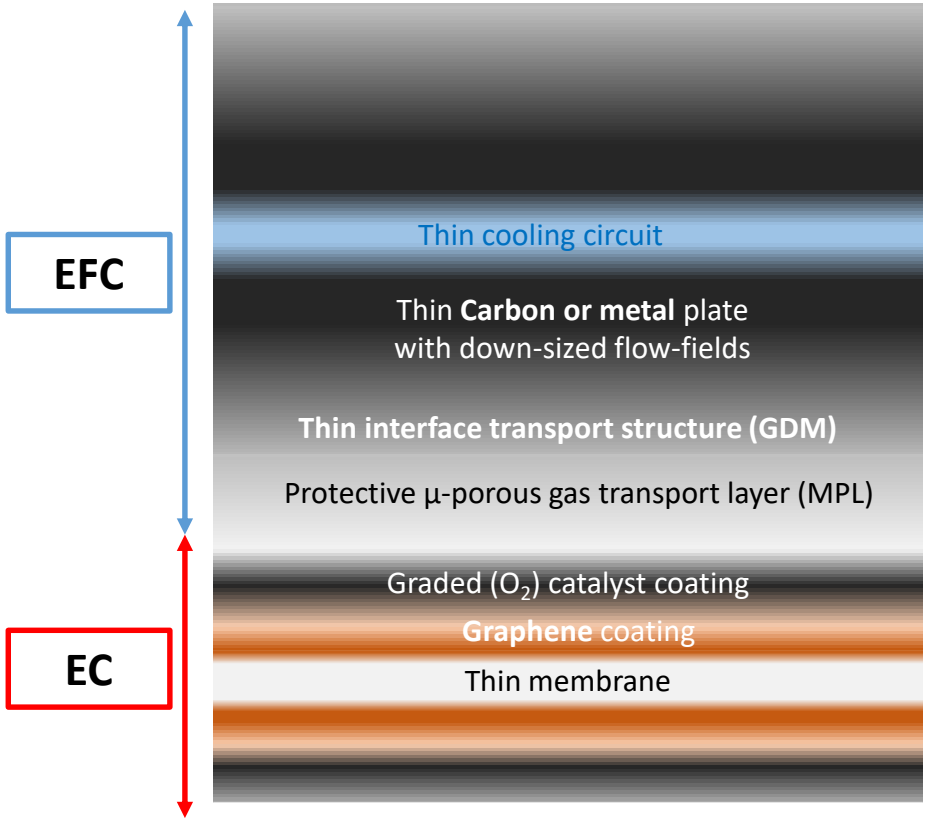
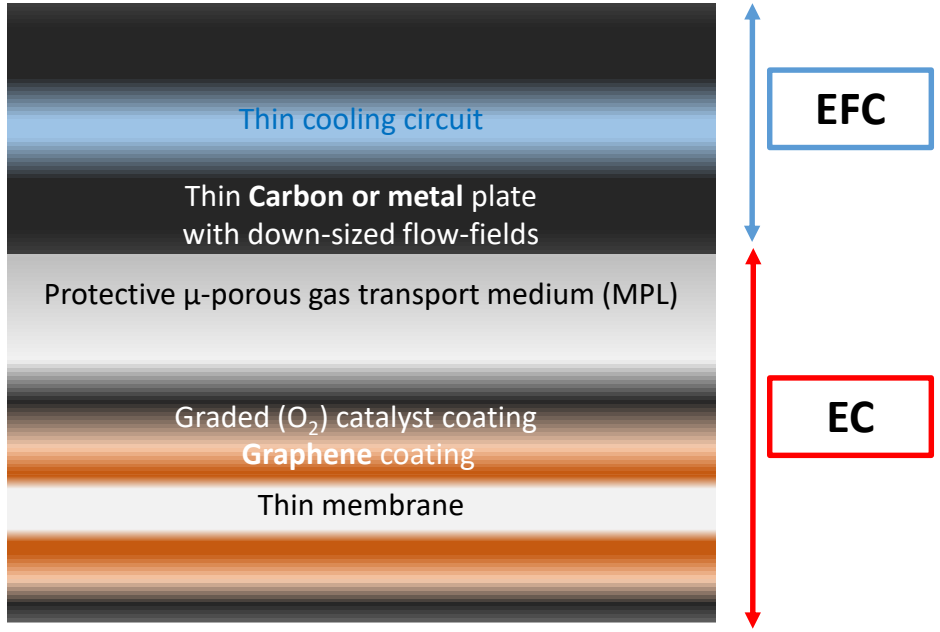


'Higher' risk approach: in addition, remove the GDM



Reduce mass, volume
Increase performance, durability

Overview of DOLPHIN

Contribution to the targets

Main KPIs	Int. SoA 2017 (ASC)	DOLPHIN	Developments
Area-specific power density (W/cm²) at 0.66 V	1.13	2.0 (+75%)	• Downscale rib-channel dimensions (EFC) • Thinner GDM (or remove GDM) and thinner membrane (<10 µm, EC) • In-plane gradients (EC)
Weight-specific power density (kW/kg) at nominal power	3.4	≥ 4.0 (≥ +18%)	• Increase W/cm² • Reduce sheet thickness down to 50 µm (EFC) • Replace metallic sheets by carbon sheets (EFC, ITP) • Remove GDM, lighter ITP
Volumetric power density (kW/l) at nominal power	4.1	≥ 5.0 (≥ +25%)	• Increase W/cm² • Reduce sheet thickness down to 50 µm (EFC) • Replace metallic sheets by carbon sheets (EFC, ITP) • Remove GDM • Thinner ITP
Cost (€/kW) at 100 000 units/year	36.8	< 20 (-45%)	• Reduce quantity of materials • New manufacturing processes
Durability (hours)	3,500	6,000 (+70%)	• Replace metallic sheets by carbon sheets (remove welding, EFC) • In-plane and through-plane gradients (EC, EFC) • SLG coated membrane
Stack max operating temperature (°C)	95	105 (+10°C)	• New membrane (EC) • SLG coated membrane (EC)

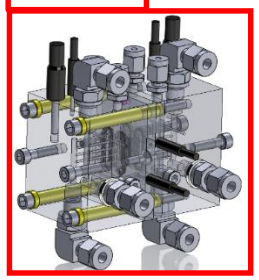
A step by step approach

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

TP1



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

TP2

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

Overview of DOLPHIN

A step by step approach

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PLATFORM 1: DIFFERENTIAL CELL TO MIMIC LOCAL CONDITIONS IN THE STACK — 1.8 cm² — CEA

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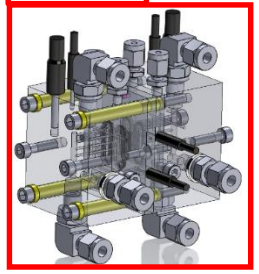

Performance/durability screening
- Cooling
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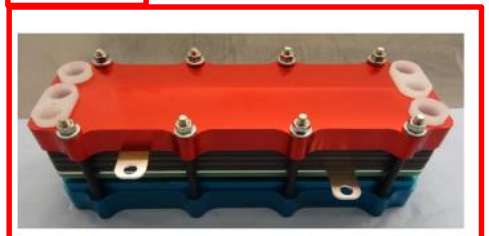
PLATFORM 3: SHORT STACK — 100 cm² — CEA, ZSW

TP2



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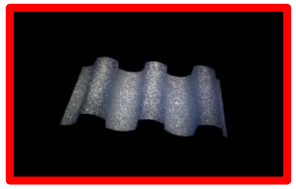
DOLPHIN 100 kW stack design & technologies

Overview of DOLPHIN

Structure of the project



UoM

WP6 - DISSEMINATION & EXPLOITATION

SYM

WP1 - STACK ARCHITECTURE DEVELOPMENT AND DESIGN

CEA

WP2 - ELECTRICAL & FLUIDICS CORE

ZSW

WP3 - ELECTROCHEMICAL CORE

CEA

WP4 - PERFORMANCE ASSESSMENT AT SINGLE CELL LEVEL

ZSW

WP5 - PERFORMANCE & DURABILITY ASSESSMENT AT STACK LEVEL

CEA

WP7 - MANAGEMENT

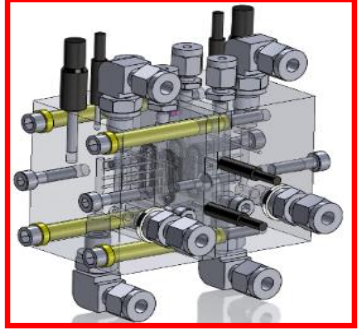
Management, dissemination & exploitation

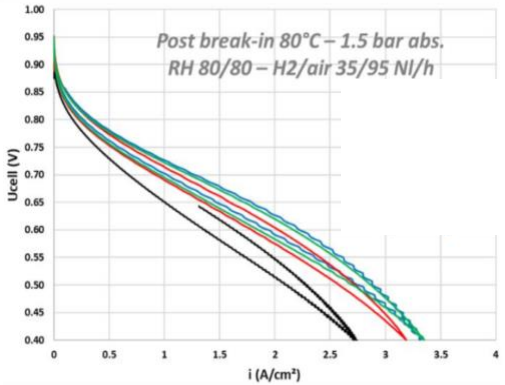
Modeling and protocols

Development & manufacturing

Assembling and tests

TP1





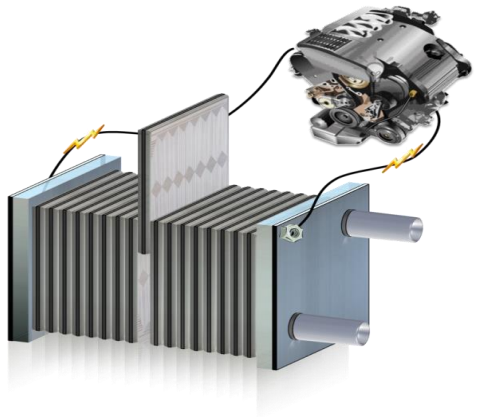
TP2

Overview of DOLPHIN

Thank you for your attention!

DOLPHIN

Disruptive pemfc stack with nOvel materiaLs, Processes, arcHitecture and optimized INterfaces



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DOLPHIN Project: 1st public workshop (cell and manufacturing technologies) - virtual – 18/06/2021