DOLPHIN

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

DOLPHIN Workshop, Ulm June 16th 2023

Global Progress and Main Highlights

J. Pauchet, all

https://www.dolphin-fc.eu/

Joel.pauchet@cea.fr

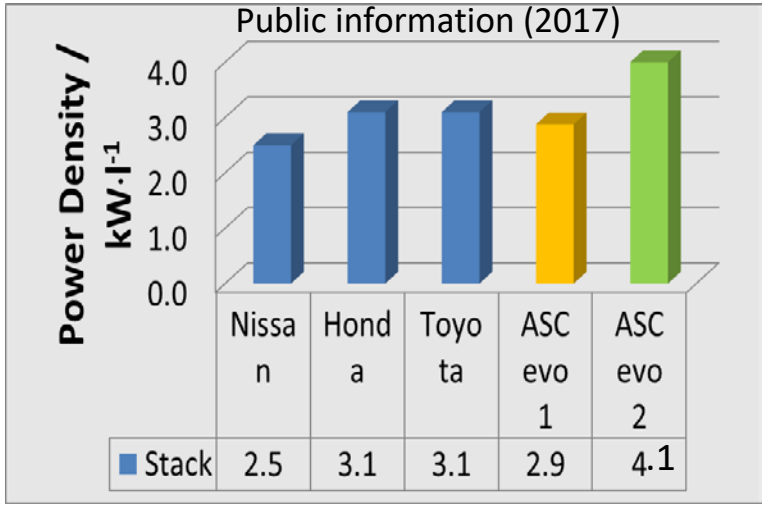
Main Objectives

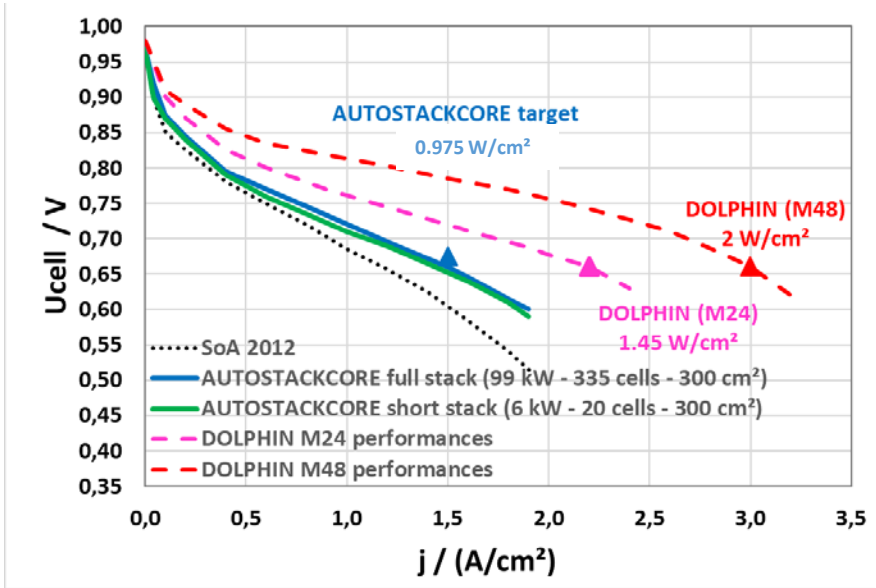
Validate **disruptive technologies for 100 kW light-weight & compact fuel cell stack designs,** with high power density and enhanced durability (under automotive application conditions), and **compatible with large scale/mass production** of full power-stacks.

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 (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)

GAIA (2023): 1,78 W/cm²@0,6 V, specific OC
ASI (2023): 1,3 W/cm²@0,65 V, system optimized OC

Challenging!





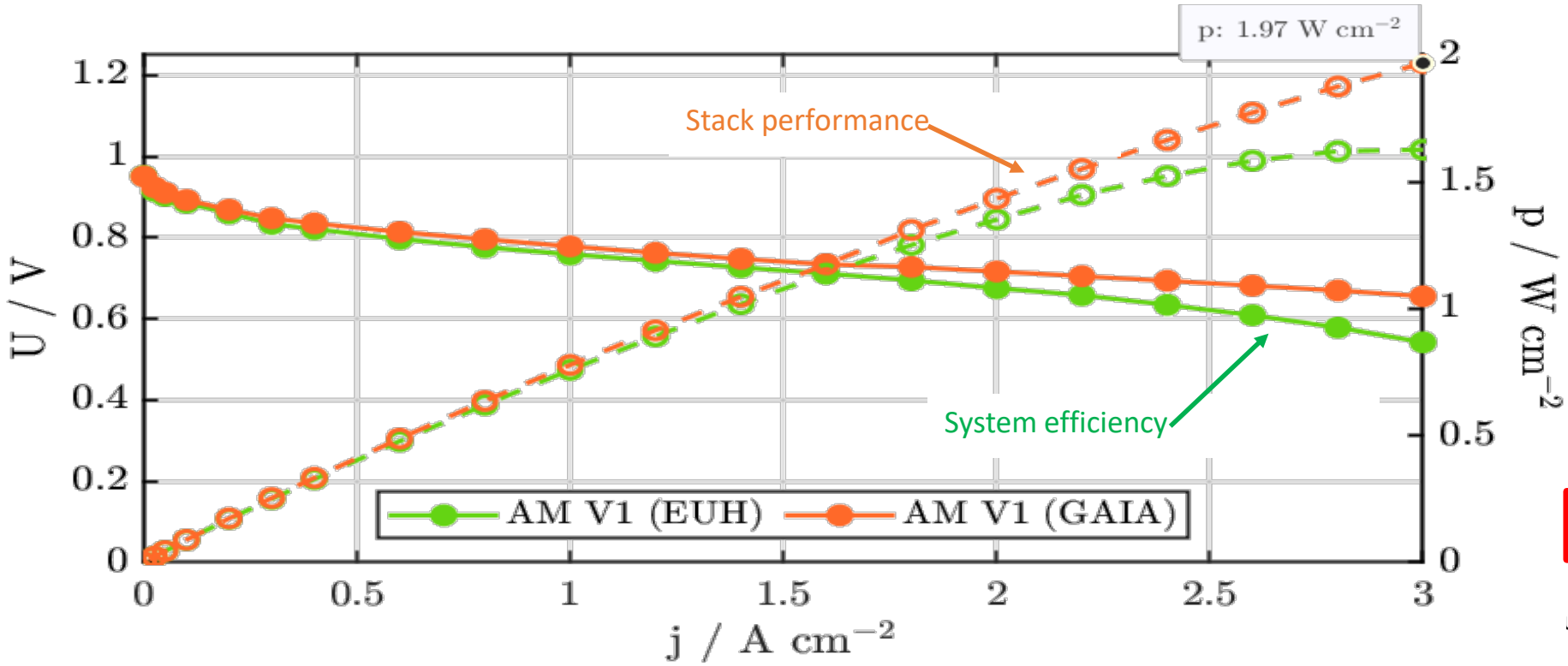
Best performance so far

SoA (ASC, 2017): 0.975 W/cm² @ 0,66V
(nominal ASC conditions)

AWP 2024 target: 2.0 W/cm²@ 0.66V

Status (06/2023, 100 cm²):
1.45 - 1.97 W/cm² @ 0.66V, 100 cm²,
OC for stack (GAIA) or system (EUH)
efficiency, 0,1+ 0,4 mgPt/cm²

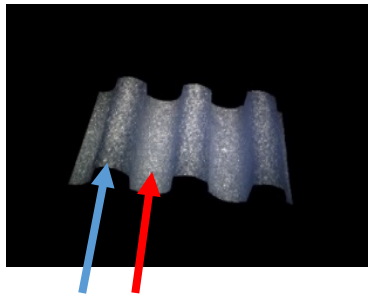
EC: membrane/ionomer (Chemours), ink formulation/process (CEA)
EFC: thin FF (Additive Manufacturing, DMG-MORI, ZSW)
TP2 100 cm²



Main developments?

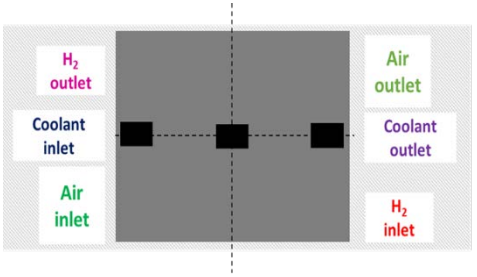
Pitch downsizing

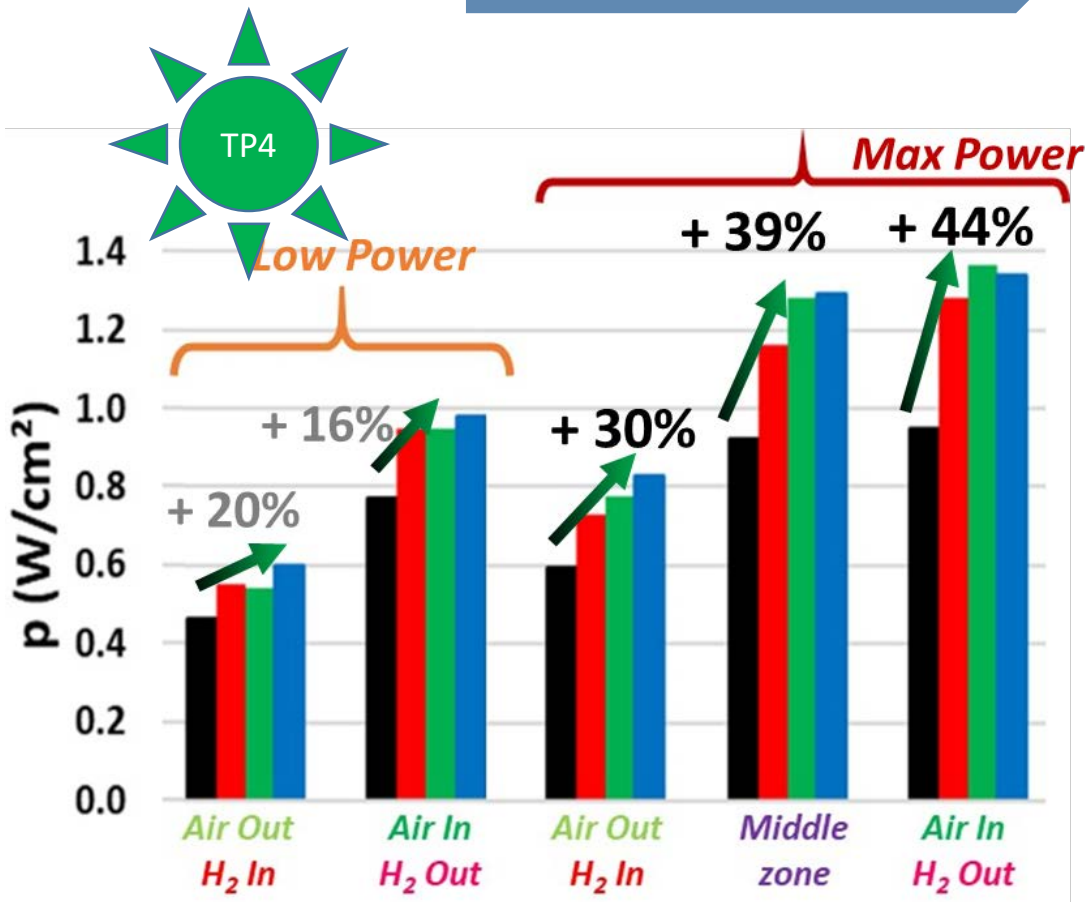
SoA (ASC, 2017): pitch 1.2 mm



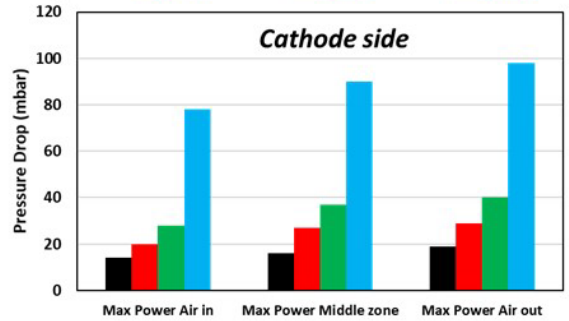
Rib/channel pitch

TP1 (1.8 cm²) to mimic local stack conditions (CEA)





Other materials and/or processes
Pitch ~ 0.4 - 0.8 mm

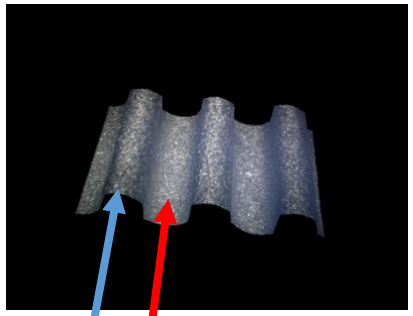


Pitch 600/600 µm
Pitch 400/400 µm
Pitch 200/200 µm
Pitch 100/100 µm

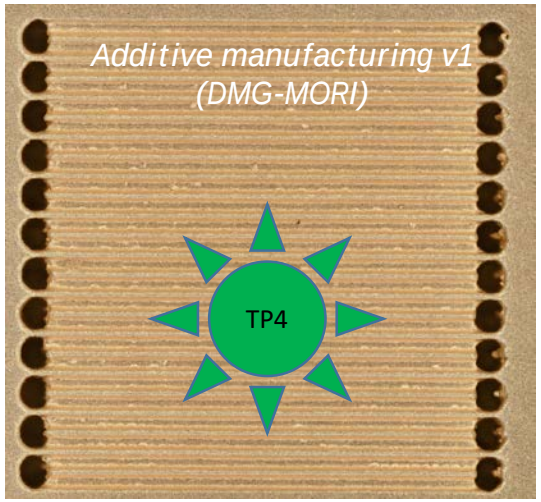
Introduced in TP4 (5 kW stack, CEA, ZSW)

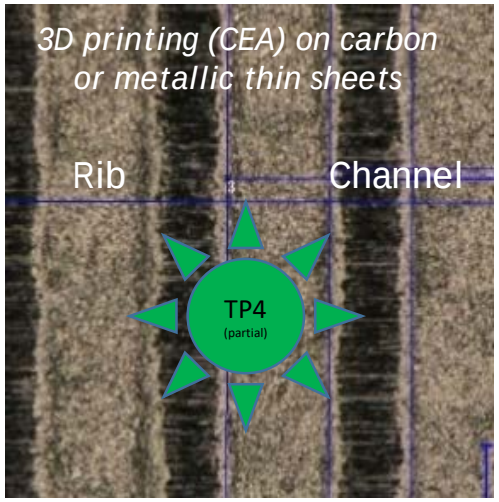
Manufacturing of thin Flow-Fields

SoA (ASC, 2017): metallic stamped, Cell pitch 1.2 mm



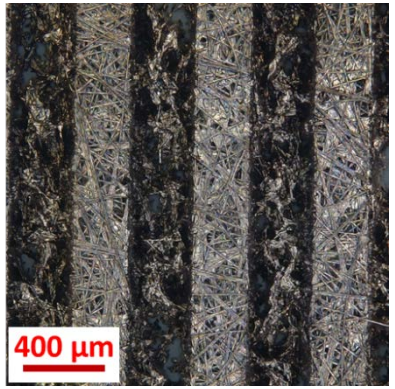
Rib / channel / depth in the range 200 – 400 µm

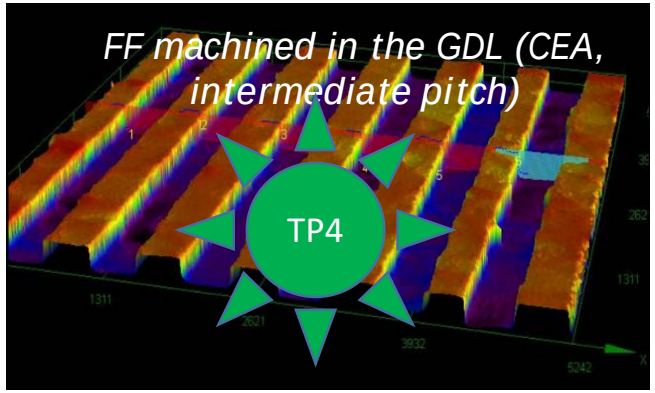


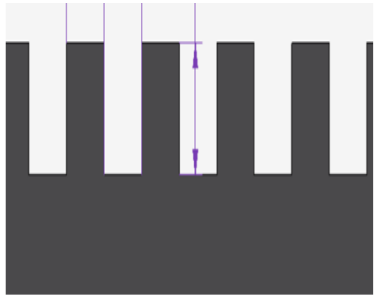


Other materials and/or processes
Cell pitch ~ 0.4 - 0.8 mm

Status (06/2023): Pitch ~ 0.4 - 0.8 mm, metallic or carbon







Laser milled graphite plate (ZSW, thin pitch)

Introduced in TP4 (5 kW stack, CEA, ZSW)

Increase of performance

SoA (ASC, 2017): 0.975 W/cm² @ 0,66V (nominal ASC conditions)

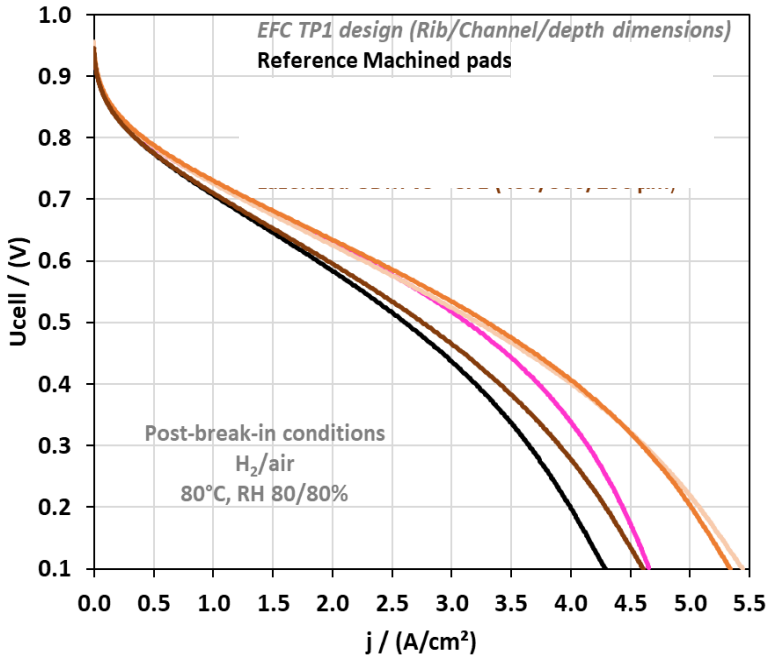
AWP 2024 target: 2.0 W/cm²@ 0.66V

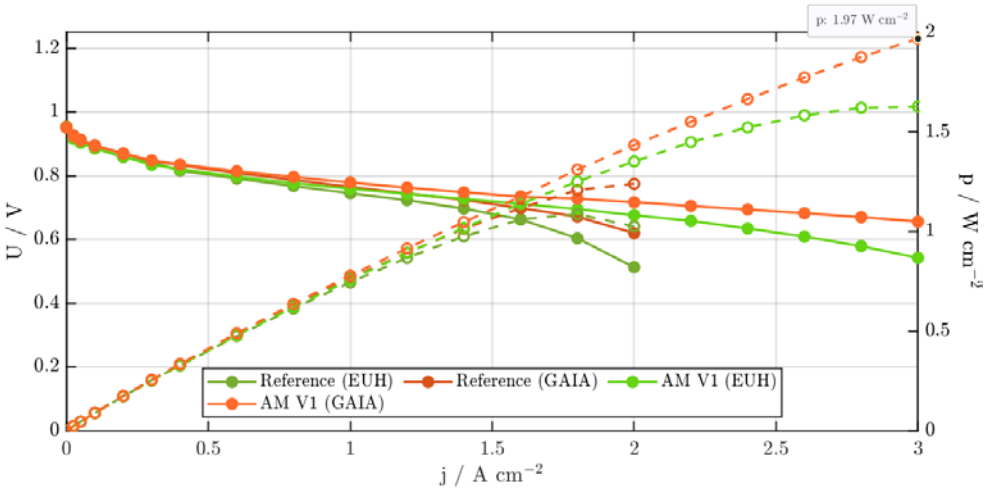
Status (06/2023): 1.45 - 1.97 W/cm² @ 0.66V, 100 cm²

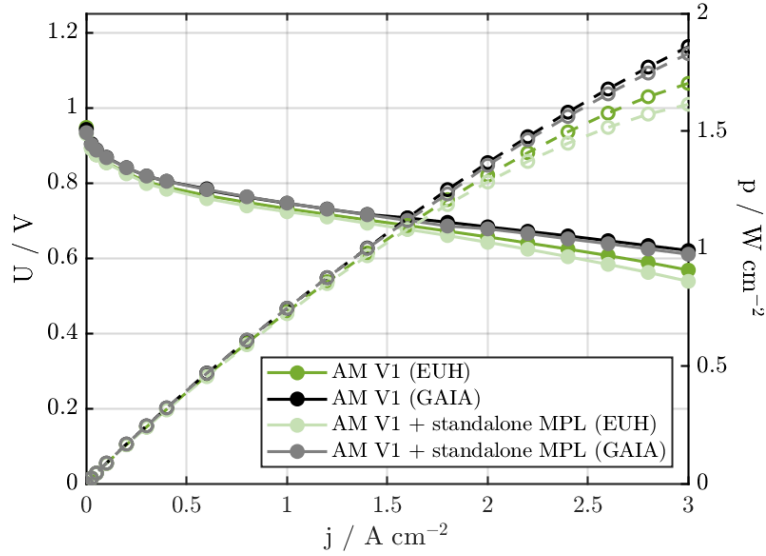
FF inside the GDL

Thin FF by additive manufacturing

Removal of the fibre substrate on one side







Introduced in TP4

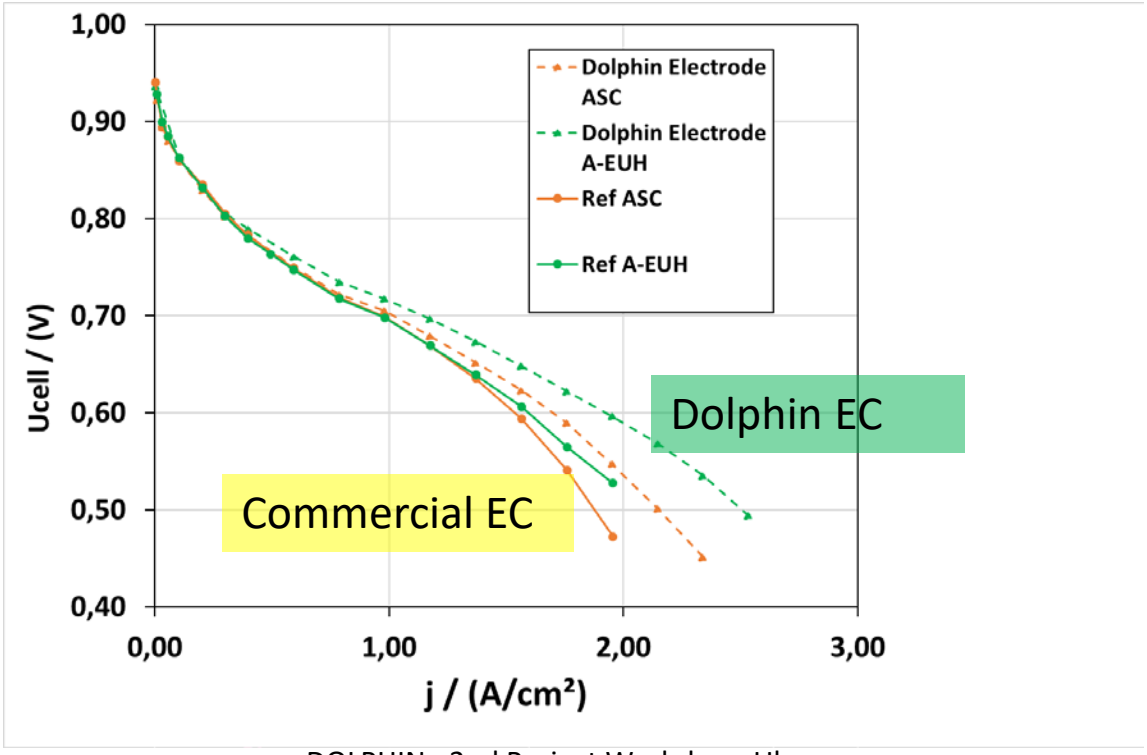
Electrochemical Core

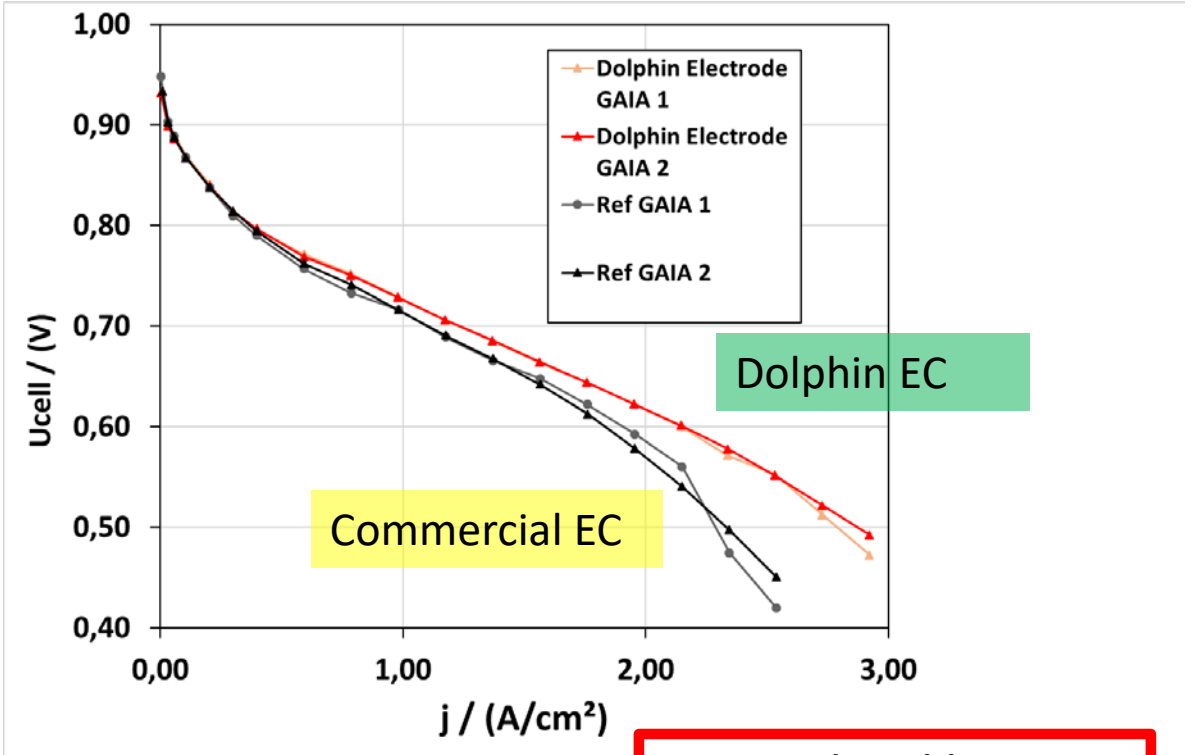
SoA (ASC, 2017): 0.975 W/cm² @ 0,66V
(nominal ASC conditions)

AWP 2024 target: 2.0 W/cm²@ 0.66V

Status (06/2023):
1.45 - 1.97 W/cm² @ 0.66V, 100 cm²,
0,3-0,4 mgPt/cm²

Chemours: NDP 8011 membrane, D2020 ionomer
CEA: ink formulation, manufacturing process
Ref GDL and EFC





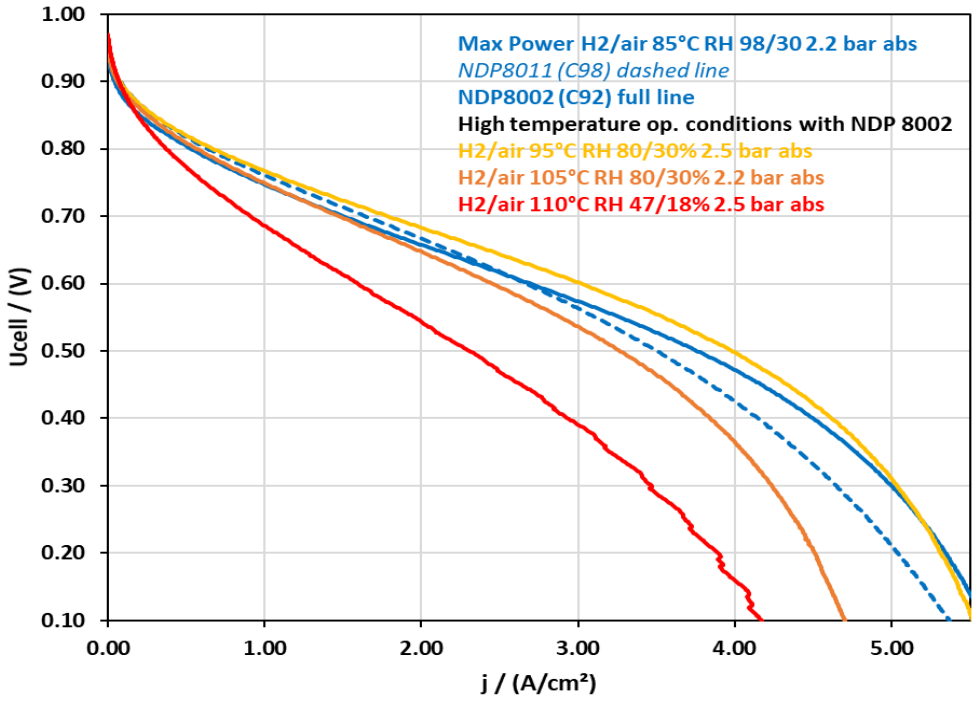
Introduced in TP4

Increase of temperature

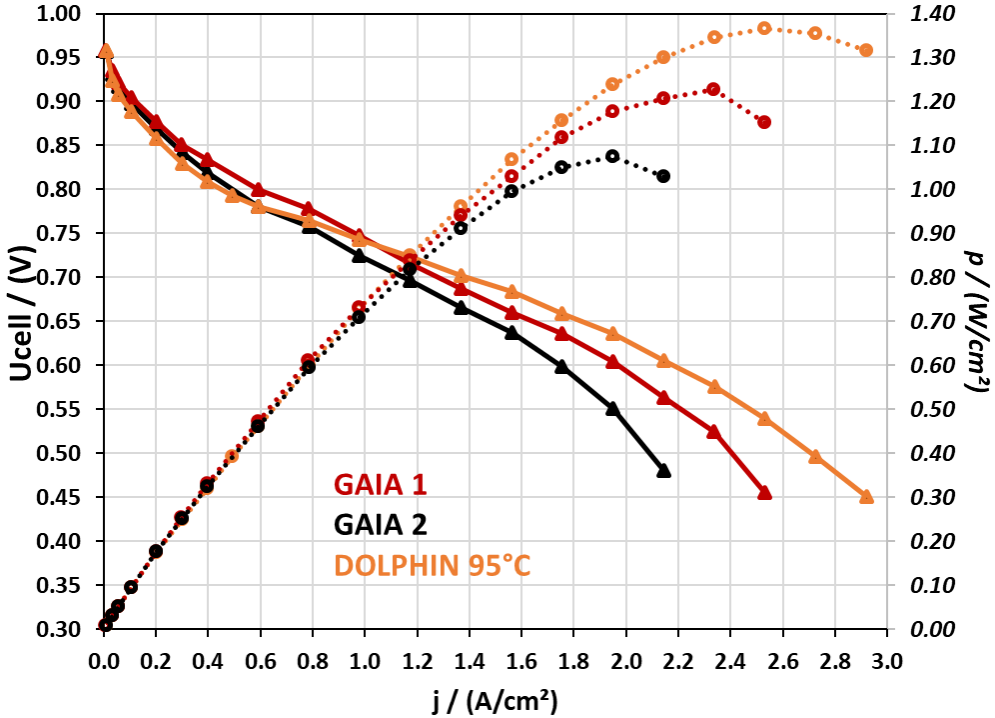
SoA (ASC, 2017): 95°C (outlet)

AWP 2024 target: 105 °C (outlet)

Status (06/2023): promising first results



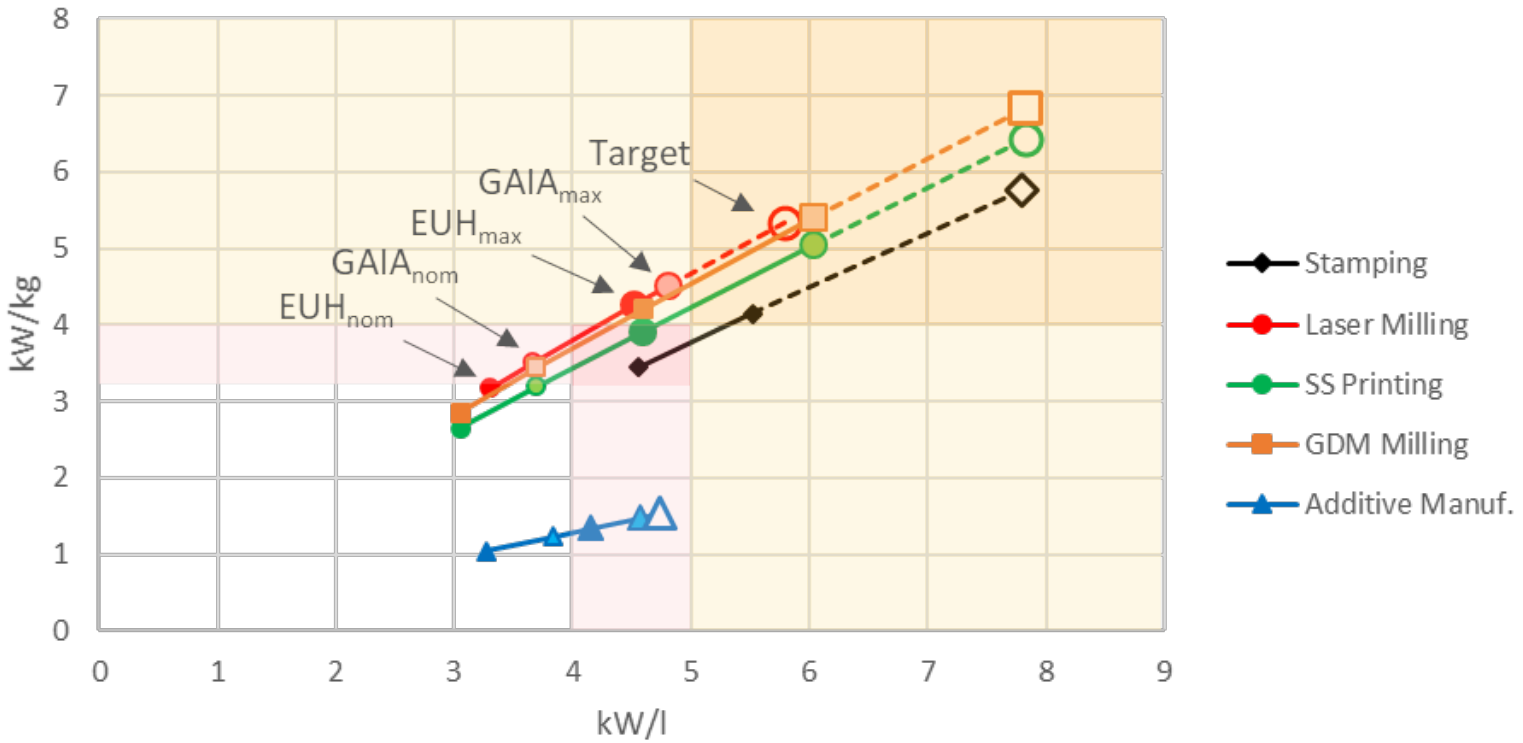
Medium temperature conditions (TP1) for the NDP 8011 and NDP 8002 membranes, DOLPHIN CCM



Medium temperature conditions (TP2, GDL 22BB, machined reference EFC, pitch 600/400/200 µm (anode) and 500/500/300µm (cathode).

Not introduced in TP4

TP4 stacks (5 kW)



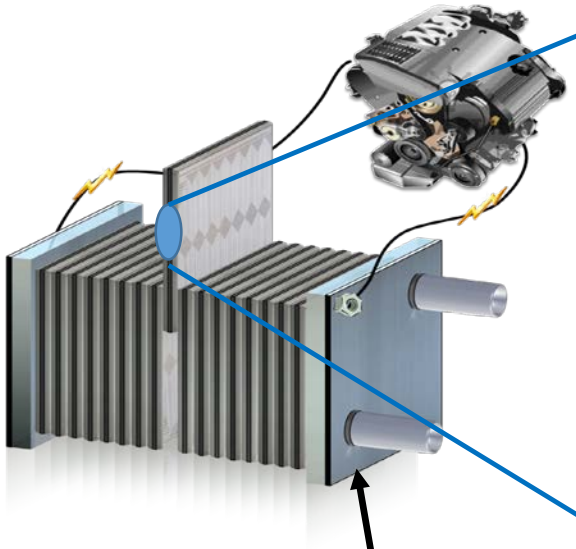
TP4-1

- Active area: 170 cm²
- Dolphin CCM: Chemours membrane + ionomer; CEA formulation + process; 0.1+0.4 mgPt/cm²
- Additive manufacturing (DMG-MORI)
- No GDM on one-side (ZSW, CEA)
- Composite Terminal Plate (Hexcel)
- Objective : high performance (1.8-2.0 W/cm²)

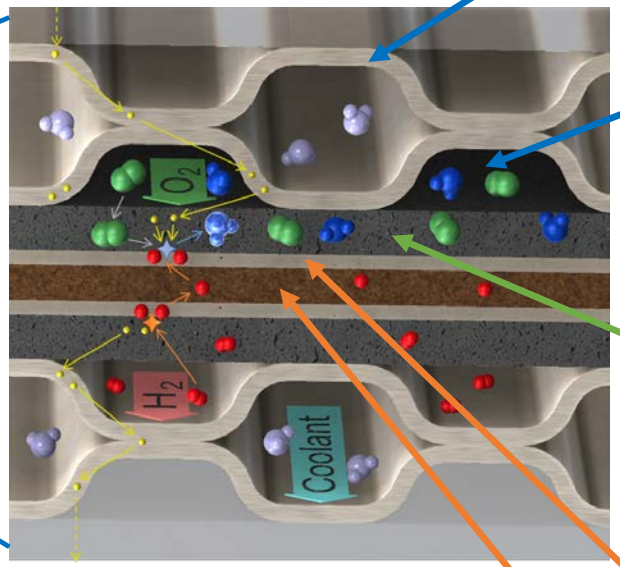
TP4-2

- Active area: 90 cm²
- Dolphin CCM: Chemours membrane + ionomer; CEA formulation + process; 0.1+0.4 mgPt/cm²
- FF machined in GDL (CEA, ZSW)
- Homogeneization: printing (CEA)
- Objective : high kW/kg, kW/l; 1.4-1.6 W/cm²

Some highlights in the following presentations



3D Lighter Integrated Terminal Plate (composite, HEXCEL)



Thinner carbon-based plates (HEXCEL)
Thinner metallic plates (SYM)
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), GDL machining (CEA)

Electrical and Fluidics Core

Thin GDL substrate (HEXCEL), with MPL and treatments (CEA)
Or only MPL without fibre substrate (ZSW)

Interfaces

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

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

Electrochemical Core

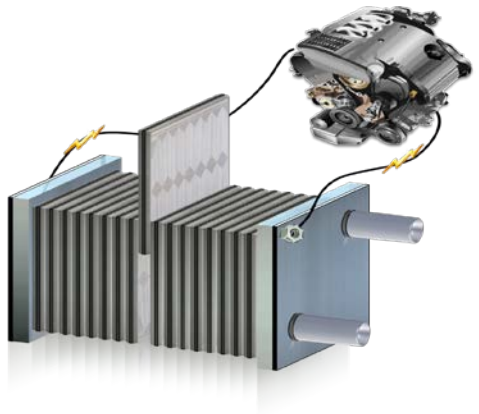
Thank you for your attention!

Clean Hydrogen Partnership

Co-funded by the European Union

DOLPHIN

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



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Joel.pauchet@cea.fr