



FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

VOLUMETRIQ

**VOLUme Manufacturing of
PEMFC Stacks for TRansportation
and In-Line Quality Assurance**



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Programme Review Days 2018

Brussels, 14-15 November 2018

PROJECT OVERVIEW



PRETEXO



JM Johnson Matthey
Inspiring science, enhancing life

- **Call year: 2014**
- **Call topic: FCH-01.2-2014**
Cell and stack components, stack and system manufacturing technologies and quality assurance
- **Project dates: 01/09/2015 – 28/02/2019**
- **% stage of implementation 01/11/2018: 90%**
- **Total project budget: 5,163,450 €**
- **FCH JU max. contribution: 4,961,950 €**
- **Other financial contribution: 201,500 € (BMW 20% own-funding, Daimler self-funded)**
- **Partners: CNRS (coordinator), JMFC, BMW, Solvay Speciality Polymers, ElringKlinger, Pretexo**



VOLUMETRIQ PROJECT SUMMARY

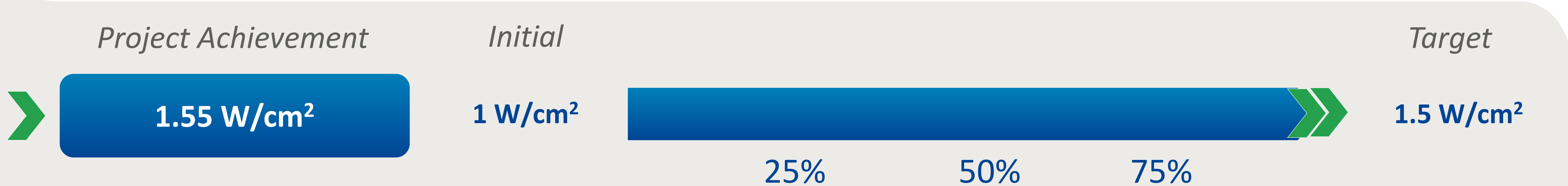
VOLUme Manufacturing of PEMFC Stacks for TRansportation and In-Line Quality Assurance



- VOLUMETRIQ aims to provide a European supply chain for membrane, catalyst coated membrane, bipolar plates, optimised stack design
- Volume manufacturing capability for components, with embedded quality control in component manufacture and assembly to enable validation of performance, lifetime and manufacturability
- Analysis of each process capability and efficiency, including costs
- Global positioning vs international state-of the art:
 - Stack power density
 - 4.1 kW/L at 2.0 A/cm² – 5.0 kW/L at 2.5 A/cm² (excluding housing)
 - autoStack-CORE 3.5 kW/L (excluding housing)
 - Mirai 3.1 kW/L (integrated into vehicle)
- Transport application - automotive



PROJECT PROGRESS/ACTIONS – Single cell power density



- VOLUMETRIQ single cell power density target 1.5 W/cm² at 0.6 V
- SoA 2017* 1.0 W/cm²
- MAWP single cell power density target for 2020 1.5 W/cm²
- VOLUMETRIQ achieved 1.55 W/cm² at 0.6 V at M35



* From "Addendum to MAWP 2014-2020, for light duty vehicles including cars"

PROJECT PROGRESS/ACTIONS – Single cell power density



Project Achievement

Initial

Target

➤ **1.55 W/cm²**

1 W/cm²

1.5 W/cm²

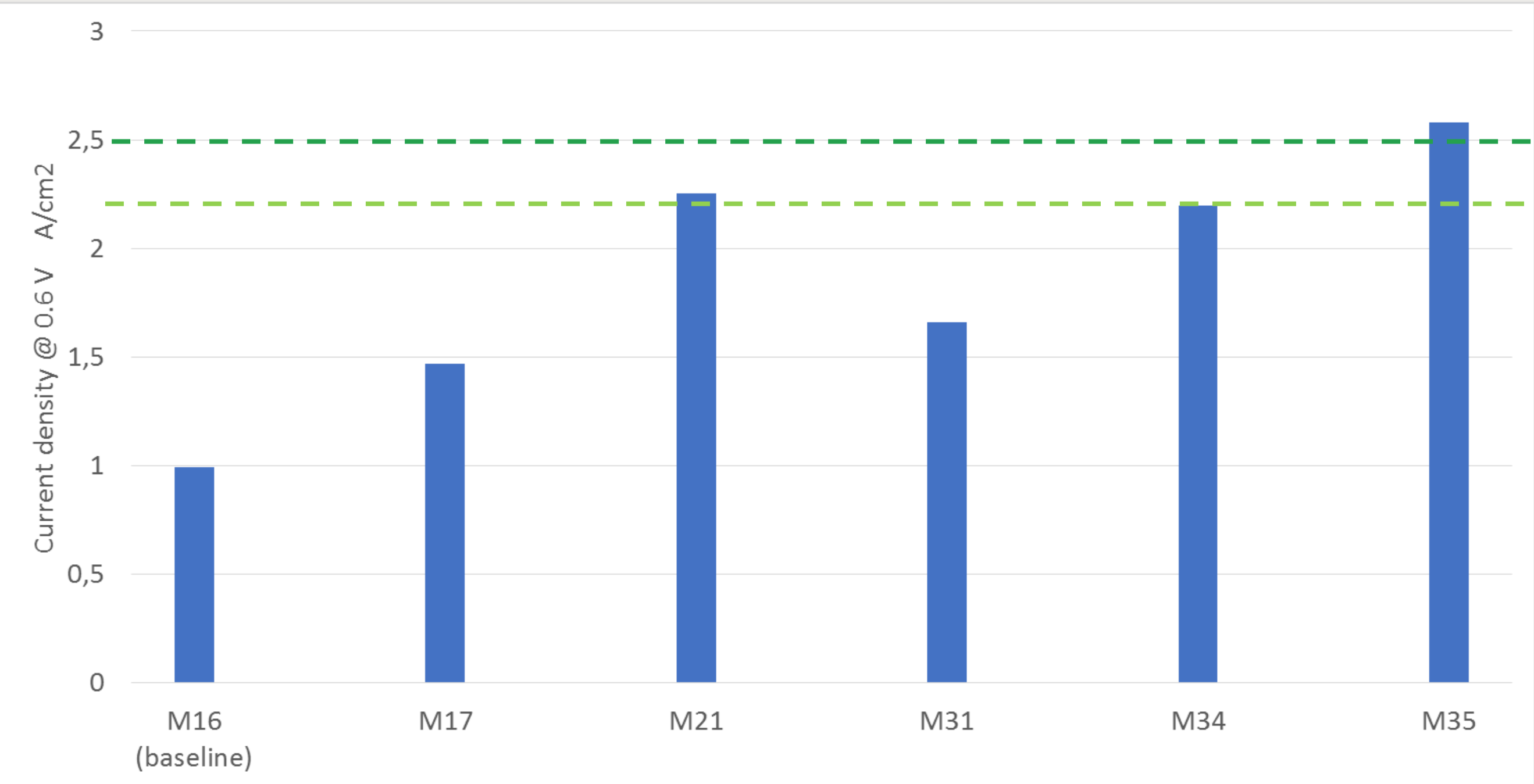


25%

50%

75%

Status at month 38 of 42 month project at 01/11/2018



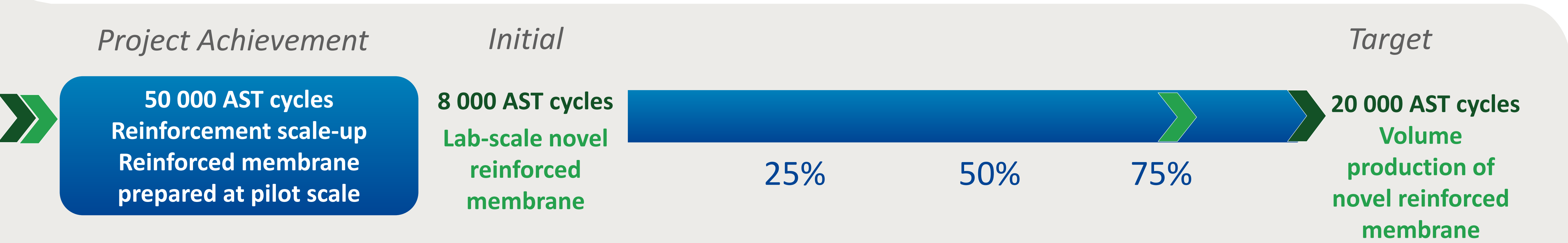
MS3, 2.5 A/cm² at 0.6 V

MS2, 2.2 A/cm² at 0.6 V

- Step-change improvements in power density at 0.6 V by introduction of improved ionomer, cathode construction and GDLs, and set of compression



PROJECT PROGRESS/ACTIONS – Membrane durability with novel reinforcement, and reinforced membrane scale-up



- VOLUMETRIQ durability target for reinforced membrane in fuel cell OCV hold / relative humidity cycle AST: 20 000 cycles
- MAWP target: N/A ; DOE target: 20 000 cycles
- Project baseline membrane using conventional reinforcement: 8 000 cycles
- VOLUMETRIQ membrane with thermostable nanofibre reinforcement, from pilot-scale fabrication: 50 000 cycles

PROJECT PROGRESS/ACTIONS – Membrane durability with novel reinforcement, and reinforced membrane scale-up



Project Achievement

Initial

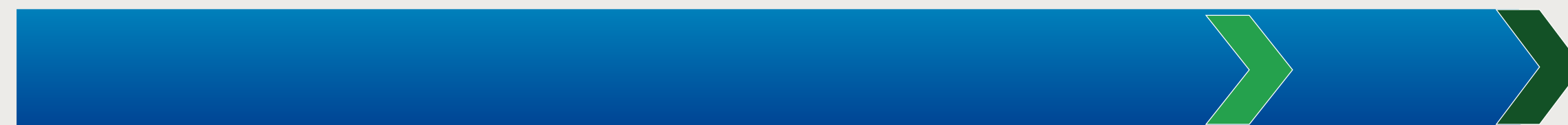
Target

50 000 AST cycles
Reinforcement scale-up
Reinforced membrane
prepared at pilot scale

8 000 AST cycles
Lab-scale novel
reinforced
membrane

20 000 AST cycles
Volume
production of
novel reinforced
membrane

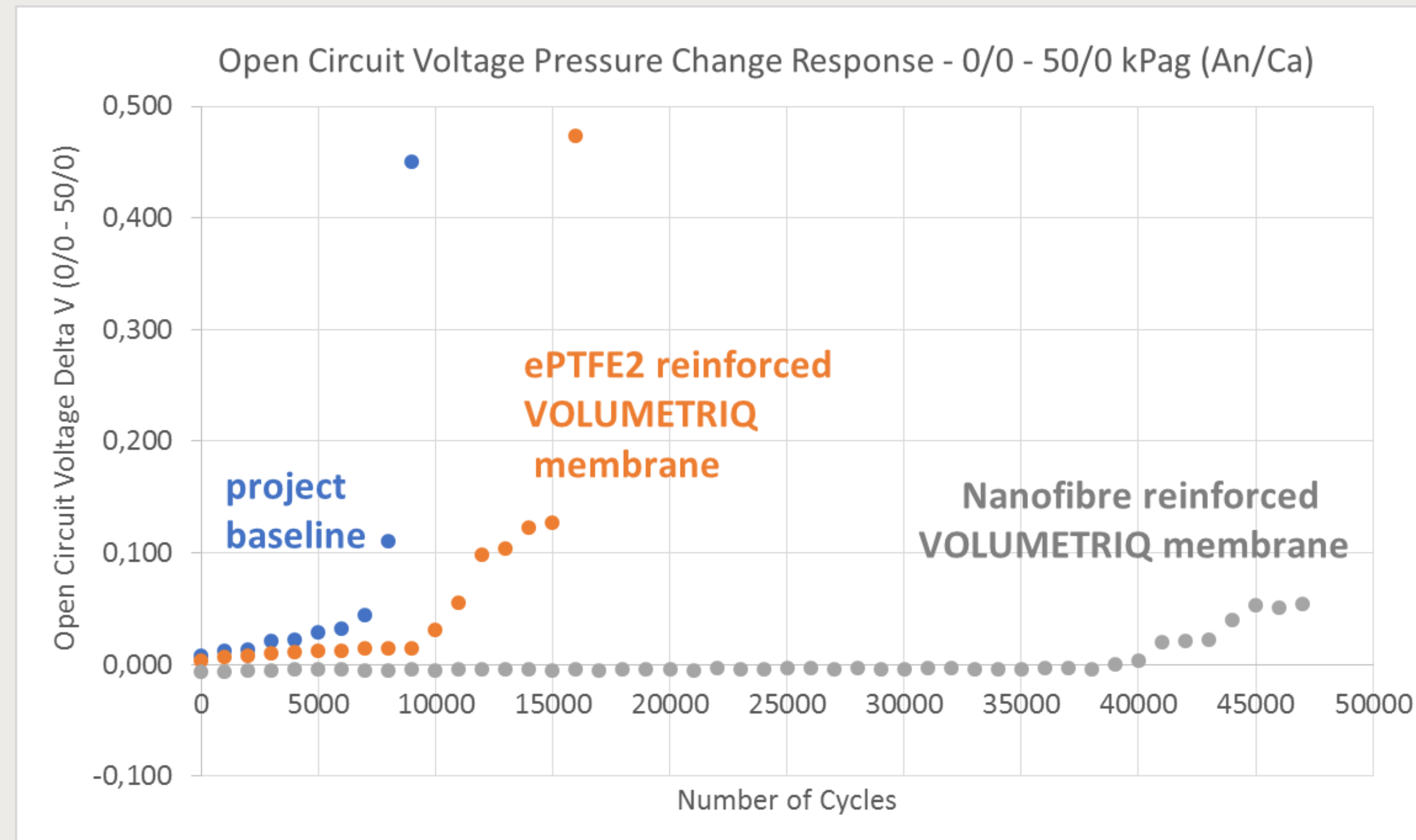
Status at month 38 of 42 month project
at 01/11/2018



25%

50%

75%



- Step-change durability improvement in AST at 90 °C with thermostable nanofibre reinforcement, all other components identical



PROJECT PROGRESS/ACTIONS – Automated Stack Assembly and In-Line Quality Control



Project Achievement

**Automated Stack Assembly
Line
Quality Control
Stack Power Density**

Initial

**Manual stacking
process
Slow QC
processes**

Target

**Automated,
> 10 000 / year
Integrated, high
precision QC**



25%

50%

75%

*Status at month 38 of 42 month project
at 01/11/2018*

- Automated assembly process confirmed through the successful assembly of a ca. 100 stacks
- QC measurement equipment capability confirmed and installed in EK facilities, first measurements running
- Performance target of 1.50 W/cm² exceeded with the project baseline single cell hardware
- VOLUMETRIQ cell hardware has 30% greater surface area and optimised cell design features. Attaining the target 5.0 kW/L is expected with 1.50 W/cm² single cell performance



PROJECT PROGRESS/ACTIONS – Automated Stack Assembly and In-Line Quality Control



Project Achievement

**Automated Stack Assembly Line
Quality Control
Stack Power Density**

*Status at month 38 of 42 month project
at 01/11/2018*

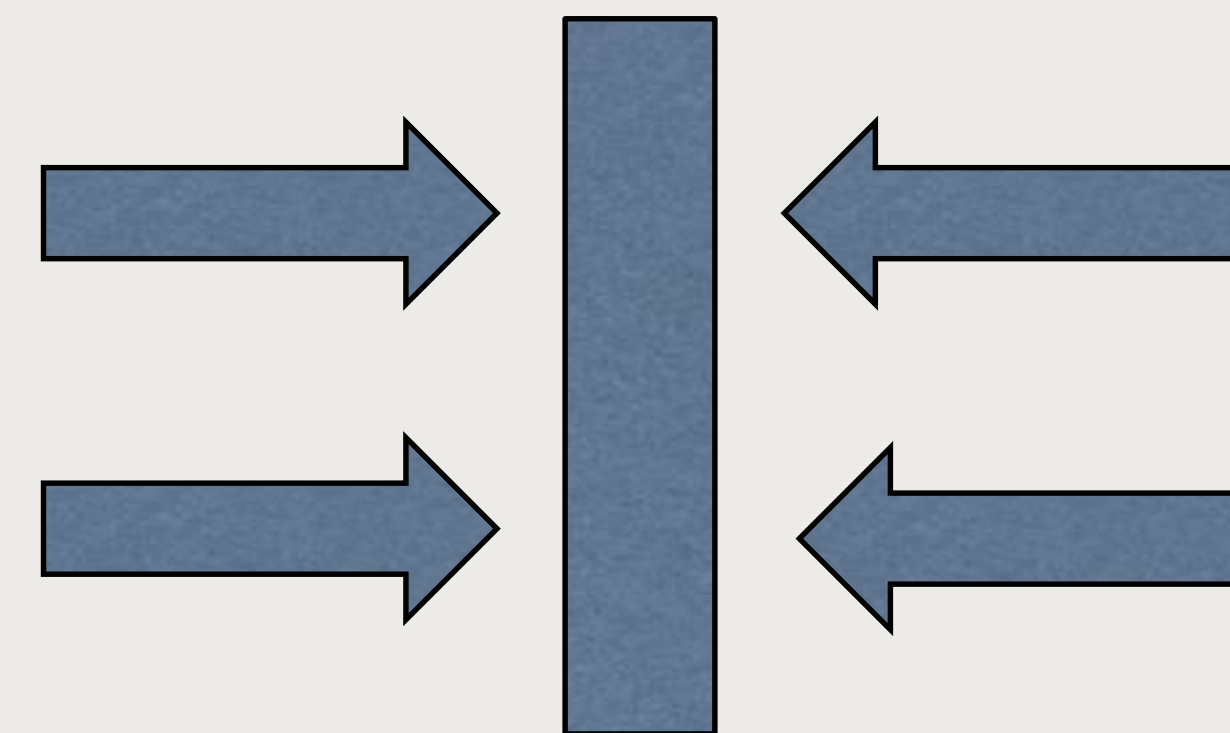
Initial
**Manual stacking
process
Slow QC
processes**



Target
**Automated,
>10 000 / year
Integrated, high
precision QC**



BPP



In-line QC method for BPP

- High Precision Quality equipment integrated in the QC Processes of the produced BPPs.
- Measures the BPP geometry in-line from both sides to an accuracy of ca. 2 μm , ensuring the production of BPP with the desired geometry and within tolerances



Risks and Challenges



Risks, Bottlenecks and Challenges	Measures taken
Redesign of bipolar plates for NM12 stack	3 month delay absorbed by shortened lead time on ensuing activities
Thermostable polymer used for nanofibre reinforcement contaminated by a salt used for polymer solution stabilisation	Change to a different thermostable polymer
Electrospun web reinforcements have different handling properties from ePTFE membrane reinforcements	Increased number of scale-up and manufacture trials
Reproducing performance of hand-made CCMs with high volume manufacture CCMs	Adapt a processing condition of the high volume manufacture



Communication and Dissemination Activities



VOLUMETRIQ web site

www.volumetriq.eu

VOLUMETRIQ conference presentations and public reports

4 invited oral and 4 poster presentations at international conferences
VOLUMETRIQ communication materials disseminated at 2 trade fairs
8 public deliverable reports on-line at www.volumetriq.eu

VOLUMETRIQ Brochure and Newsletters

Published electronically and hardcopies:

- Project information pamphlet at M6
- Annual newsletters at M9, M21, M33 (and M42)

VOLUMETRIQ participation in FCH 2 JU events

Oral presentation at PRD 2016, Posters + Stack Demo at PRD 2016, 2017
Presentation at Workshop on Manufacture (Oct 2018)

VOLUMETRIQ Publications

- 1) New perfluorinated ionomer with improved oxygen permeability for application in cathode PEM-FC, *Journal of Power Sources* 396 (2018) 95–101
- 2) Design of Heterogeneities and Interfaces with Nanofibres in Fuel Cell Membranes, *Handbook of Nanofibers*. Springer, pp 1-37, 2018

Social media

#VOLUMETRIQPEMFC



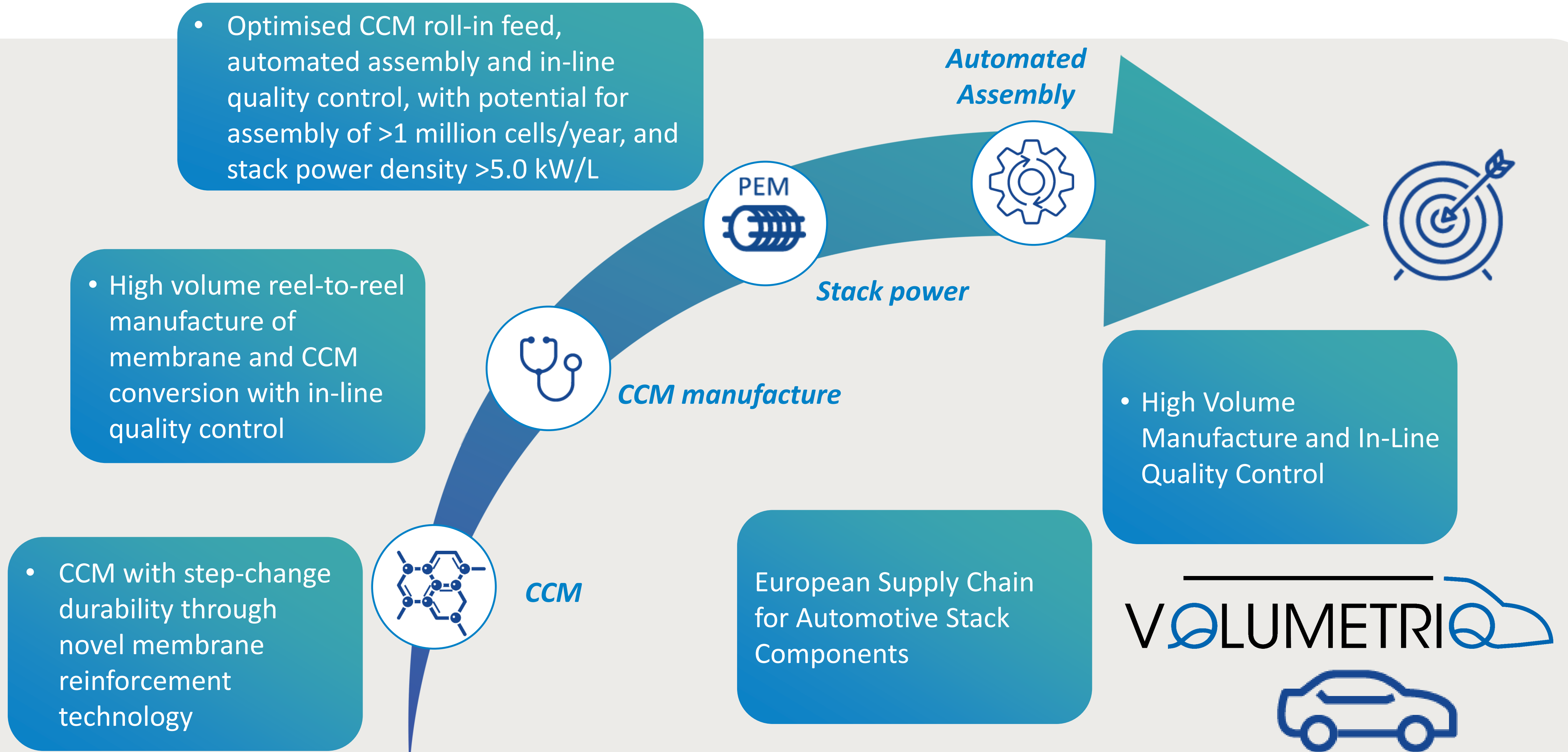
EXPLOITATION PLAN



Exploitation Plan Item	Partner	Exploitation Activity
Product commercialisation	Solvay	To commercialise an improved Aquivion ionomer grade
	EK	To commercialise the NM12 automotive stack
	JMFC	To commercialise novel reinforced membrane
Use of components in next generation MEA products	JMFC	To introduce VOLUMETRIQ components in next generation MEAs as commercial products
Use of production line	EK	To use automated stack assembly line to assemble stacks at high volume
Technology improvement	EK	To use improved manufacturing technology to produce products to automotive quality with lower cycle time and increased yield
Further R&D	JMFC, CNRS	To continue the development and scale-up of electrospun reinforcement technologies for fuel cell membranes
	Solvay	To complete development of a high gas diffusion ionomer and evaluate commercialisation potential
...		



Potential Impact



SYNERGIES WITH OTHER PROJECTS AND PROGRAMMES



Interactions with projects funded under EU programmes

from VOLUMETRIQ to INSPIRE: modified conventional and novel nanofibre reinforcements

from INSPIRE to VOLUMETRIQ: gas diffusion layers

from VOLUMETRIQ to GRASSHOPPER: modified conventional reinforcements

between VOLUMETRIQ and FitForAmanda: FitForAmanda will share their experience of automated stack assembly with the VOLUMETRIQ team at a workshop organised by INSPIRE





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