FCH JU Awards 2019, Brussels, Belgium - VOLUMETRIQ Best Success Story

This year's Best Success Story winner: ***'Driving forward fuel cell technologies'***, involves 5 projects, VOLUMETRIQ, INSPIRE, CRESCENDO, GAIA and PEGASUS, which are making fuel cells more affordable and competitive.

The successful projects reduce fuel-cell technology production costs, speed up manufacturing, develop new materials to increase fuel-cell performance and demonstrate how people can rely on hydrogen energy. Overall, they pave the way for a world-class European fuel-cell industry that sustains clean energy. The Awards were presented at a ceremony at the Royal Museums of Fine Arts in Brussels on 20 November 2019, attended by about 300 industry, research and EU representatives.

"EU public support is speeding forward European hydrogen and fuel cells technology. All projects exchanged material and are using each other's outcomes [...]. The stack will be competitive worldwide, strengthening European jobs and industry and increasing automotive performance". ***Deborah Jones, coordinator of VOLUMETRIQ, CRESCENDO and GAIA and research director at the French National Scientific Research Council (CNRS).***

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Contact Us
Project Coordinator

Dr Deborah Jones
ICGM - AIME
Université Montpellier
Pl. Eugène Bataillon
34095 Montpellier France
deborah.jones@umontpellier.fr

www.volumetriq.eu

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VOLUMETRIQ

Volume Manufacturing of PEMFC Stacks for Transportation and In-Line Quality Assurance

VOLUMETRIQ has reached its goals !

All the stack builds and tests necessary to demonstrate the required power density of a full stack were completed. Results derived from **newly developed NM12 cells** from ElringKlinger showed excellent performance values at short and full stack level. The current density target of 2.5 A/cm² at 0.6 V was achieved, with slight changes to the originally defined operating conditions. The full stack power exceeded the targeted 90 kW. With a total power output of 111 kW, the stack volumetric power density was determined as 5.4 kW/l including endplates and 6.6 kW/l on the cell block.This is very encouraging regarding future commercialisation with the promising full stack capability.

The **cost assessment was completed** based on a set of assumptions such as material usage and the necessary number of cells, which were derived from test results and actual manufacturing trials.

The cost estimation for a high-volume production of fifty thousand units per year showed a normalised cost of 68 €/kW including the PGM content. This number is within the project cost target, however, there is still a potential for continuous cost reduction, focusing on product development towards "design to cost".

In parallel, and at automotive single cell level, VOLUMETRIQ has demonstrated 2700 hours of drive cycle testing, allowing reasonable **expectation of 5000-6000 hours durability**.

From new ionomer, reinforcement and membrane development, through consideration of roll format options for high volume production of catalyst-coated membranes (CCMs), manufacture of high performance CCMs and the implementation of quality control measures, to new stack hardware design and production, and build of a **high volumetric power density automotive stack, the VOLUMETRIQ team has ticked all the boxes.**

6 partners

1 Associate partner

CNRS Montpellier, FR

Joint research unit with Montpellier University, leading research organisation in novel approaches to proton conducting membrane development since 1990.

Johnson Matthey Fuel Cells, UK

Global leader in sustainable technologies and developer, manufacturer and supplier of membrane electrode assemblies and their sub components to fuel cell stack and system developers worldwide, for over 40 years.

Solvay Speciality Polymers, IT

leading chemical company working in the fuel cell arena for 15 years, focused on special polymers with application in the hydrogen & fuel cell industry, including Aquivion® PFSA.

BMW, DE

An automotive company that has been pioneering hydrogen powered vehicles for more than 35 years.

ElringKlinger AG, DE

Tier 1 metallic bipolar plate supplier for the automotive fuel cell industry, with experience in developing processes and manufacturing of components for fuel cell stacks for almost 15 years.

PRETEXO, FR

Since 2007, SME devoted to facilitating and improving information sharing, communication and dissemination between partners and communication towards the public.

Daimler, associate partner, DE

Automotive company, developing fuel cell electric vehicles and components since 1991, with more than 250 FCEVs and 50 buses which have operated successfully since 2004 in customers hands.

Achievements and Output

New cell design NM12

Once all requirements and test conditions had been defined, initial testing with baseline hardware NM5 was carried out. A new cell design NM12 was developed in parallel and fed into the testing programme starting with single cells and growing to full stack level. The initial current density at a cell voltage of 0.6 V was 2.37 A/cm² and could be enhanced to 2.5 A/cm² with the NM5 hardware. By introducing the NM12 cell format, the current density has been increased even further to 2.67 A/cm².

The next big challenge was to achieve the same performance with short stacks using the new cell hardware. Usually the short stack performance is closer to what can be expected in a full stack. The goal for full stack performance was achieved with a cell stack delivering a total power of 111 kW, higher than the originally targeted 90 kW stack (Figure 1). Based on this full stack result, the calculated volumetric power density was determined as 5.4 kW/l including endplates and 6.6 kW/l on the cell block, which is above average compared to state of the art fuel cell technology.

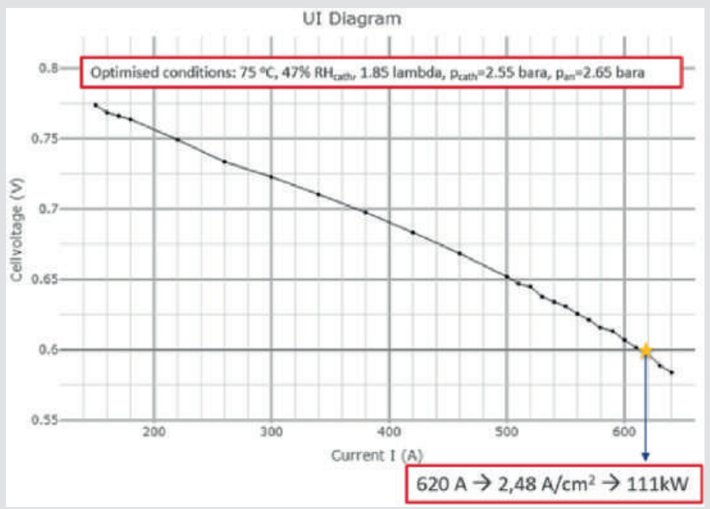
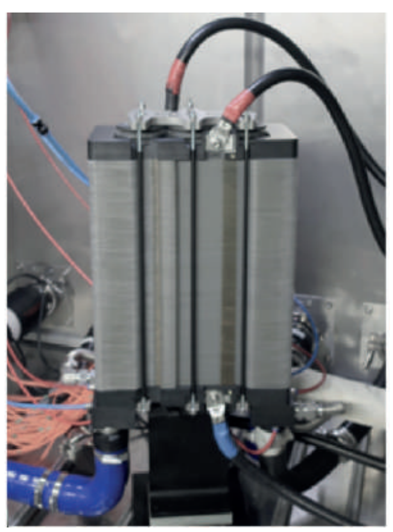


Figure 1. VOLUMETRIQ NM12 stack developed at ElringKlinger.



VOLUMETRIQ short and full stacks

The short stack and full size stack (Figure 2) with the novel NM12 hardware were assembled and tested in year 4.

The cell voltage distribution of the NM12 full size stack exhibits outstanding homogeneity, with only ca. 10 mV between the highest and lowest cell voltages, further demonstrating the high standards of the NM12 hardware.

Figure 2. NM12 full size stack hardware showing end plates, cables for cell voltage monitoring, clamping fixture and media interface

Optimisation of the stamping strategies

Initial work on developing the project reference MEA focused on optimising the catalyst layer to membrane interfaces. Various parameters of JMFC's roll-to-roll CCM (catalyst-coated membrane) production process were optimised in accordance with the VOLUMETRIQ goal of selecting a bill of materials designed for high-volume processes. CCMs with new components were fabricated by JMFC, and different cell-build parameters were trialled. The performance target was reached with the final down-selected CCM associated with cutting-edge gas diffusion layer technology selected by EK, giving a single cell performance of 2.67 A/cm² at 0.6 V, or 1.6 W/cm² under project operation conditions.

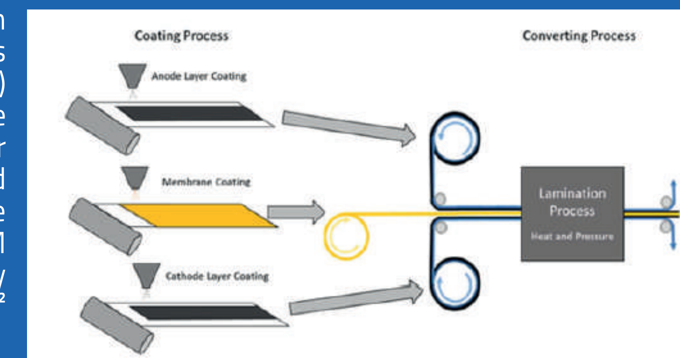


Figure 3. Processes involved in CCM manufacture

The JMFC and EK teams developed and assessed roll format options for scale-up activities. The roll format, the way in which a roll of CCM is supplied, is independent from the CCM bill of materials. It includes any backings or interleaves that the CCM may be supplied on/with, and widths of material, among other parameters. A range of CCM manufacturing options were proposed and technically assessed, followed by a cost and versatility assessment before one format was down-selected. This down-selected format was used in cost predictions and was fabricated by JMFC for handling trials at EK

Exceptional Durability Membrane

Improved ionomer with different specifications and composition was prepared at high volume by Solvay for use in the membrane, and a novel high oxygen permeability ionomer was developed for the cathode catalyst layer. Solvay also further improved the processability of its supported radical scavenger powder. In parallel, JMFC sourced ePTFE reinforcements having lower anisotropy of mechanical properties in the machine and transverse directions. However, ePTFE materials are still intrinsically weak at fuel cell relevant temperatures and CNRS has developed the use of advanced, thermostable polymer reinforcements that have radically different dependence of their strength on temperature.

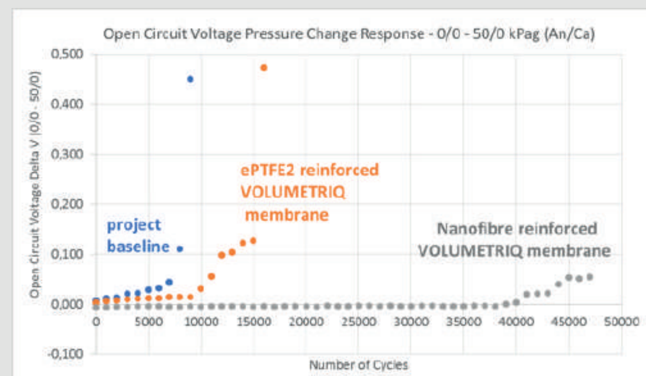


Figure 4. Combined OCV/RH cycling at 90 °C of ePTFE and nanofibre reinforced Aquivion membranes

The objective in VOLUMETRIQ to demonstrate the manufacturability of a thin, low equivalent weight, nanofibre reinforced membrane using roll-to-roll high volume manufacturing processes was achieved. CNRS introduced advanced grades of PBI, validated their properties for membrane reinforcement and developed a novel membrane construction. Scaled-up PBI electrospun roll material was then used successfully on the JMFC production coating line, and tens of linear metres of reinforced membrane were fabricated. The upscaled electrospun-reinforced Aquivion membrane has survived 48,000 combined relative humidity/open circuit voltage cycling at 90 °C, exceeding the project target of 20,000 cycles and surpassing the previous project state of the art using incumbent reinforcement technology by a factor of 4 (Figure 4).