H2UpClose #10: Coventry University

Inside the Minds Driving Hydrogen Innovation

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H2UpScale

Clean Hydrogen Partnership

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H2UpScale Project is happy to present the H2UpClose interviews' cycle.
Below the tenth interview with Coventry University.

In one sentence, what problem are you obsessed with solving in this project?

Coventry University is focused on making virtual fuel cell stacks behave more like real ones, so HiL testing of high-power balance-of-plant (BoP) components does not overestimate performance, power availability or durability.

Finish this: "If we get this thing right, ______ will change for ______."

If we get this right, virtual stack testing will become a more realistic route to designing safer, more efficient fuel cell systems for high-power applications. What's sometimes forgotten is that the weakest cell, not the 'average' cell, tends to define the safe operating envelope.

What's the "before vs after" story?

The "before" is an idealised stack where every cell behaves the same; the "after" is a virtual stack that captures cell-to-cell variation and realistic operating limits.

Why does solving this problem matter now and not in five years?

High-power PEMFC systems need balance-of-plant components that can control air and hydrogen flow, pressure, humidity and heat reliably at scale. That matters now because heavy-duty, maritime and aviation applications are moving beyond today's 100–200 kW systems toward ≥250 kW and multi-MW architectures. If virtual stack models assume all cells are identical, HiL testing can produce operating envelopes that look safe on screen but are too optimistic in reality..

What are the top two constraints that make this hard?

The hard constraints are realism and speed: the model must capture cell-by-cell voltage limits while remaining usable in a HiL environment.

What happens if industry does nothing about it?

If industry does not address this, BoP components may be validated against virtual stacks that miss the real limiting cases: membrane dry-out, flooding, pressure cycling, reactant starvation, excess heat generation and accelerated MEA degradation.

Where are the hidden costs or risks most people miss?

The hidden risk is that HiL testing against a low-fidelity stack model may miss edge cases or fail to capture subtle BoP–stack interactions, leading to expensive late-stage design changes or compromising system performance and durability.

What is your role and what are your goals in the project?

Coventry University is supporting the H2UpScale HiL work by helping define the HiL framework, BoP component test protocols and KPI evaluation approach. Practically, our contribution is a virtual fuel cell stack model that can simulate a distribution of cell voltages, rather than treating the stack as one idealised average cell. The goal is to help test physical BoP prototype components against a virtual ≥250 kW stack in a way that reflects real stack operating limits.

What piece of the puzzle is your team uniquely positioned to deliver?

Coventry's distinctive contribution is stack-level electrochemical insight: linking BoP conditions to the cell-by-cell voltage distribution that ultimately limits available power and durability. The experimental capabilities at Coventry's Centre for Advanced Low-Carbon Propulsion Systems (@C-ALPS) include a range of PEMFC test stands ranging from subscale differential cells up to 70kW stack test benches. This capability, combined with our eletrochemical engineering expertise, enables us to develop and validate high-fidelity stack models grounded in sound electrochemical and fluid engineering theory. H2UpScale provides a unique opportunity to test our approach on truly state-of-the-art

BoP hardware operating on a purpose-built HiL platform being developed by TNO. We anticipate that virtual stacks with enhanced fidelity will expose operating limits earlier, before expensive system-level testing.

What added value does your activity bring?

We aim to add value by bringing realism and technical assurance to the HiL test campaign. A conventional stack model can make every cell look identical, but real stacks are limited by the weakest cell. By modelling the cell voltage distribution, the HiL test can identify when the minimum cell voltage approaches critical limits, even if the average stack voltage still looks acceptable. This matters because power must be de-rated when the weakest cell falls too low, and low-voltage cells are also more vulnerable to heat generation, starvation and accelerated ageing.

Compared to state-of-the-art, what is actually new in your work?

Compared with the state of the art, the innovation is not just scaling the stack model to higher power, but representing the spread of cell behaviour inside the stack. At present, the stack model simulates voltage distribution as a function of current density at fixed air stoichiometry. The next step is to include air stoichiometry, cathode pressure, humidity and, crucially, operating history, so the model can reflect how compressor behaviour, humidification, hydrogen recirculation and pressure dynamics affect individual cells differently in real-time.

What metric should people track to judge progress, and why?

The key metric is minimum cell voltage, alongside the spread between the strongest and weakest cells. These are the values that show whether a virtual stack is still inside a realistic operating envelope. A practical benchmark is whether the model can predict when the minimum cell approaches the de-rating region, typically around 0.50 - 0.45 V, under realistic BoP-driven changes in air supply, humidity, pressure and hydrogen recirculation.

Baseline vs target: where did you start and where do you need to land?

The baseline is a virtual stack response based on current density at fixed air stoichiometry. The target is a higher-fidelity virtual stack that also accounts for air stoichiometry, cathode pressure and humidity, enabling HiL testing to capture realistic limits on available power, efficiency and durability.

Which society or market long-term goals will H2UpScale help achieving?

H2UpScale supports the long-term goal of deploying reliable, high-power PEMFC systems in heavy-duty transport, maritime and aviation. Coventry's contribution helps de-risk that transition by improving the virtual stack representation used during BoP validation. If the virtual stack captures realistic weakest-cell behaviour, developers can make better decisions on operating limits, control strategies, auxiliary functions and durability before full-scale system demonstrations.

What is in your opinion the most credible deployment scenario – why that one?

The most credible deployment scenario is high-power heavy-duty applications where BoP reliability directly affects uptime, efficiency and safety.

How does this de-risk scale-up to multi-MW or fleet level?

This approach de-risks scale-up because it lets physical BoP components be tested against a virtual stack that reflects cell-level constraints, rather than a simplified average response. Better virtual validation should reduce risk in the system development cycle, avoid late-stage surprises, shorten development loops and improve confidence before committing to full-system demonstrators.

Whose day gets better if you succeed? Tell me that person's story.

The person who benefits is the engineer trying to decide whether a compressor, humidifier or hydrogen recirculation strategy is safe to operate across a demanding load cycle. Instead of relying on average stack behaviour, they can see whether any part of the virtual stack is being pushed toward damaging conditions. The mindset that matters is systems thinking: BoP components cannot be judged in isolation, because their real value depends on how they interact with every cell in the stack.

What is the next big milestone you're trying to hit?
The next milestone is to extend Coventry's virtual stack model beyond current density effects to include air stoichiometry, cathode pressure, humidity and operating history, then align it with the HiL framework and BoP test protocols.

What kind of partner or data do you want to attract with this post?
If you are developing high-power fuel-cell BoP components, control strategies or stack diagnostics, connect with the H2UpScale consortium to help make virtual validation more representative of real stack limits.

Where can people follow progress or get involved right now?
People can follow progress and get involved by visiting the H2UpScale project website, connecting with consortium partners on LinkedIn, or subscribing to project updates and newsletters shared by the participating organizations.

Website: www.h2upscale.eu
LinkedIn: https://www.linkedin.com/company/h2upscale

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