



AFC Energy

AFC Energy plc  
AGM Presentation

25 April 2017

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01

Introduction

# Three Year Accelerated Path to Commercialisation



In December 2014, AFC Energy's commercialisation strategy was updated to deliver technical and commercial progression over a three year window.

## 2015

**Focus:** build and commission world's largest alkaline power plant

### Commitments:

- Construction, installation and commissioning of 240kW power plant
- Upscale fuel cell stack from 9 to 101 cells
- Deliver 11 technical/project milestones announced in December 2014

### Delivered:

- 204kW produced from industrial scale fuel cell plant in Germany
- Aggregate power dispatched to the grid during testing > 1.3MWh
- In excess of 10kW of power generated from multiple fuel cell stacks operating at the plant, against a 10kW design rating
- Automation of start up, operation and shutdown fully demonstrated through AFC proprietary software
- Fuel cell system reviewed and signed off by German engineers for safety and robustness of design

## 2016

**Focus:** delivery of second generation fuel cell and initiation of commercial pipeline

### Commitments:

- Develop Generation 2 fuel cell system
- Operate fuel cell stacks for > 1 month
- Complete design/engineering for 10kW and 1MW fuel cell systems
- Advance contracts for pilot and commercial power plant opportunities
- Entry into strategic partnerships in support of accelerated commercialisation strategy

### Delivered:

- Delivered Generation 2 fuel cell system which operated for greater than 1,000 hours
- Joint Development Agreement with De Nora
- Strategic engineering partnership with plantIng
- Basic design and engineering completed on 10kW system
- Initiated and advanced dialogue for several commercial fuel cell opportunities

## 2017

**Focus:** fuel cell deployment

- Deliver commercial fuel cell system in collaboration with De Nora
- Power Project Evaluation and Deployment
- Long term goal of 1GW of capacity installed or under development by 2020

## Reflection on 2016

How to build upon delivery of 240 kW FC at Stade?

What lessons did the 240 kW Stade project provide?

Can AFC Energy demonstrate its P.L.A.C.E?

Why not just chase projects?

Does AFC Energy have the right team to deliver?

Communication?



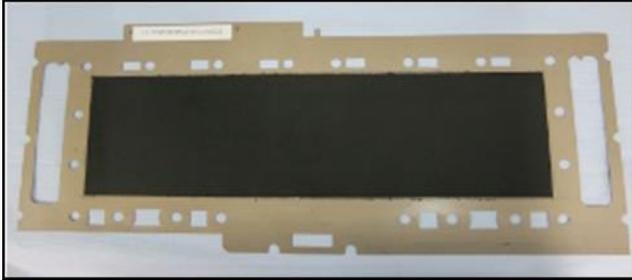


02

# Technology Overview

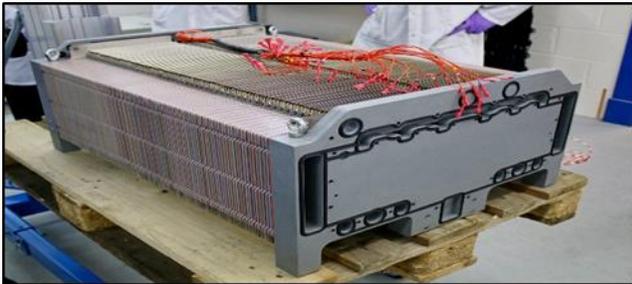
# Industrial Metrics Targeted by AFC Energy (P.L.A.C.E)





Electrode

- Acceptance of lower grade hydrogen at industry standard
- Significant reduction in electrode failure rate
- Underlying chemistry – no material change
- Ongoing initiatives to remove nickel from substrate – significant cost saving
- Catalyst recovery and recycling



Stack

- Material reconfiguration of stack architecture and design
- >10 % increase in power output per stack due to decreased parasitic losses
- Significant redesign of flow plates
- Reuse of all non sealing stack components

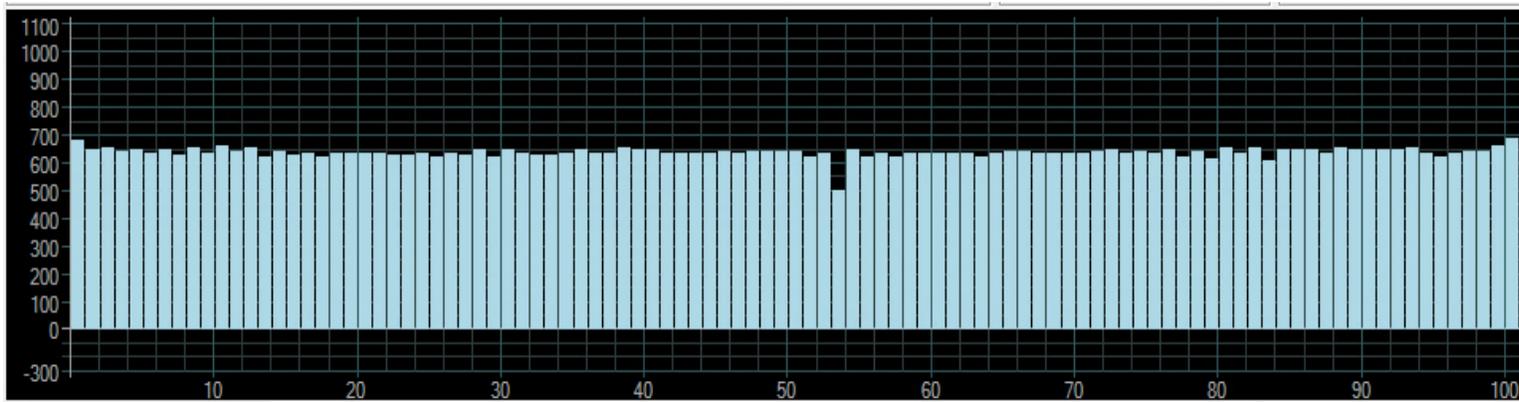


Balance of Plant

- Enhanced air treatment, inlet and exhaust systems
- Hydrogen recirculation initiative commenced
- Improvements to system control for remote monitoring
- Optimisation of inverter interface with grid in collaboration with Siemens

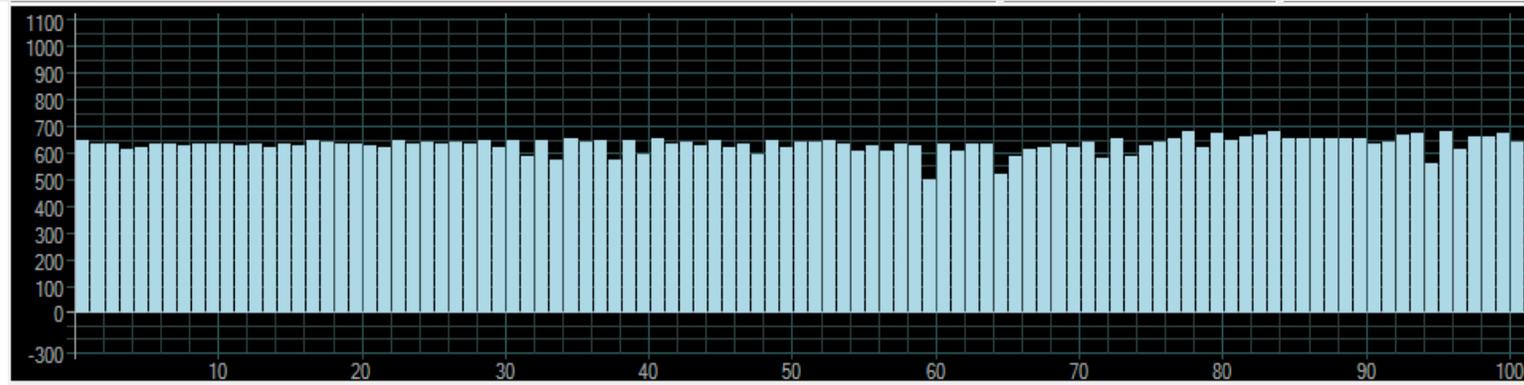
# Power - Results

Milestone 10  
(Oct 15)



Left – Low power stack

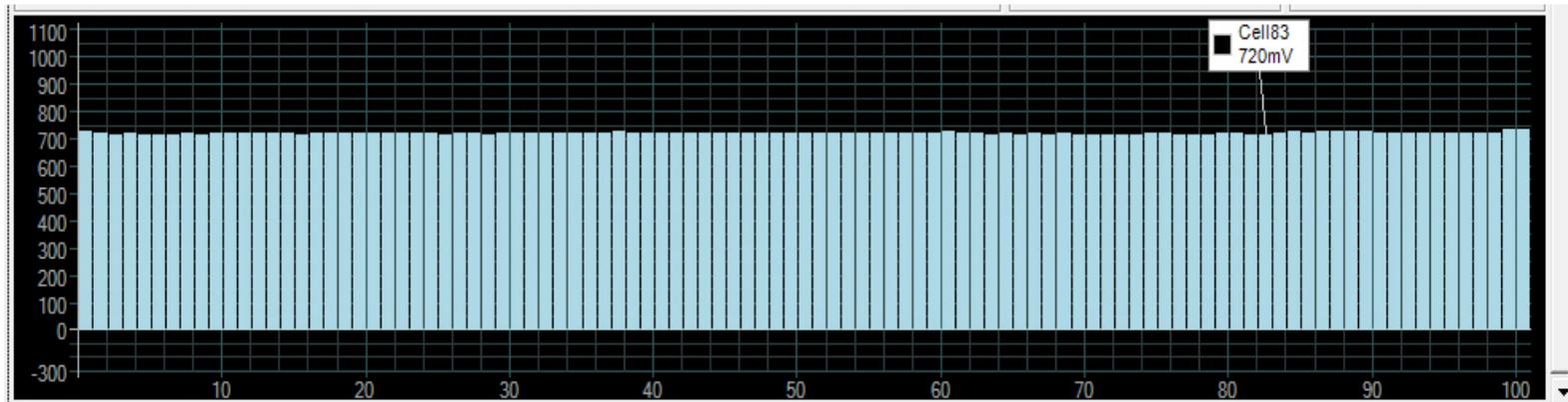
Milestone 11  
(Jan 16)



Left - 10kW stack  
High power cells with high  
standard deviation of cell voltages

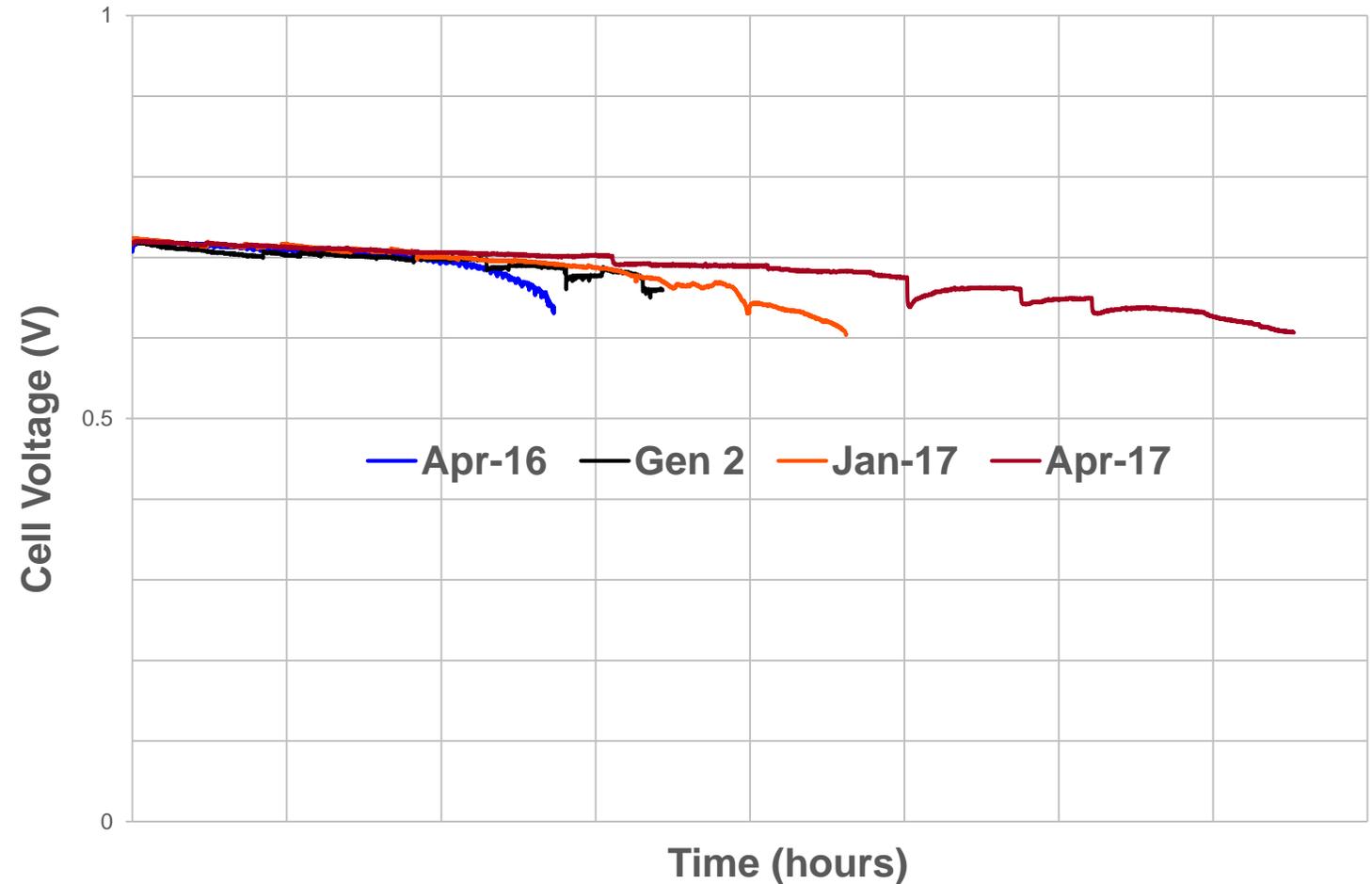
Below - 10kW stack  
High power cells with low standard  
deviation of cell voltages

State-of-the-art  
(April 17)



# Longevity - Results

- > Longevity test results on AFC Energy Fuel cell stacks
- > Majority of improvement on cell longevity down to stack design and configuration
- > April 2017 stack operation ongoing



# Availability - Results

Key contributor to system availability (> 90%) is the performance of the Balance of Plant (BoP).

Reliability is focused on areas of mechanical, chemical and control systems.

Specific target areas in the BoP design being tested at Stade are :

- hydrogen supply
- air treatment
- air exhaust and
- overall control system incl. inverters and grid interface

Process control attention focused around remote monitoring and control (Stade)

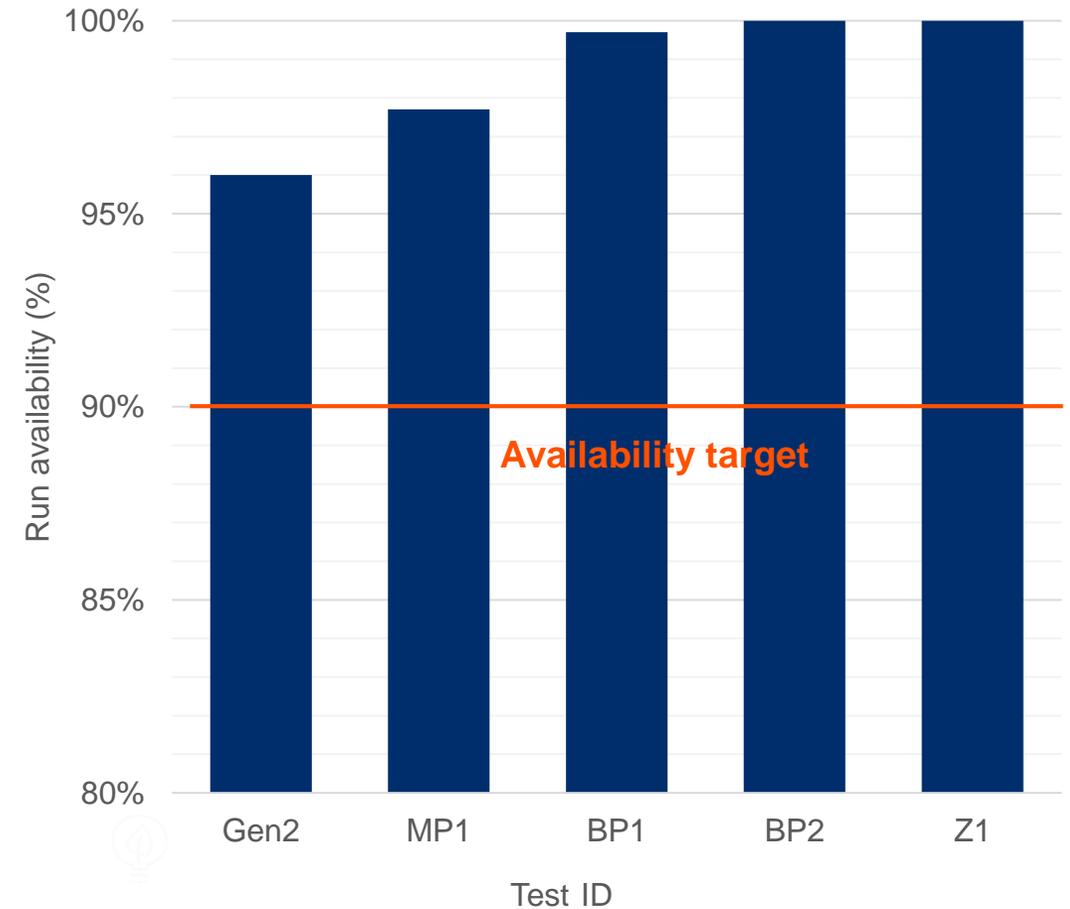


Figure: Availability of fuel cell derived electricity in recent and salient tests.

# Cost - Results (observations only)

## Commercially sensitive but worthy of some observations

- Most significant cost driver is to target longevity of the cells
- AFC Energy with De Nora are targeting doubling of current target stack lifetime within the next 12 months
- Revised stack configuration significantly drives cost out of the current design
- Project opportunities – comparison still made to conventional thermal power plants. This is our reality.
- Quality and availability of Hydrogen drives scale opportunities
- Economies of scale are key in driving fuel cell costs down

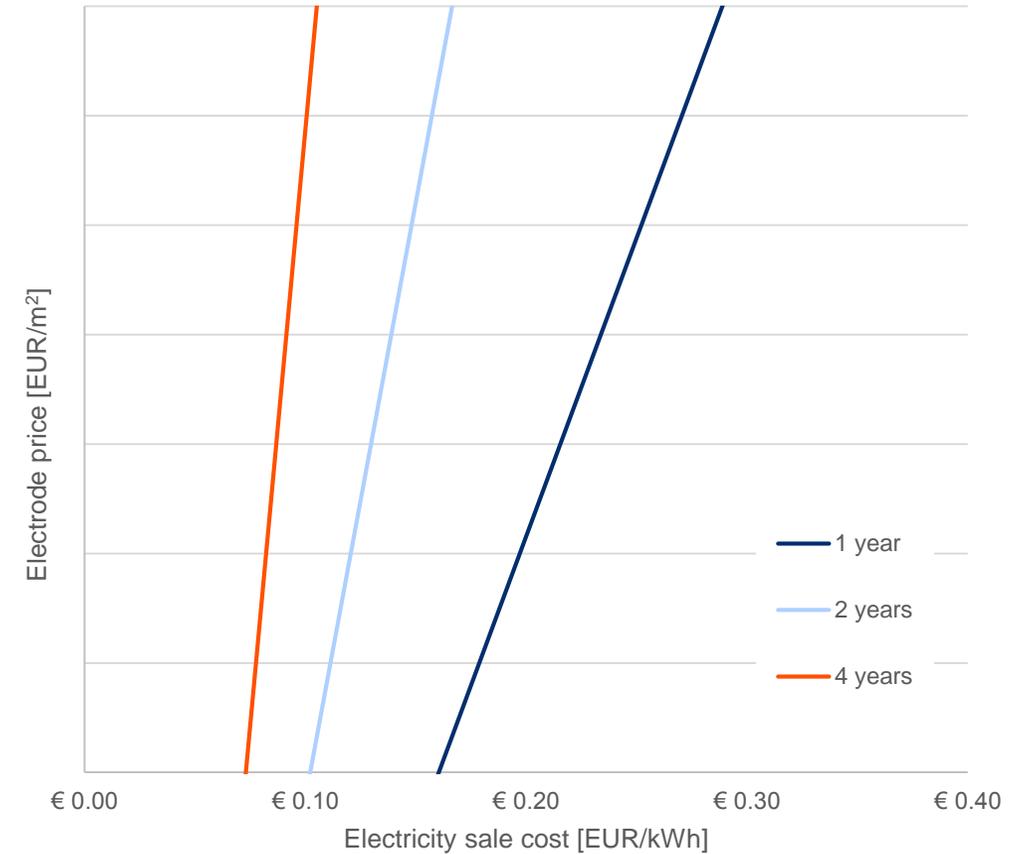


Figure: Electrode price against electricity sale price. The different lines represent different electrode durability.

# Efficiency (Electrical) – Results

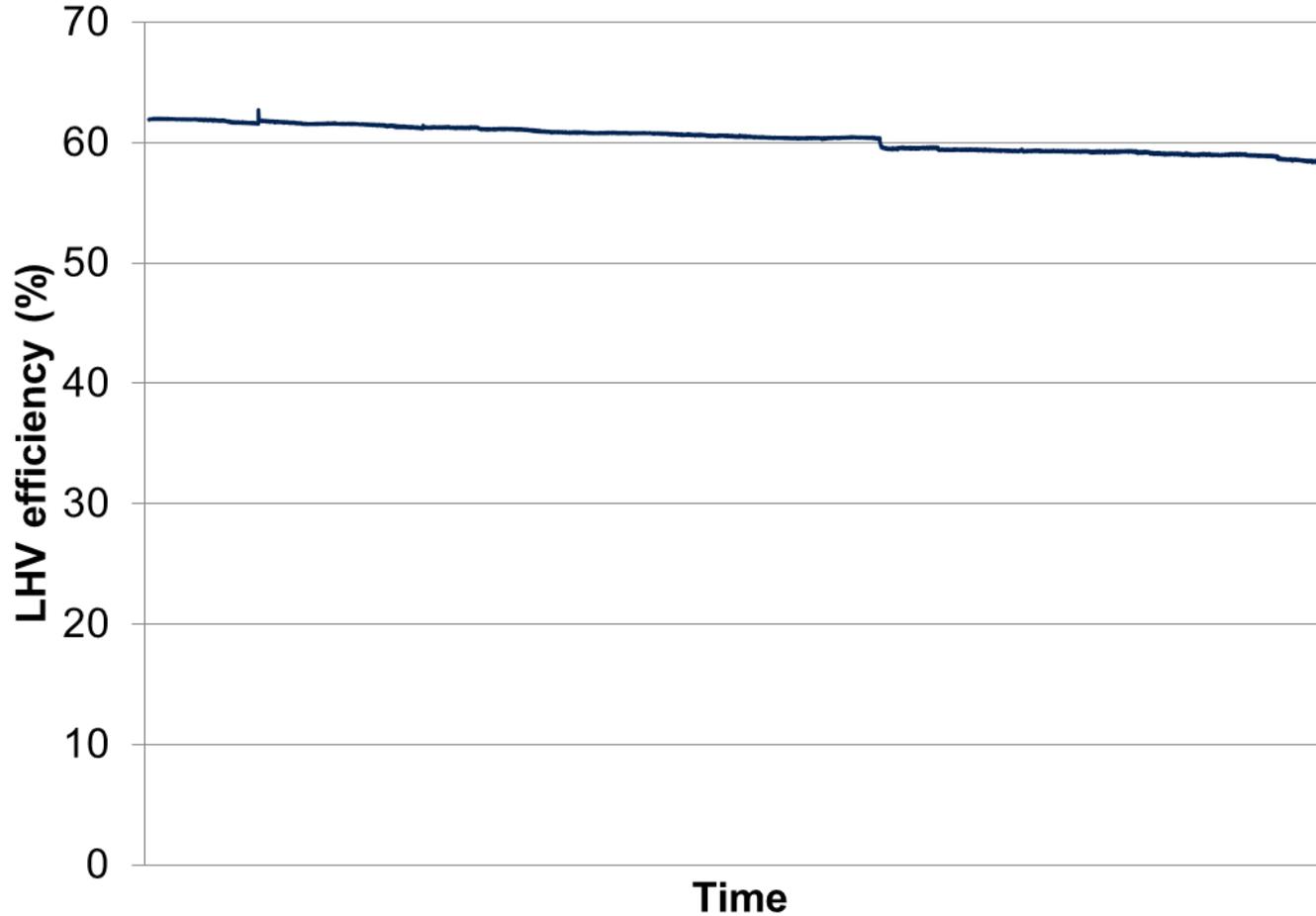
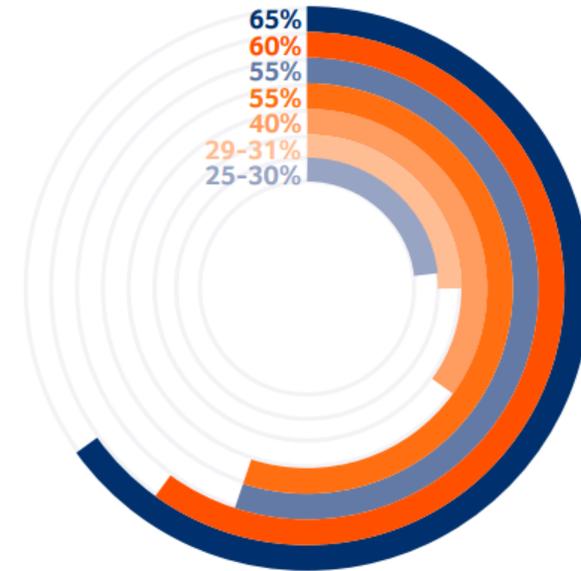


Figure: Efficiency of an AFC stack based on average cell voltage

## ELECTRICAL EFFICIENCY



<b>65%</b>	<b>ALKALINE</b>
<b>UP TO 60%</b>	<b>SOLID OXIDE</b>
<b>UP TO 55%</b>	<b>POLYMER ELECTROLYTE MEMBRANE</b>
<b>UP TO 55%</b>	<b>MOLTEN CARBONATE</b>
<b>40%</b>	<b>PHOSPHORIC ACID</b>
<b>25-30%</b>	<b>DIESEL GENERATORS</b>
<b>29-31%</b>	<b>GAS TURBINE (SIMPLE CYCLE)</b>

Source: [www.afcenergy.com/technology/advantages;](http://www.afcenergy.com/technology/advantages;)  
[www.power.cummins.com;](http://www.power.cummins.com;) [www.corporate.man.eu](http://www.corporate.man.eu)

# De Nora Joint Development Agreement



- Joint Development Agreement (JDA) signed in August 2016 between AFC Energy and De Nora
  - ❑ Purpose: to target technical advancement of AFC Energy fuel cell system and accelerates commercialisation of AFC Energy's technology platform.
- Focus to date on electrode performance – principally improve electrode longevity without a loss of power
- 145 fuel cell test programme demonstrated material enhancements to cell performance through collaboration

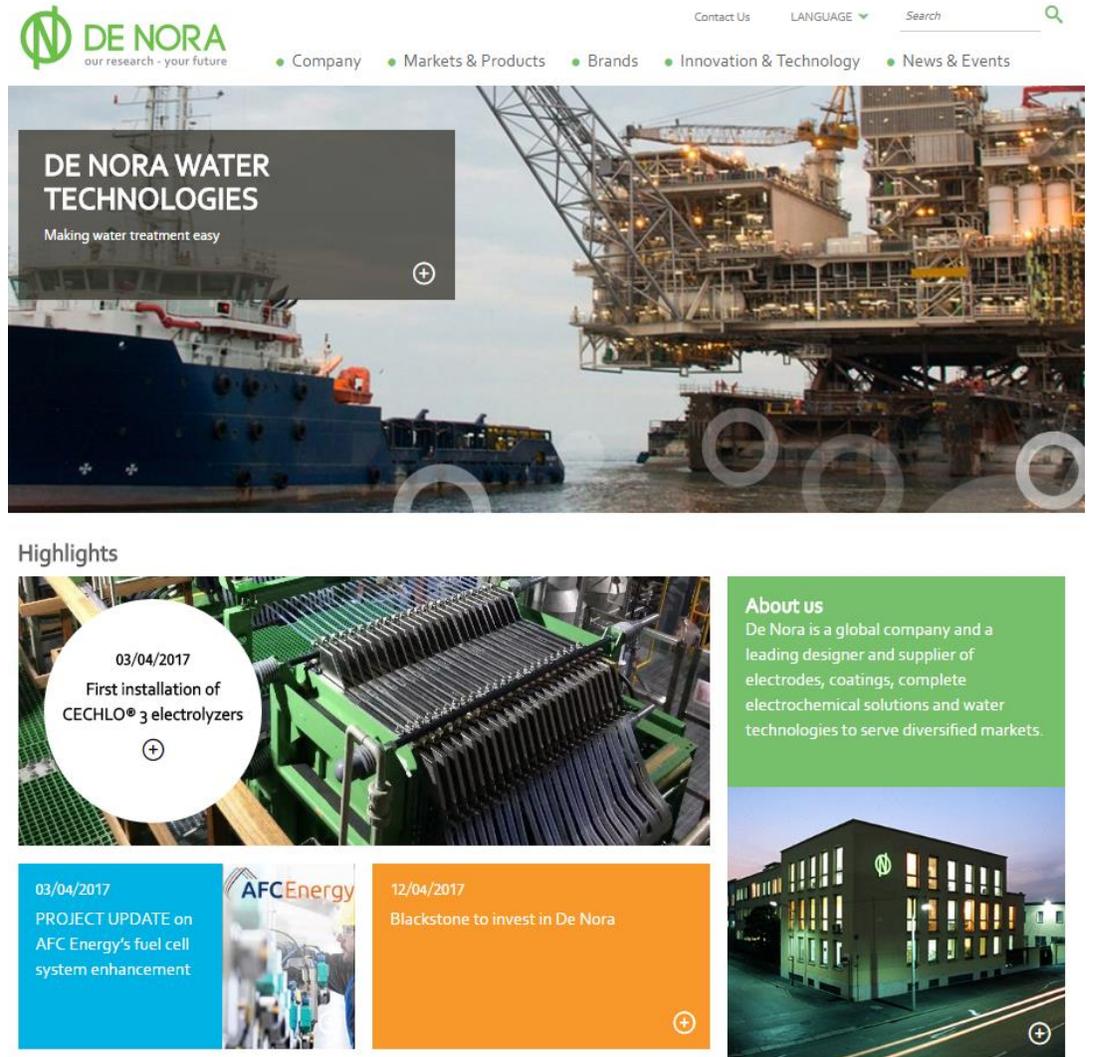
In April 2017, following conclusion of phase 1 of the JDA, a joint Gateway Business Case Review was conducted by both companies, based on an assessment of :

- ❑ Technical results and success against pre-defined electrode and system performance metrics
  - ❑ Identification of achievable cost targets of mass produced electrodes for a commercial fuel cell product capable of deployment in target markets
  - ❑ The size, scope and progression in accessing target addressable market for AFC Energy's fuel cell product,
- Joint decision in April 2017 was made to expand scope of JDA into Phase 2 based on success of Gateway Review



# De Nora Joint Development Agreement (cont'd)

- > Work to commence on Phase 2 effective immediately with commitment to increase resourcing and funding from both parties
- > Outcome of Phase 2 collaboration expected to include:
  - > Focus on full commercial integration of fuel cell electrodes into stack design
  - > Validation of commercial scale stack at Stade
  - > Finalise design of commercial fuel cell electrode architecture and stack design capable of mass production with warranted performance metrics
  - > Open dialogue on terms for mass electrode manufacturing agreement with De Nora



The screenshot shows the De Nora website homepage. At the top left is the De Nora logo with the tagline "our research - your future". To the right are navigation links for "Company", "Markets & Products", "Brands", "Innovation & Technology", and "News & Events". Further right are links for "Contact Us", "LANGUAGE", and a search bar. The main banner features a large image of an industrial facility with a blue ship in the foreground. The text on the banner reads "DE NORA WATER TECHNOLOGIES" and "Making water treatment easy". Below the banner is a "Highlights" section with three items: 1) "03/04/2017 First installation of CECHLO® 3 electrolyzers" with an image of electrolyzers; 2) "03/04/2017 PROJECT UPDATE on AFC Energy's fuel cell system enhancement" with the AFC Energy logo; 3) "12/04/2017 Blackstone to invest in De Nora" with an image of a modern building at night.

# De Nora Joint Development Agreement (cont'd)

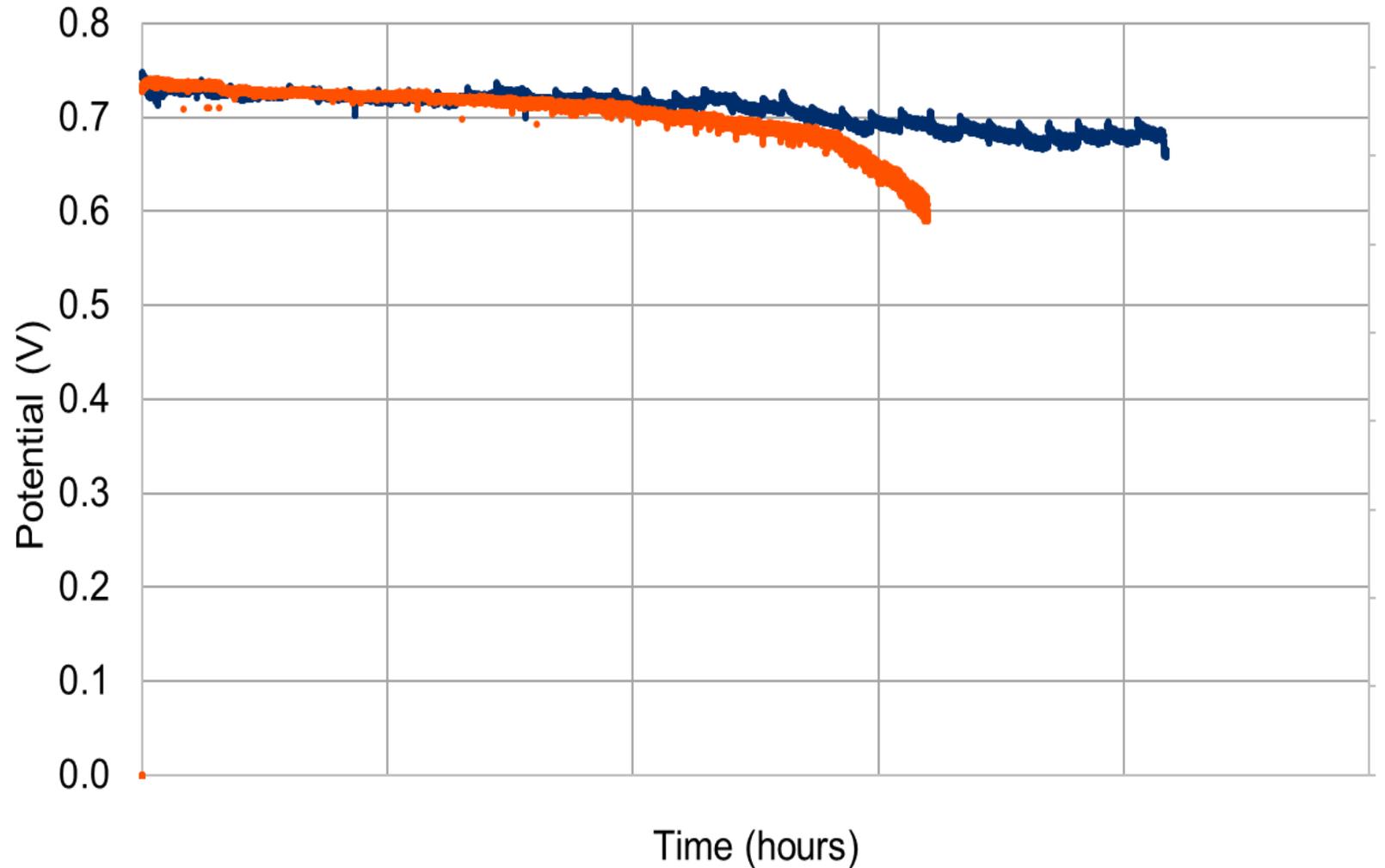
The electrode durability challenge is largely centred on the cathode.

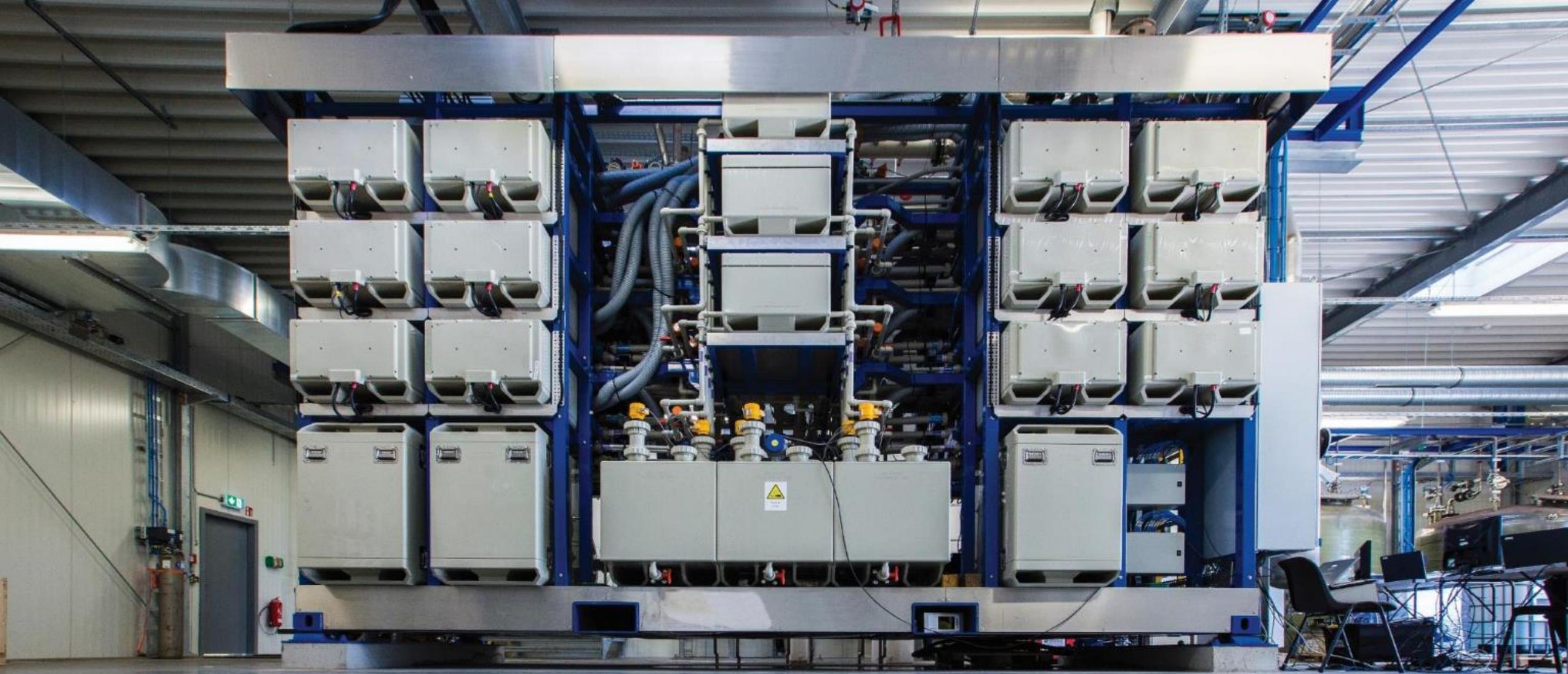
A flat line at a high potential is targeted

Right: Accelerated ageing test of a cathode under the Joint Development Agreement against an AFC Energy Generation 2 cathode.

KEY:

- JDA Cathode
- AFC Energy Gen 2 Cathode





03

Business Overview

## Immediate Addressable Market Opportunities

Large scale stationary industrial power plants

Integration with industrial and chemical plants with surplus hydrogen

Off grid decentralized power generation

## New Fuel Cell Integration Solution Opportunities

Hydrogen Battery

Integration with water treatment technologies

## Countries of Focus

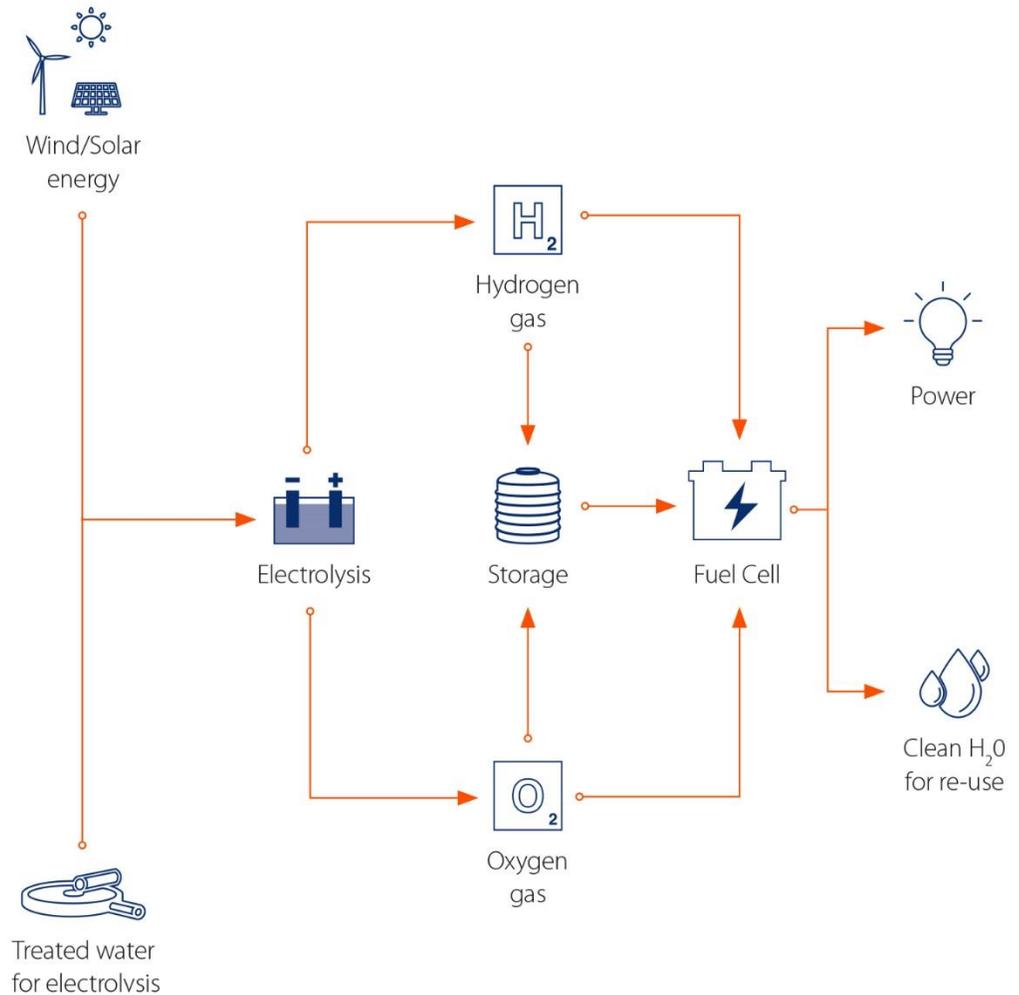
- > Germany
- > UK
- > Japan
- > U.A.E

- > Korea
- > Saudi Arabia
- > Other Middle East

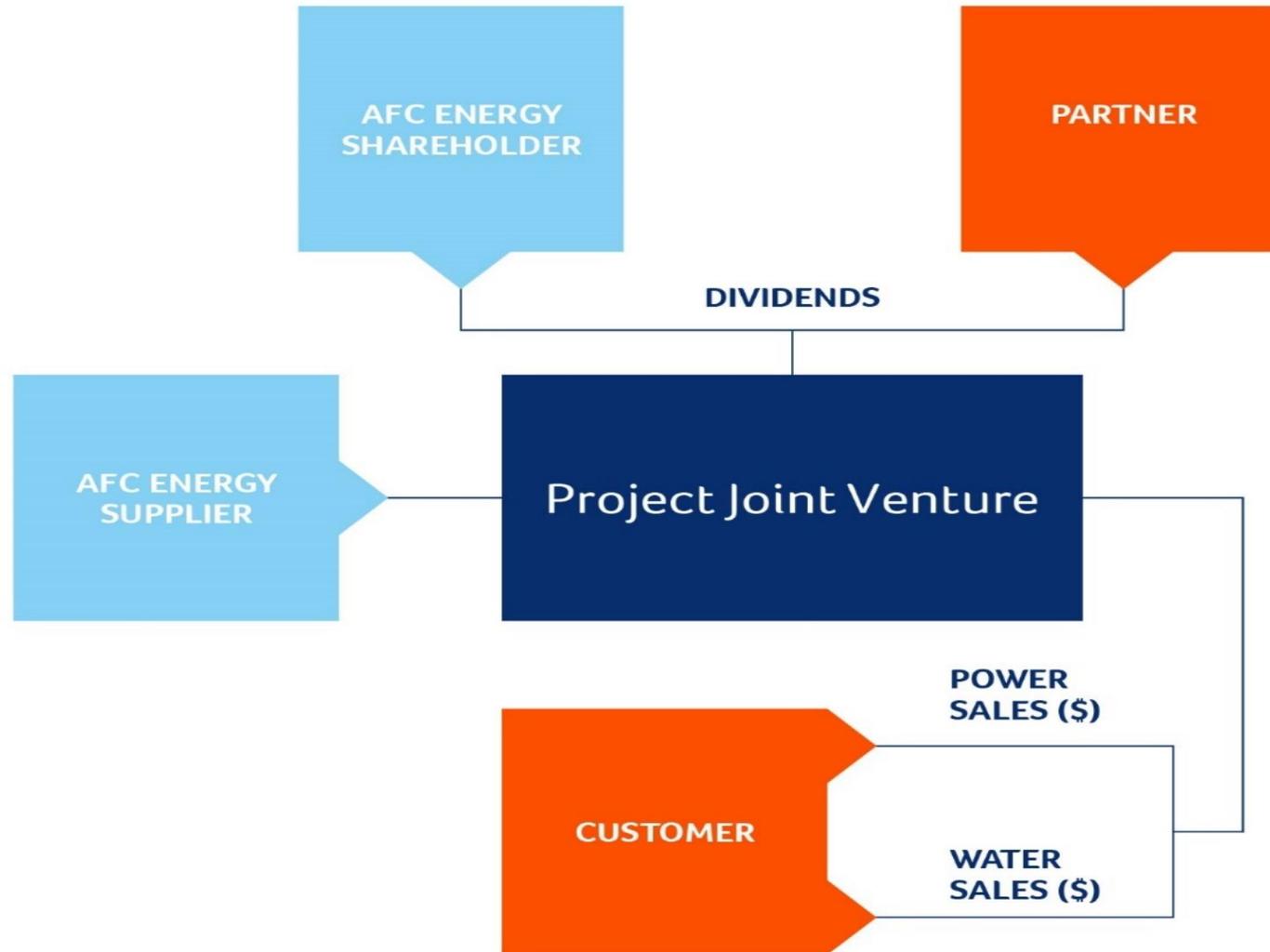
# Hydrogen Battery

The AFC Energy fuel cell can be deployed as part of a 'Hydrogen battery' scheme. When grid demand is low excess power generated from renewable sources, such as wind or solar can be diverted to a water electrolyser for hydrogen generation.

The produced hydrogen can then be stored and optimally released to our fuel cells at periods of peak demand (with higher tariffs), to support grid power requirements, when required.



# Business Model

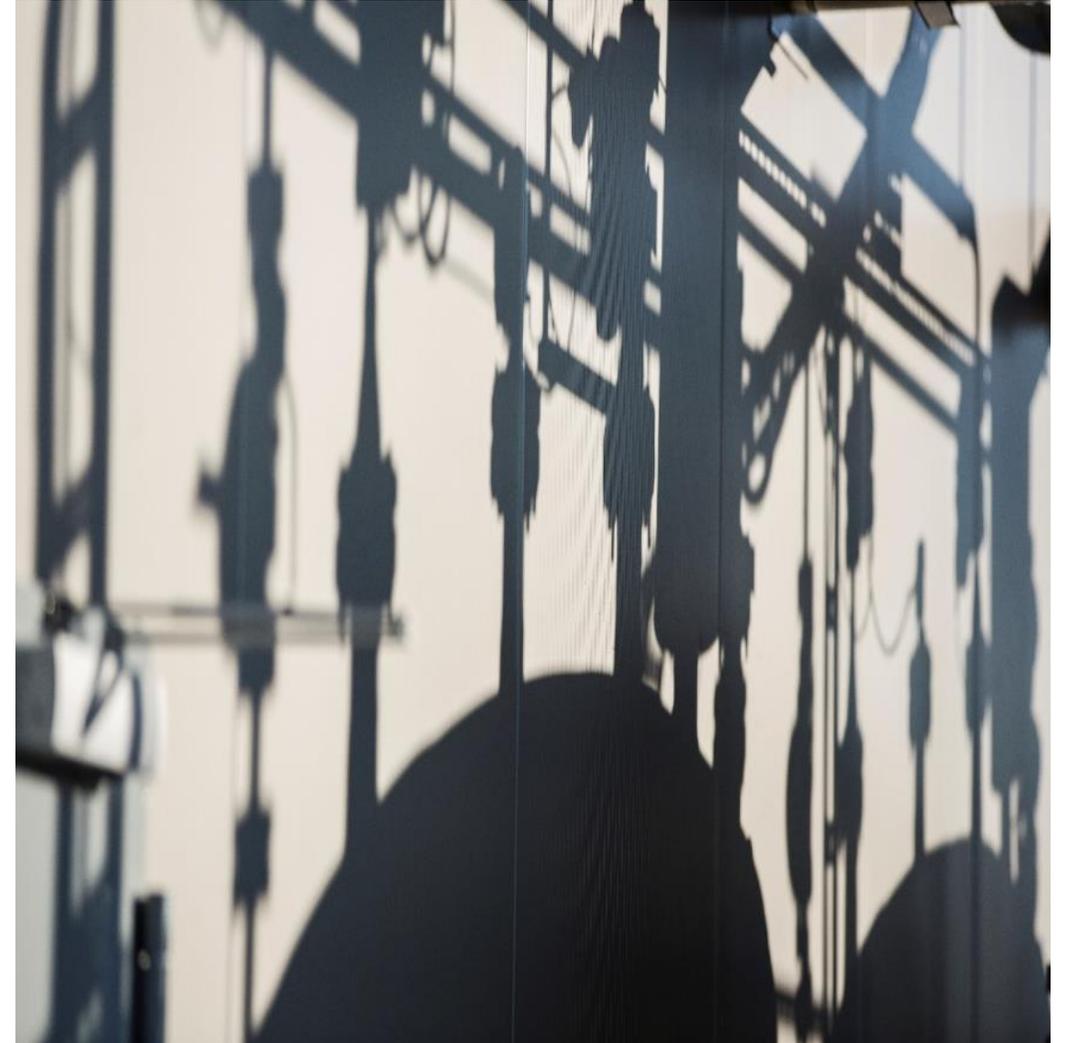


Converting the opportunities being discussed requires;

- Hydrogen of a quantity and quality - addressed via Scoping Studies / Front End Engineering Design work
- Demonstrable data for a FC design that can be scaled
- Commercial model that works for both parties
- Manufacturing capability to meet project deadlines

Opportunities under discussion include;

- Korea Deployment of a demonstration 240 kW FC unit
- Germany Scoping study for a 1MW FC unit with industrial partner
- GCC region Multiple opportunities both Scoping Studies (1MW FC → multi-MW deployment) and demonstration units (80 kW and 240 kW FC unit) ahead of multi-MW roll-out
- UK Three  $\geq 1$ MW units ahead of multi - MW roll-out



## Commercial Pipeline – Peel Environmental

- ▶ Peel Group – Leading infrastructure, transport and real estate investors in the U.K
- ▶ Peel Environmental is at the forefront of developing new infrastructure for the environmental technology, waste management and mineral sectors across the U.K
- ▶ Owner of Protos Industrial Park in Chester – strategic energy hub of the north west
- ▶ Project Collaboration Agreement signed with AFC Energy for fuel cell deployment at Protos
- ▶ AFC Energy likely developer of the project – consistent with business model
- ▶ In discussion with hydrogen sources in the region for long term off take
- ▶ Dialogue with local enterprise Partnerships has commenced
- ▶ AFC Energy now a member of the Northwest Hydrogen Hub





04

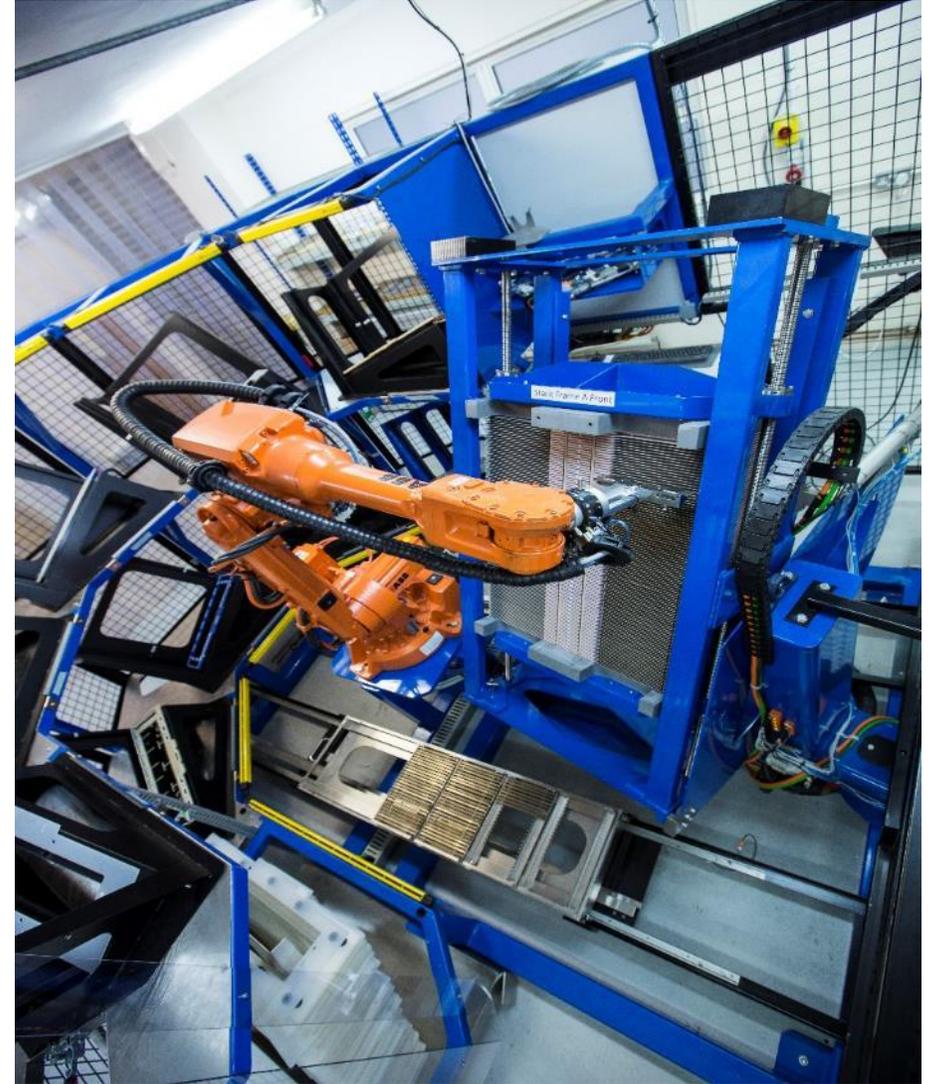
Conclusion

- > Progression with De Nora towards delivery of a commercial fuel cell system with confirmed electrode and stack design capable of mass manufacture and warranties
- > Validation of commercial fuel cell stack and electrode performance of Stade, Germany
- > Verification of multiple fuel cell deployment opportunities through to front end engineering and Design stage of development and procurement of >1MW fuel cell commercial reference plants
- > Complete engineering on Hydrogen Battery solution in conjunction with industry partner



# Robust Foundation for Industrialisation

- ▶ Experienced Leadership and Management team now in place to drive technology commercialisation forward
- ▶ Excellent progress with world leading industrial partner to support robust technology platform
- ▶ Strong evidence of significant progress on fuel cell development over past 12 months
- ▶ Well capitalised following recent fundraise
- ▶ Progression of commercial project pipeline with existing and targeted project partners
- ▶ Delivery of Three Year accelerated path to commercialisation





Thank you for your kind attention – we are now open for questions.

[www.afcenergy.com](http://www.afcenergy.com)

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