HORIZON EUROPE PRGRAMM
Topic HORIZON-JTI-CLEANH2-2024-04-01

GA No. 101192169

RESCUE

RELIABLE AND EFFICIENT DUAL FUEL SYSTEM FOR CIVIL PROTECTION DURING NATURAL DISASTERS USING HT-PEM TECHNOLOGY

RESCUE

Deliverable report

D8.1 – Single cell test matrix

Clean Hydrogen Partnership
Co-funded by the European Union

WP	8	Management
Deliverable No.	D8.1	Single cell test matrix

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Project details

PROJECT TITLE	
PROJECT NUMBER	101192169
PROJECT ACRONYM	RESCUE
PROJECT NAME	Reliable and Efficient Dual Fuel System for Civil Protection during Natural Disasters using HT-PEM Technology
CALL	HORIZON-JTI-CLEANH2-2024
TOPIC	HORIZON-JTI-CLEANH2-2024-04-01
STARTING DATE OF THE PROJECT	01-01-2025
PROJECT DURATION	48 months

Project Abstract:

This proposal entitled "RESCUE – Reliable and Efficient Dual Fuel System for Civil Protection during Natural Disasters using HT-PEM Technology" is about the development and the demonstration of a fuel cell system which allows the operation using 100 % of hydrogen and additionally using methanol and assures 50 kW of electrical power, with peak power of up to 100 kW. The containerised and modular design in combination with the duel fuel approach leads to an application flexibility for various important facilities during natural disasters like the civil protection with different energy requirements. The HTPEM technology is characterised by increased operating temperature of around 160 °C and enables a simplified cell design and operation regarding water management, heat rejection and direct use of reformates. After system requirements (WP2), the fuel cell module equipped with the fuelling possibilities will be constructed and tested in laboratory environment (WP3). After fuel cell and fuel container constructions (WP4), the system integration (WP5) considering safety and transport certification requirements (WP2/9), demonstration using defined load profiles and conditions with performing grid integration is planned (WP6). Testing for at least 2,000 hours on site of a civil protection organisation shows the system capabilities and completes the project (WP7). State-of-Health against the criterium of system efficiency and fuel flexibility on system and on fuel cell level is analysed and accompanies the whole project duration (WP8). Dissemination and exploitation are mandatory in this project (WP10).

Key Words: Hydrogen, Methanol, Fuel Cells, HT-PEMFC

PARTICIPANT Nº	PARTICIPANT ORGANISATION NAME	SHORT NAME	COUNTRY
1	DEUTSCHES ZENTRUM FUR LUFT - UND RAUMFAHRT E.V.	DLR	DE
2	ADVANCED ENERGY TECHNOLOGIES AE EREUNAS & ANAPTYXIS YLIKON & PROIONTONANANEOSIMON PIGON ENERGEIAS & SYNAFON SYMVOULEFTIKON Y PIRESION	ADV	EL
3	ETHNIKO KENTRO EREVNAS KAI TECHNOLOGIKIS ANAPTYXIS	CERTH	EL
4	DANMARKS TEKNISKE UNIVERSITET	DTU	DK
5	BUNDESANSTALT TECHNISCHES HILFSWERK	THW	DE
6	PROACT SYMVOULOI VIOMICHANIKIS ASFALEIAS IKE	PROACT	EL

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1. Objective

The test matrix serves for a standardized assessment of long-term suitability and multifuel tolerance of FC components along all single cell measurements at DLR during WP8 with a duration of four years.

2. Method and Test Equipment

Contamination and degradation study of main components MEA and BPP is performed under defined controllable test conditions. A single cell test bench (inhouse engineering, Germany) with compression unit and 25 cm² cells (qCf 25/100, balticFuelCells, Germany) is used. The general test procedure is:

1) Cell conditioning for two days at constant load
2) Initial characterisation (polarisation curves, EIS, CV, LSV)
3) Cell operation with defined parameters and contamination
4) Operando EIS and periodical FC process water collection
5) Final characterisation

It is planned to compare a moderate long-term testing up to 1,000 h using relevant gas mixtures with harsh fuel switching in an application relevant interval of few hours. Reference testing of 500 h is performed using H_2 (purification grade of 5.0) with air.

3. Components

MEAs are planned to be delivered by the partner Advent Technologies (Advent PBI MEA) and are based on the Celtec®-Technology. On an optional small part of the project, the new MEA (Advent Ion Pair™ MEA) will also be tested. BPP are planned to be delivered by the partner Advent Technologies with graphitic 5-fold serpentine flow fields.

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4. Test conditions

The test conditions are an operating temperature of 160 °C, a cell contact pressure of 0.75 MPa, a constant load at a current density of 0.3 A cm^{-2} and 0.6 A cm^{-2} each (or a cycled load test) and an ambient pressure. The test duration is 500 h for each fuel mixture at constant load or fuel switching at constant load. Selected tests will have a duration of up to 1,000 h. Synthetic dry air is supplied to the cathode side along all tests. Stoichiometries are H_2/air of λ=1.5/2.0. Conditions of 180 °C, 0.6 A cm^{-2} and a backpressure of 1 or 2 barg can be used in additional testing for MEA comparison (PBI and Ion Pair), which is an option in case of available additional testing capacities during the project only.

5. Fuel mixtures

On the one hand hydrogen is purchased with different purifications and on the other hand gas compositions are pre-mixed in cylinders by appropriate suppliers and connected to the test bench to be supplied to the HT-PEM single cell anode. Gas humidification is not considered. The planned gas compositions in Table 1 are dependent on the possibilities of mixing and delivery by the supplier and are subject to change.

Table 1 Gas compositions

Hydrogen	Process gas mixtures from
High purity grade 5.0 from inhouse tank at DLR *(>99.999 %; used at hydrogen refueling stations)*	Methanol reforming (H_2 68%, CO_2 22%, N_2 9%, CO 1%)
Industrial grade 1.8 purchased in bundles *(>98.000 %; discussed for hydrogen transportation in reused natural gas pipelines)*	Ammonia cracking (N_2 25%, H_2 75%, NH_3 0.3%)
Hydrogen with targeted contamination of 10 ppm H_2S (optional 1 ppm)	Methane reforming (H_2 75%, CO_2 9%, CO 13%, 3%CH_4)
Hydrogen with targeted contamination of 180 ppm formaldehyde (optional 220 ppm)	

6. Test protocol

1) Cell conditioning for two days at constant load
   - Incorporation of the MEA
     - Opening the MEA packaging and visual inspection
     - Determination of thickness and weight at begin of test (BoT)
     - MEA incorporation in the measuring cell and fixing the cell compression pressure

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    - Tightness test of the measuring cell with MEA
- Cell break-in
    - Heating up to 120 °C under nitrogen
    - Supplying reaction gases and further heating up to 160 °C
    - Setting the current density to 0.3 A cm^{-2} as the cell voltage arises
    - Cell operation at constant load of 0.3 A cm^{-2} for two days

2) Initial characterisation (polarisation curves, EIS, CV, LSV) at begin of test (BoT)
    - Polarisation curves ***H_2/air***
        - 0.3 A cm^{-2} > 2.0 A cm^{-2} > 0.0 A cm^{-2} > 2.0 A cm^{-2} > 0.3 A cm^{-2}
        - 0.5 A steps with 30 s holding time; limits are 0.1 V and 2.0 A cm^{-2}
        - For evaluation, range from 0.0 A cm^{-2} > 1.0 A cm^{-2} and in each case the voltage value at the end of 30 s holding time is used.
    - Impedance spectroscopy (EIS) ***H_2/air***
        - Recording of EIS at current densities of 0.03 A cm^{-2}, 0.3 A cm^{-2} and an appropriate high current density in the mass transport region.
        - All measurements in the frequency range from 100 mHz to 100 kHz with an amplitude of 10 mV r.m.s.
    - Anode-side switching to the fuel mixture to be tested
    - Polarisation curves ***fuel/air***
        - Analogous to H_2/air
    - Impedance spectroscopy (EIS) ***fuel/air***
        - Analogous to H_2/air
    - Voltammetry
        - The fuel cell setup is used as a two-electrode setup with cathode as WE and anode as CE/RE.
        - Cyclic voltammetry (CV) curves under 100 mL min^{-1} N_2 on cathode side and H_2 on anode side are recorded using a scan rate of 100 mV s^{-1} in the potential window 0.05 to 1.00 V vs. RHE, 7 cycles.
        - Linear sweep voltammetry (LSV) curves are recorded under 300 mL min^{-1} H_2/N_2 in each case with a scan rate of 2 mV s^{-1} from 0.1 to 0.5 V vs. RHE.
    - Switching to fuel cell operation and starting the planned test
3) Cell operation with defined parameters and contamination
    - See previous chapters
4) Operando EIS and periodical FC process water collection
5) Final characterisation at end of test (EoT)
    - Analogous to 1)
    - Cell cooling down to 120 °C
    - Gas switching to nitrogen on both sides
    - Switching off the cell heating
    - MEA removing after cooling down
    - Determining thickness and weight (EoT)
    - Storage under vacuum until further analysis

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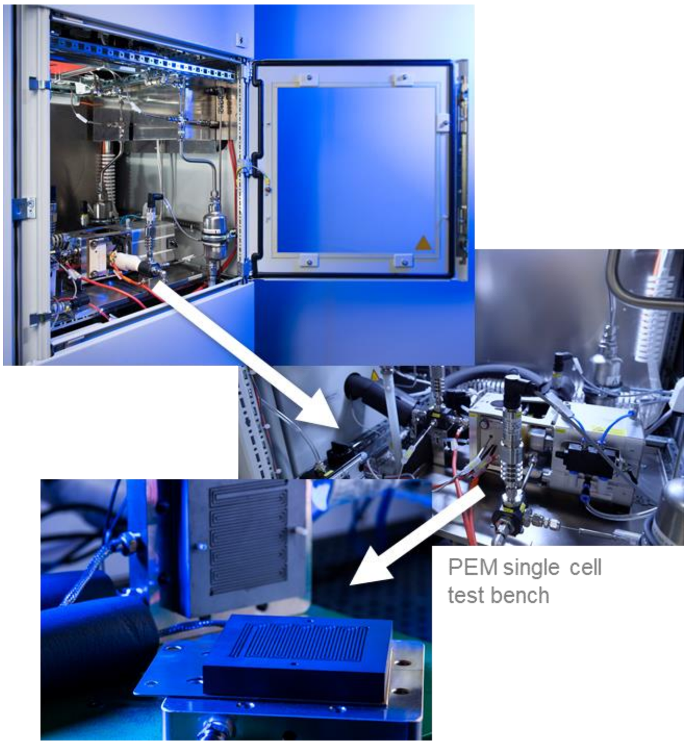

Figure 1 PEM single cell test bench operable using HT-PEM conditions at 160 °C and equipped with a compression unit and 25 cm² cells. Image source: © DLR (CC BY-NC-ND 3.0).

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