HySA Infrastructure
Hydrogen South Africa

LOCALLY DEVELOPED TEST STATION FOR WATER ELECTROLYSIS CHARACTERIZATION WITH ADVANCED CAPABILITIES

Artem S. Pushkarev, **Irina V. Pushkareva, Christiaan Martinson, Samuel Mamathuntsha, Henco Brink, Sam Modise, Aleksandr Malakhov, Dmitri Bessarabov**

HySA Infrastructure Centre of Competence, North-West University, Faculty of Engineering, Private Bag X6001,Potchefstroom Campus, 2520,South Africa

Pushkarev_as@outlook.com; 32869509@mynwu.ac.za

INTRODUCTION

- Proton exchange membrane (PEM) water electrolysis is the key technology for getting green hydrogen from renewable energy sources, but its widespread adoption is hindered by challenges related to cost, durability, and the usage of platinum group metals (PGMs). **To foster innovation in materials and cell/stack design, advanced approaches for "in-situ" and "ex-situ" characterization of the cell itself or its components in realistic conditions are necessary**.
- There is an acknowledged need for objective comparative assessment of the behavior of electrolyzer components and devices in harmonized conditions, so some testing protocols were suggested [1].
- To unpack the PEM water electrolyzer losses breakdown, the test station with wide "in-situ" testing capabilities is necessary.

FEATURES

- Independent anode and cathode circulation loop allowing the asymmetrical, symmetrical circulation, or dry-cathode operation mode.
- Accurate test cell temperature management is allowed using the reactant water preheating and direct test cell heating through the implemented jacket (see Image 1).
- Active water quality management (3 high-precision conductivity sensors and ion-exchange resins) ensures the water conductivity of 0.1….1.0 μS cm^{-1} (in line with [1]).
- Operation in H_2/N_2 mode for anode catalyst layer characterization via cyclic voltammetry to access an electrochemically active surface area (EASA).
- "In-situ" gas content measurements to access efficiency and cross-over using gas chromatography are allowed.
- "In-situ" electrochemical impedance spectroscopy measurements in the full current density range allowed by Zahner electrochemical workstation based on the Zennium X and EL1002.
- Polarization measurements are allowed with a high current power supply (0–200 A_{DC}) or electrochemical workstation (limited to 1 kW heat dissipation). In the latter case, big single cells or small stacks can be fully characterized (extra voltage/EIS channels available).

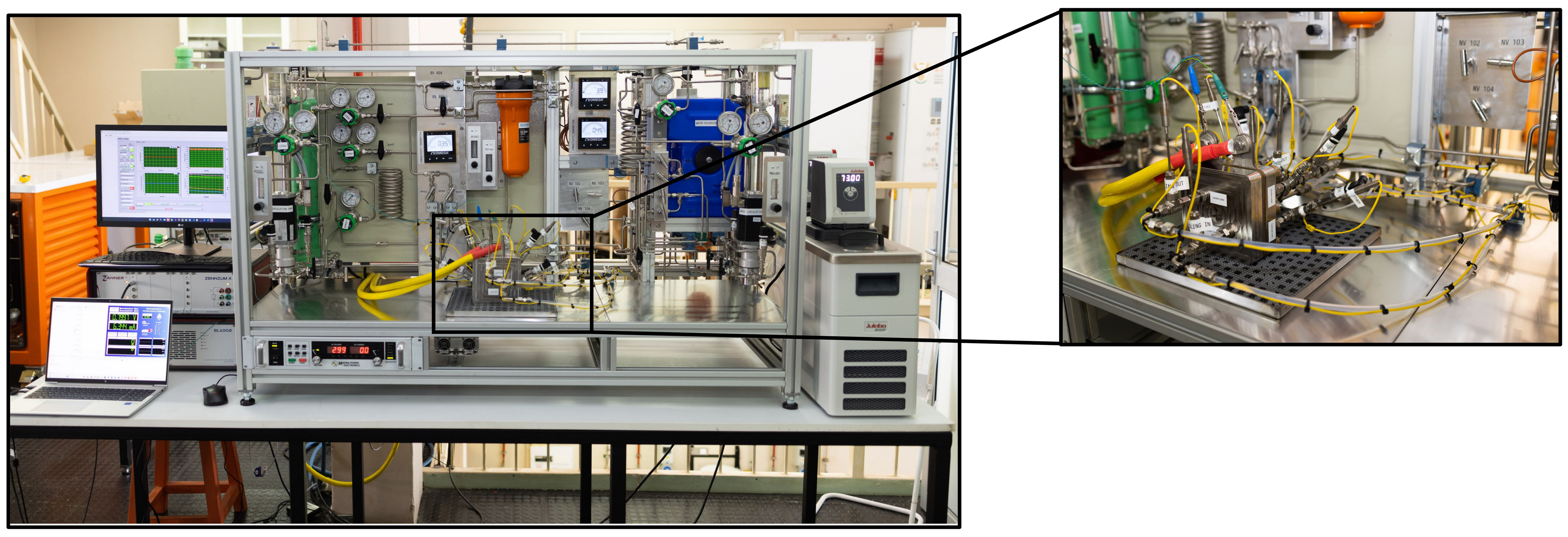
SOME LESSONS LEARNED

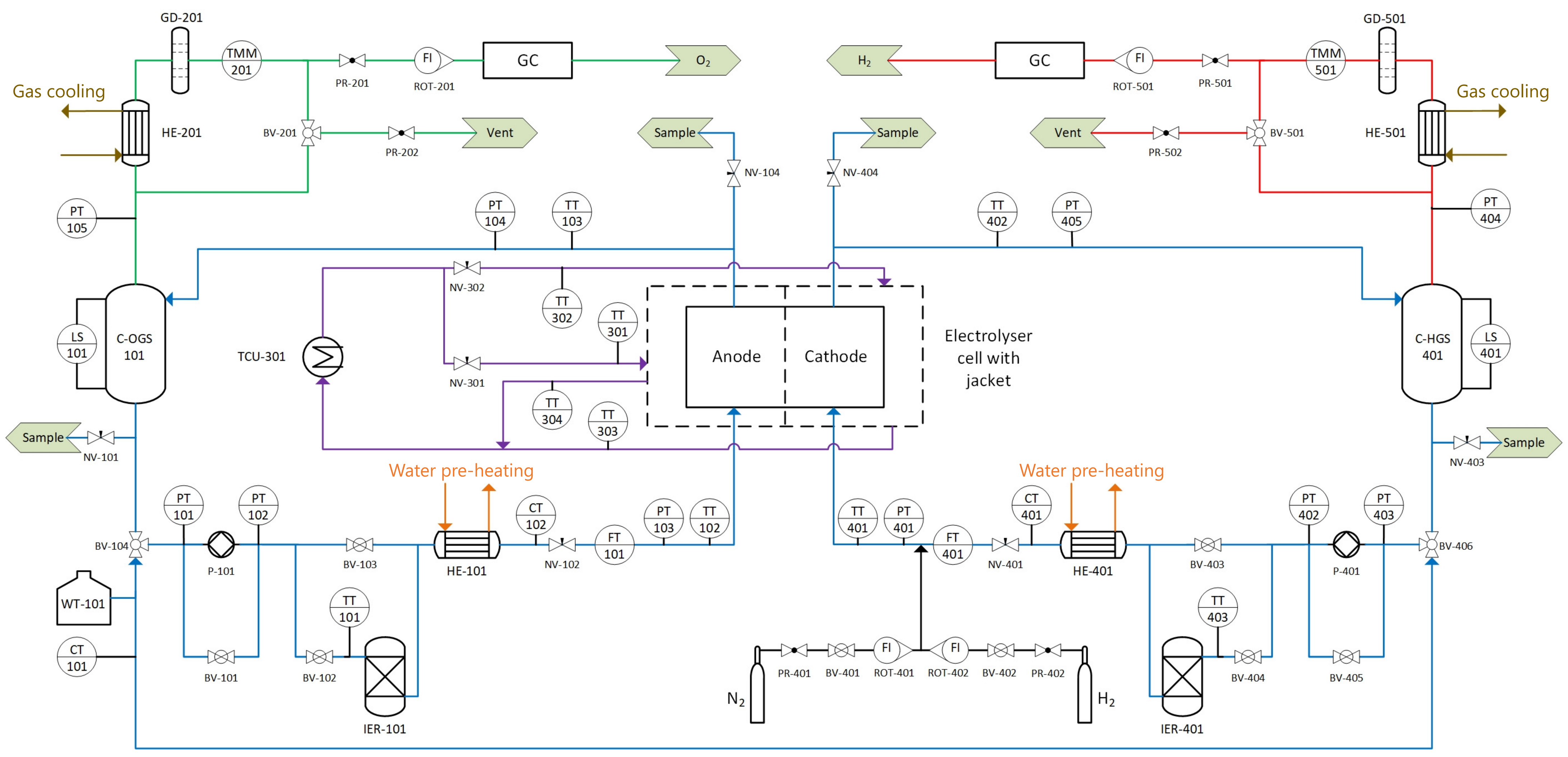
- Lab-made and commercial test cells of different sizes can be tested with an ensured operational temperature.
- Water quality is ensured within a safe conductivity range to avoid a significant performance drop due to cation contamination (if not intentional),
- dual-heating scheme ensures quick test cell temperature stabilization.

[1] G. Tsotridis, A. Pilenga, EU harmonised protocols for testing of low temperature water electrolysers, Westerduinweg, The Netherlands, 2021

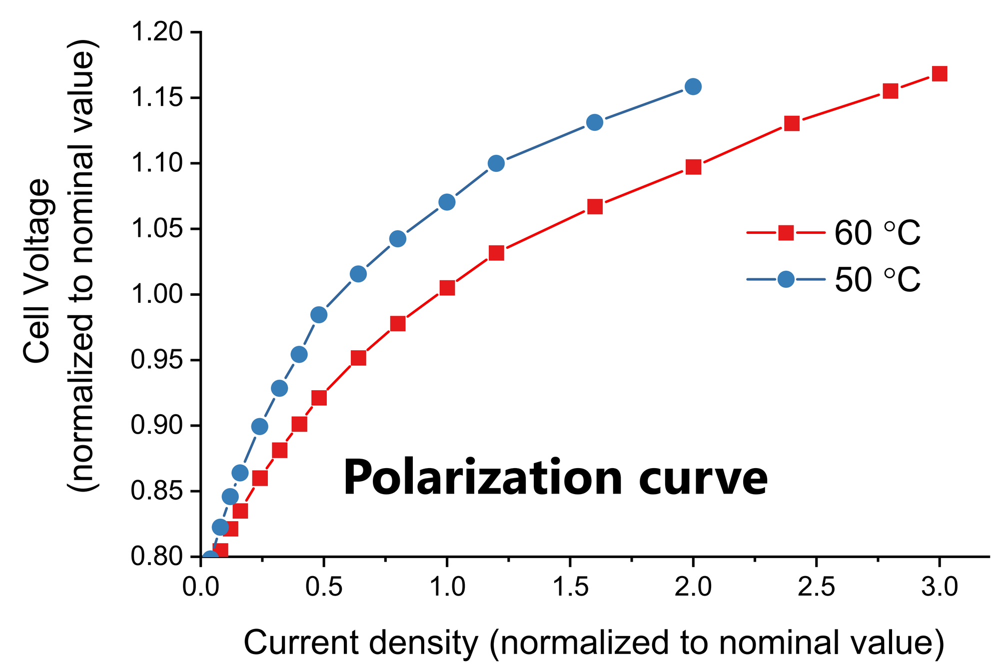
[2] C. Rozain, E. Mayousse, N. Guillet, P. Millet // Appl. Catal. B: Environ., 2016, 182, 153-160

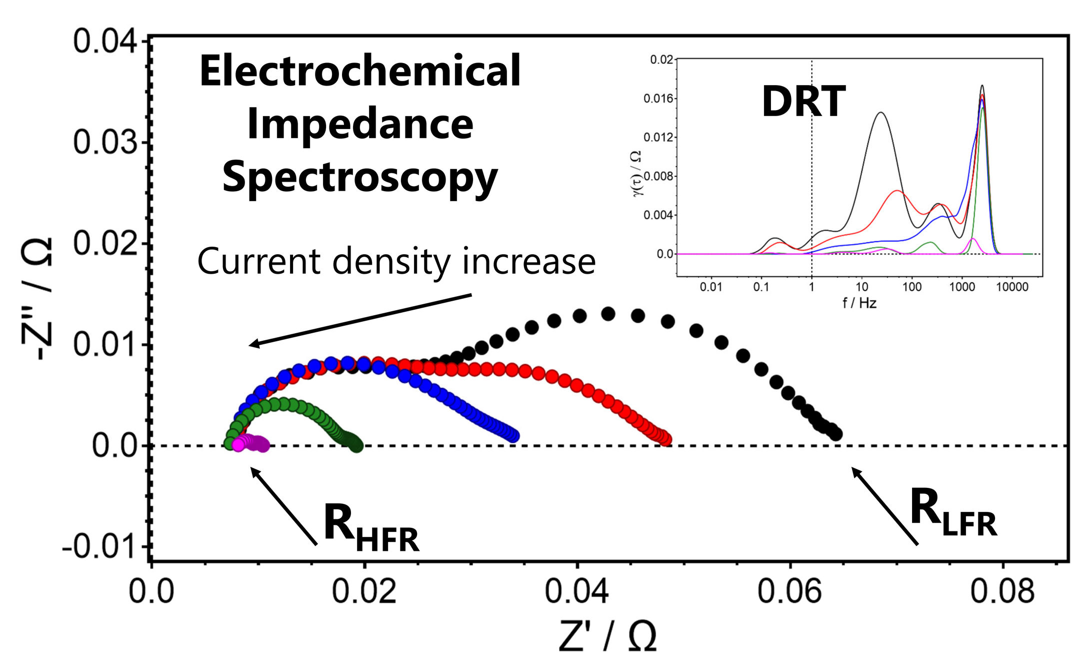
TEST BENCH AND TEST CELL

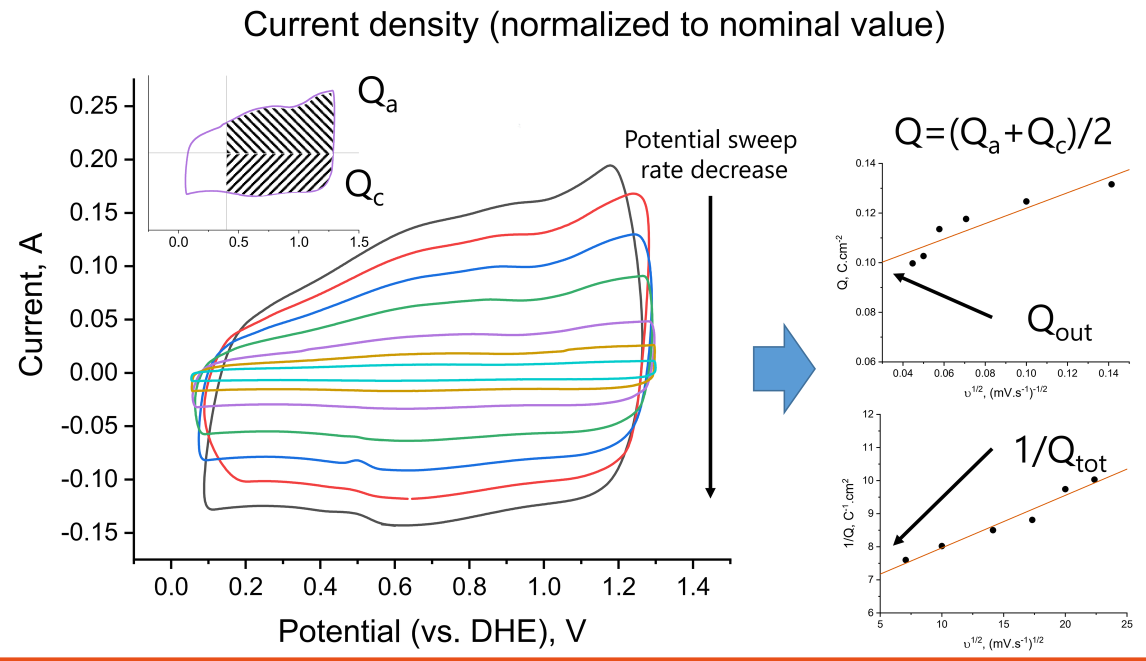




Component	Description	Component	Description	Component	Description
------------	Water lines	WT-XXX	Water Tank	TT-XXX	Temperature Transmitter
------------	Hydrogen line	C-(O/H)GS-XXX	Oxygen/Hydrogen Gas Separator	PT-XXX	Pressure Transmitter
------------	Oxygen line	GD-XXX	Gas Dryer	FT-XXX	Flow Transmitter
------------	Jacket Heating line	BV-XXX	Ball Valve	LS-XXX	Level Sensor
HE-XXX	Heat Exchanger	NV-XXX	Needle Valve	TMM-XXX	Thermal Mass Flow Meter
IER-XXX	Ion Exchange Resin	PR-XXX	Pressure Regulator	GC-XXX	Gas Chromatographer
P-XXX	Pump	ROT-XXX	Rotor meter	TCU-XXX	Temperature Control Unit

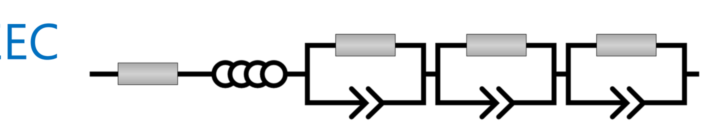






To extract the data from EIS:

- EEC



- Distribution of Relaxation times

$$Z(\omega) = R_0 + Z_{Pol}(\omega) = R_0 + \int_0^\infty \frac{\gamma(\tau)}{1 + j\omega\tau} d\tau$$

Anode electrochemistry and EASA [2]

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