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Technical Deepdive
Advanced Diagnostics Hardware

Presentors/Authors:
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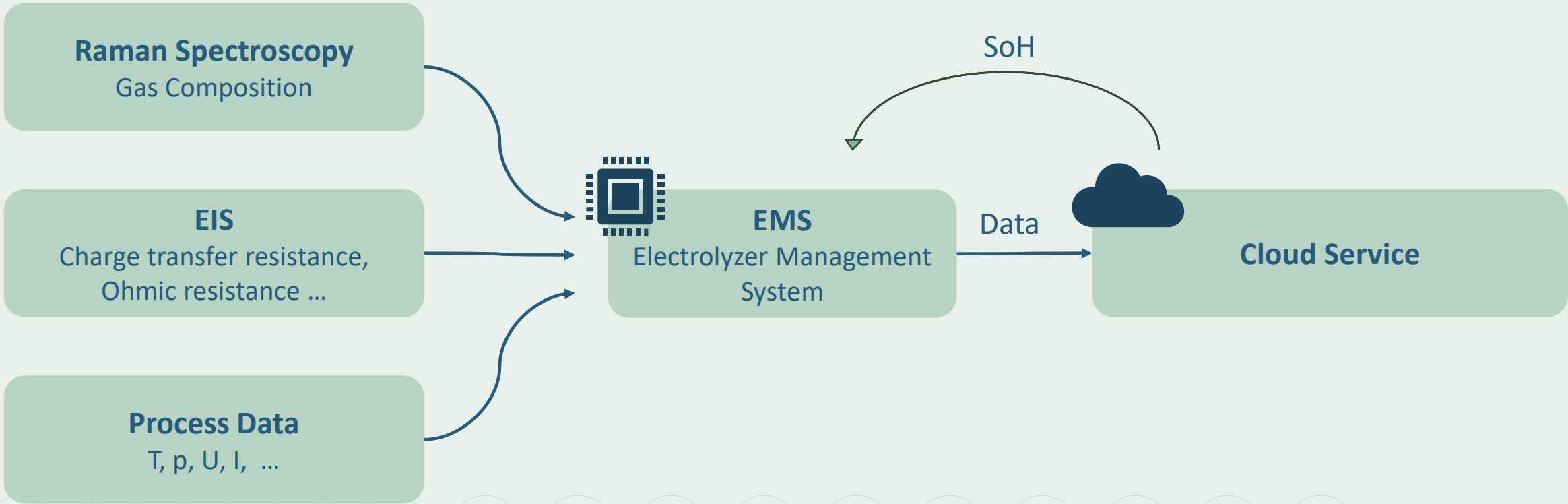
Introduction – System Concept

Goal: State of health analysis, recommend optimized operating conditions (no closed-loop control)



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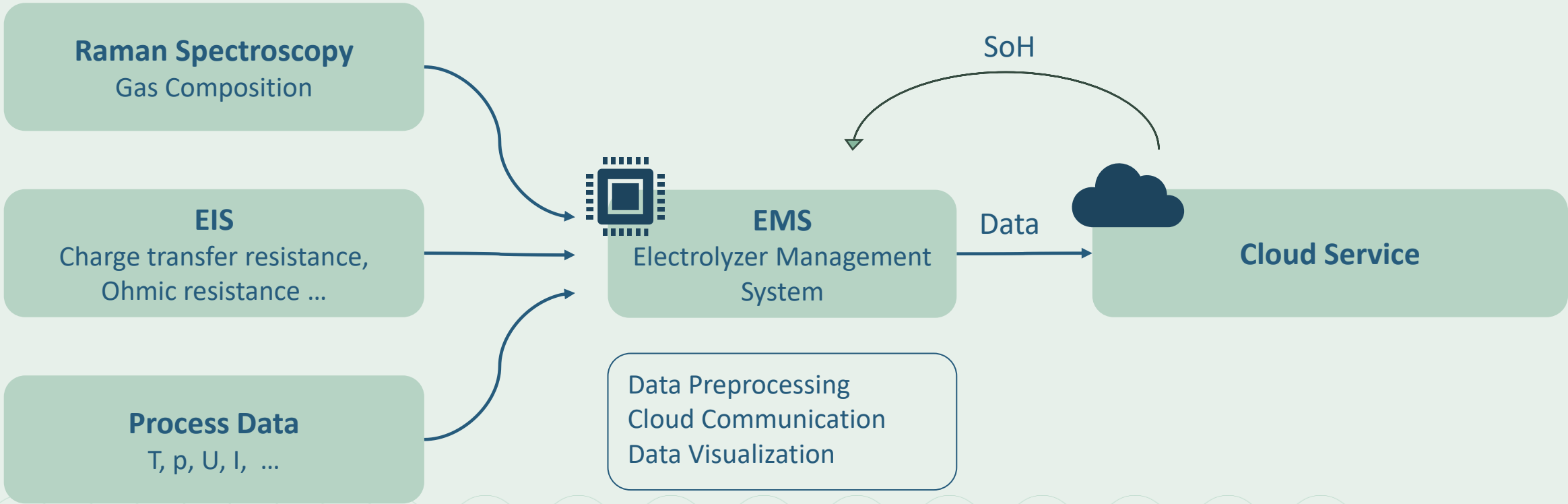

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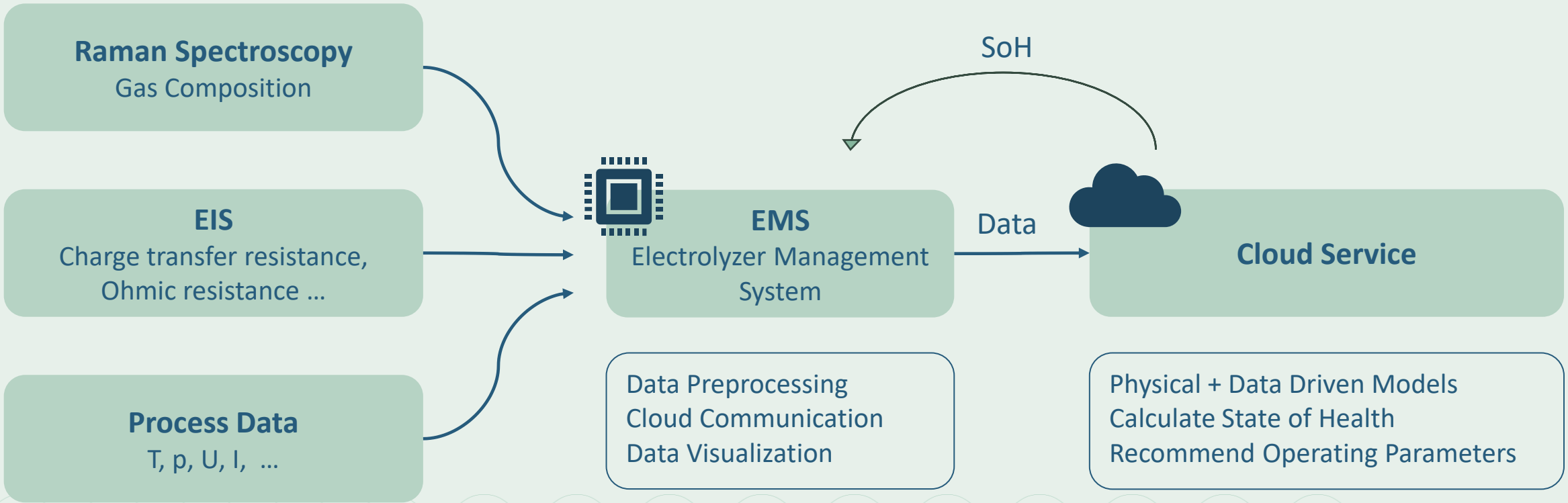

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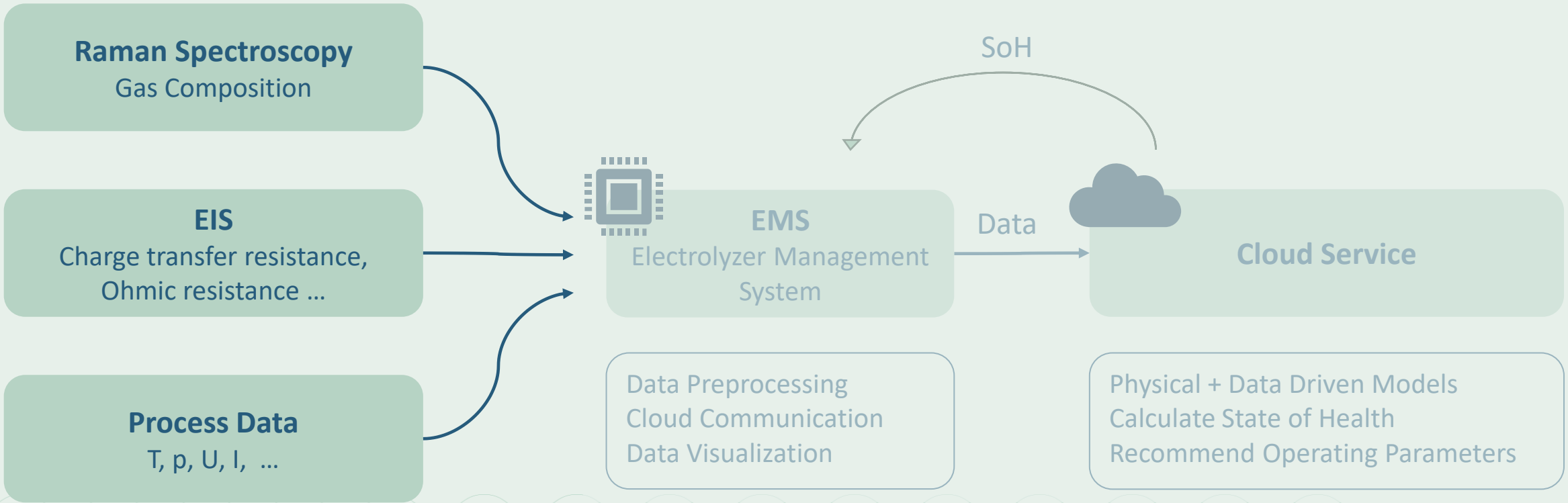
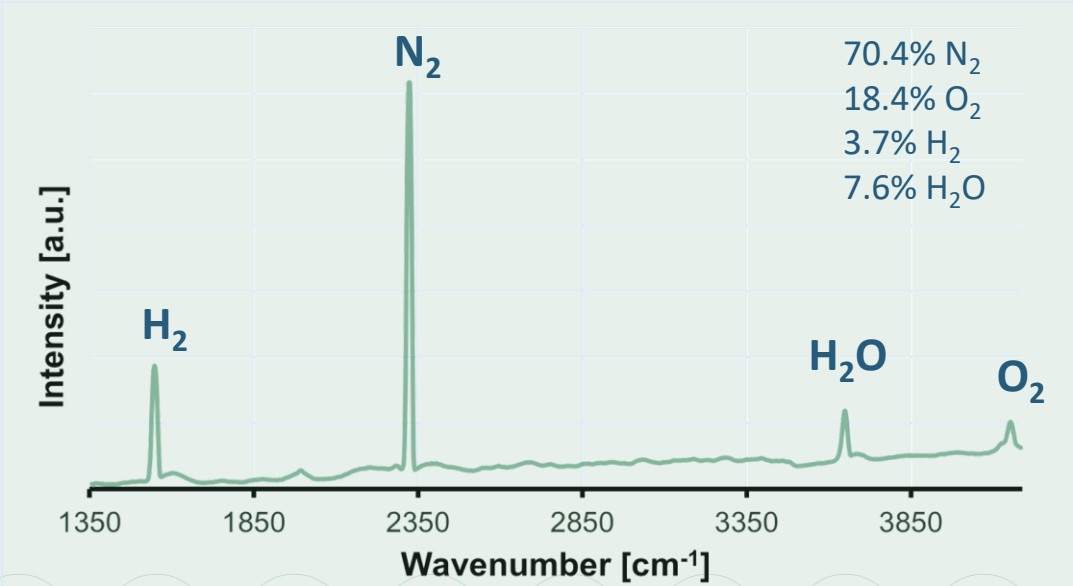


Raman Spectrometer

Gas Crossover - Indicator for Electrolyzer Health

- Hydrogen crossover to Oxygen Electrode
- Oxygen crossover to Hydrogen Electrode



Gas phase Raman spectroscopy

- Inline measurement developed by HORIBA
- Short measurement times between 1 s and 20 s
- Identification and quantification of H_2 ,N_2 , O_2 and H_2O between < 1% and 100 %
- Measurement channels for anode and cathode outlets

D3.2
Lab-scale Raman

Electrochemical Impedance Spectroscopy

Essential tool for assigning degradation to cell components

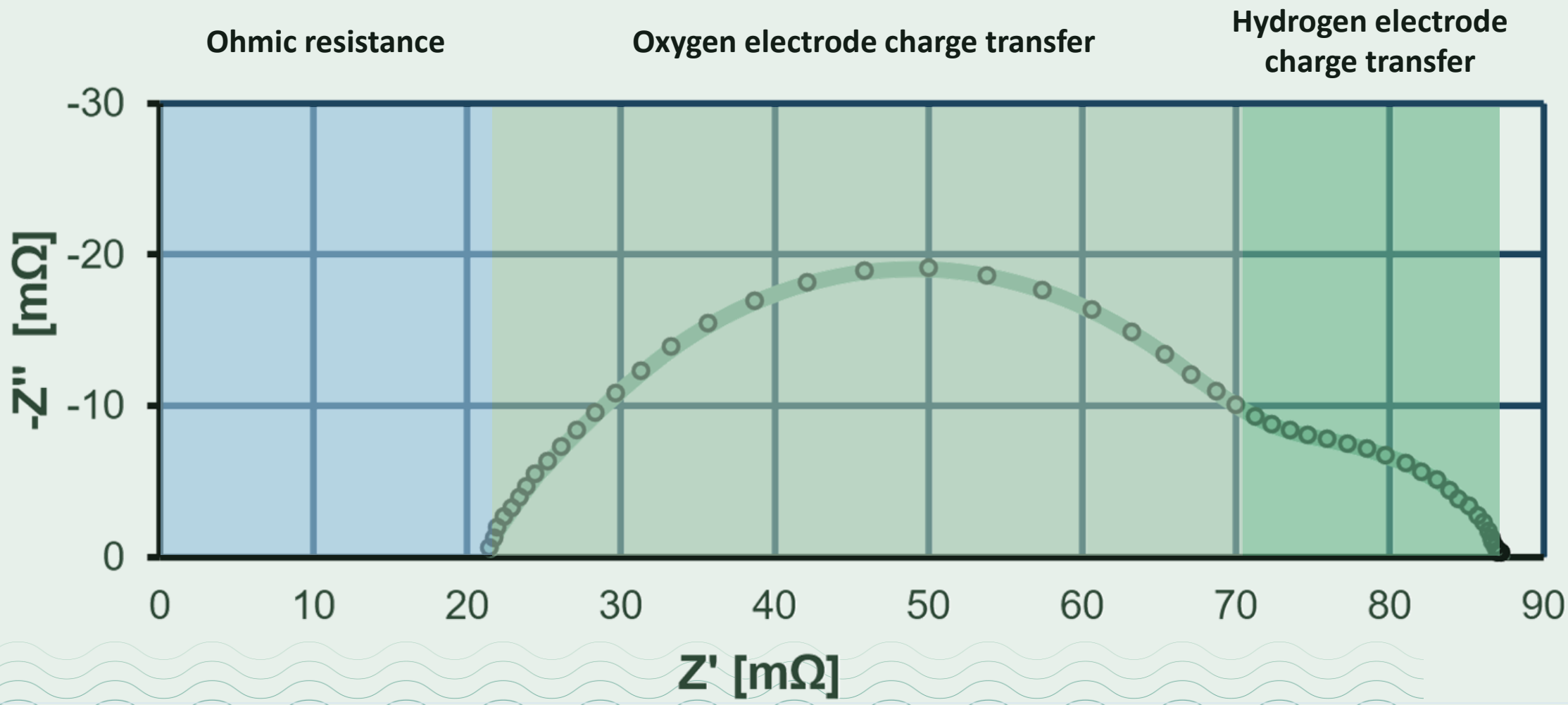
The challenge – Transition from lab- to large-scale

- Low cell resistances in large-scale systems (mΩ - µΩ range)
- Maintain frequency bandwidth at high modulation currents
- Modulation independent of electrolyzer current supply

Features for large-scale tests

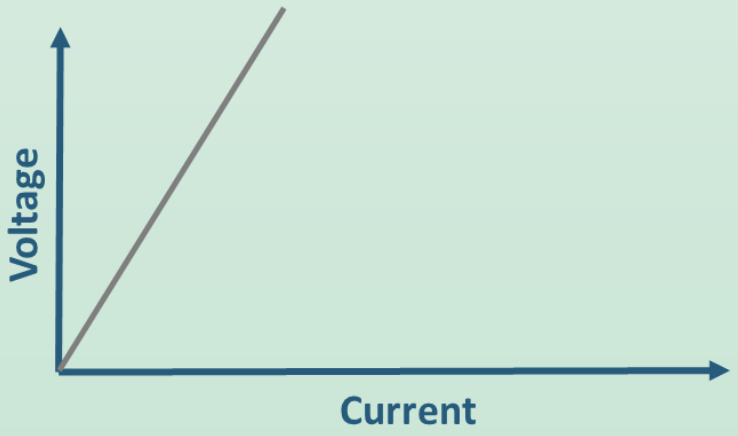
- Support for > 10 kA DC currents and 2 MW power
- Provision of sufficiently high modulation currents
- Parallel measurement of multiple cells or cell groups

D3.6
Lab-scale EIS


Ohmic resistance
Oxygen electrode charge transfer
Hydrogen electrode charge transfer
-30
-20
-10
0
-Z'' [mΩ]
0
10
20
30
40
50
60
70
80
90
Z' [mΩ]

Electrochemical Impedance Spectroscopy

Lab-scale (Ω - mΩ)



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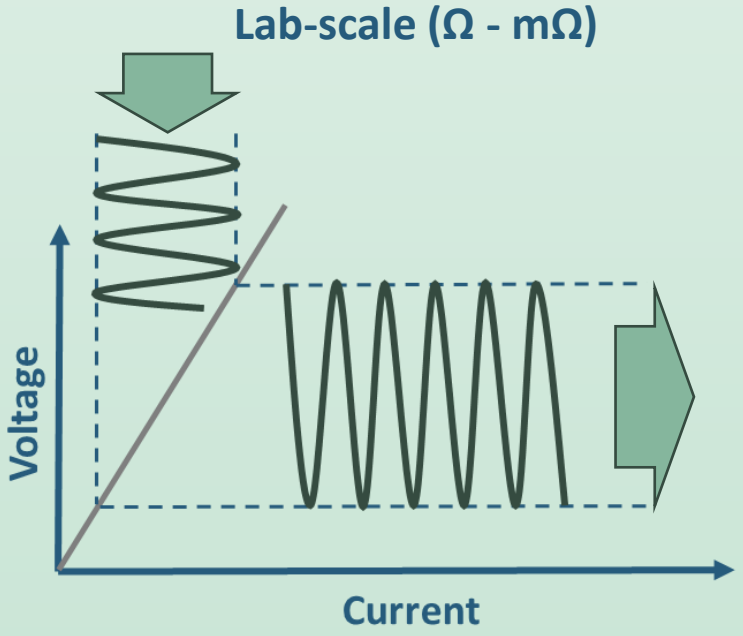
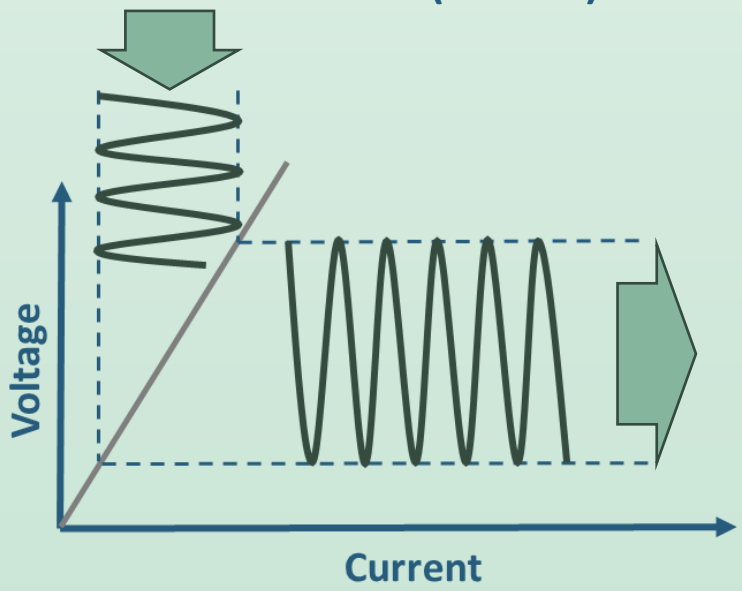


- Lab rule-of-thumb:
  Modulate 5 % of DC current

Electrochemical Impedance Spectroscopy

Lab-scale (Ω - mΩ)



- Lab rule-of-thumb:
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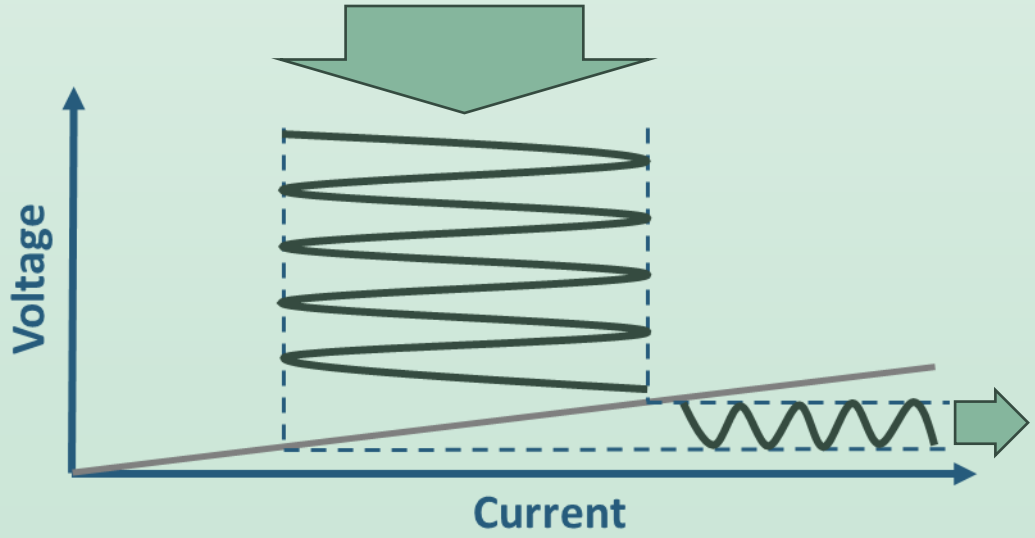
Large-scale (mΩ - µΩ)



- Maintain frequency bandwidth at high modulation currents
- Frequency limit of most power supplies < 5 kHz
  Modulation independent of PSU

Test benches

Lab-scale

PEM | Alkaline | SOEC

Air Liquide | stargate hydrogen | UNIVERSITY OF TWENTE.

Adaptations to include:

- Lab-scale EIS (Sivonic)
- Raman Spectrometer Prototype (Horiba)

Large-scale

Alkaline

Fraunhofer IWES | stargate hydrogen

- 2 MW Horiba test bench installed at Fraunhofer IWES
- Electrolysis stack (Stargate Hydrogen)
- EMS system (Dumarey)
- Raman spectrometer (Horiba)
- EIS (Sivonic)

Thank you for your attention!

Contact: kurt.klauke@horiba.com

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