FOUNDATION FOR THE DEVELOPMENT OF NEW HYDROGEN TECHNOLOGIES IN ARAGON

S2C2 | Solar2Chem Conference

High selective electrochemical conversion of CO_2 to CO as a key step in jet fuel synthesis at mild conditions

Eduardo Bernad Quílez

R&D Technician, PhD Candidate

Aragon Hydrogen Foundation

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4AirCRAFT

Solar2Chem Conference

High selective electrochemical conversion of CO_2 to CO as a key step in jet fuel synthesis at mild conditions

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SOLAR CHEM 2

ICIQ Institut Català d'Investigació Química

ROYAL SOCIETY OF CHEMISTRY

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Max Planck Institute of Colloids and Interfaces

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OLLSCOIL NA GAILLIMHE UNIVERSITY OF GALWAY

UNIVERSITY OF CAMBRIDGE

MARIE CURIE ACTIONS

Aragon Hydrogen Foundation

FOUNDATION FOR THE DEVELOPMENT OF NEW HYDROGEN TECHNOLOGIES IN ARAGON

Private, non-profit research center, created to promote the use of Hydrogen as energy vector

Initiative promoted by the Government of Aragon in 2003 & the support of the local industry and other entities. Currently 88 member in our Board of Trustees.

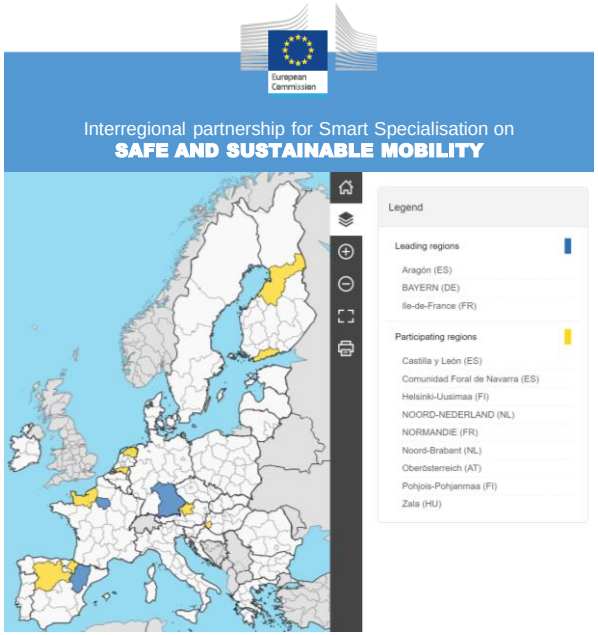
International and national participation

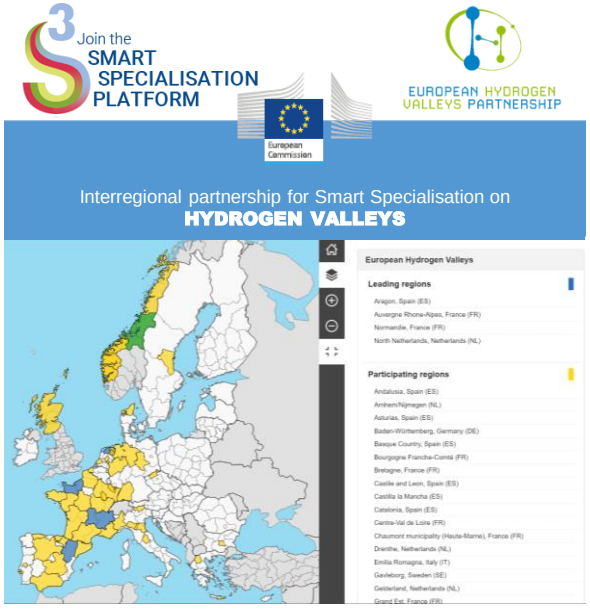
Hydrogen Europe Research

Board Member - Hydrogen Valleys Cross-Technical Committee Leader

GOBIERNO DE ARAGON
Departamento de Innovación, Investigación y Universidad

Recognized as Research Group:
H2 + I. Hydrogen for the Research





AeH2

Asociación Española de Pilas de Combustible APPICE

PTE HPC

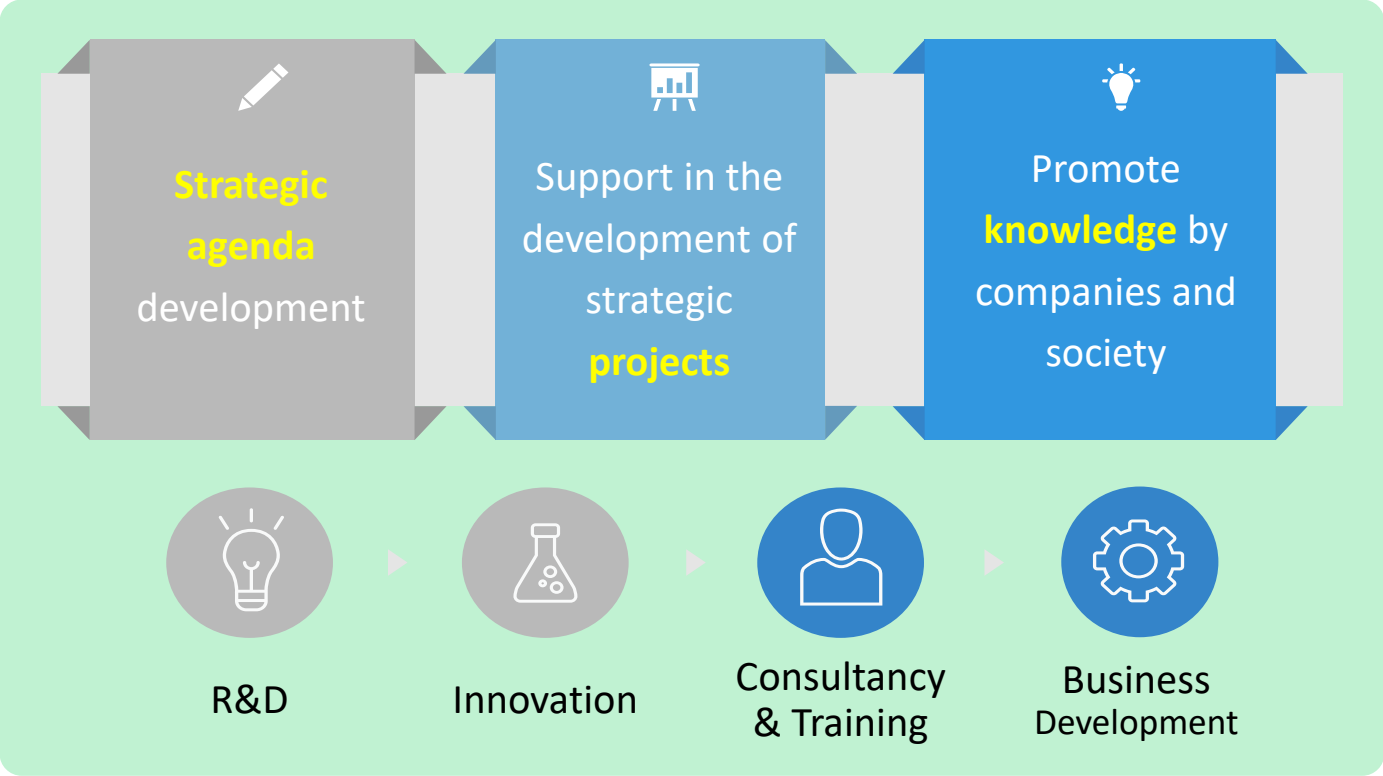
AENOR

CLÚSTER ENERGÍA ARAGÓN

iea

CENELEC
EUROPEAN COMMITTEE FOR ELECTROTECHNICAL STANDARDIZATION

Aragon Hydrogen Foundation



Strategic Agenda Development

Cluster for the sustainable development and innovation based on the Hydrogen Economy

The Ebro Hydrogen Corridor is the most suitable area to lead the deployment of hydrogen in Southern Europe

COMMON OBJECTIVE

Sustainable development of the territories

COMMON VISION

Willingness to collaborate Interregional and Multisectoral to undertake the coordinated development of renewable hydrogen with actions throughout the value chain

COMMON GOAL

Lead the deployment of hydrogen in southern Europe, achieve sustainable results that produce social, economic and environmental benefits, favoring the technological and industrial positioning of Spain and the European Union in this future sector.

Facilities

1,200 m² building with offices, laboratories and a unique workshop prepared to work with large H_2 equipment.

635 kW wind

100 kW PV

62 kW PV (self-consumption)

250 kW alkaline, industrial scale

20 kW alkaline, test bench

5 kW PEM

15 kW AEM

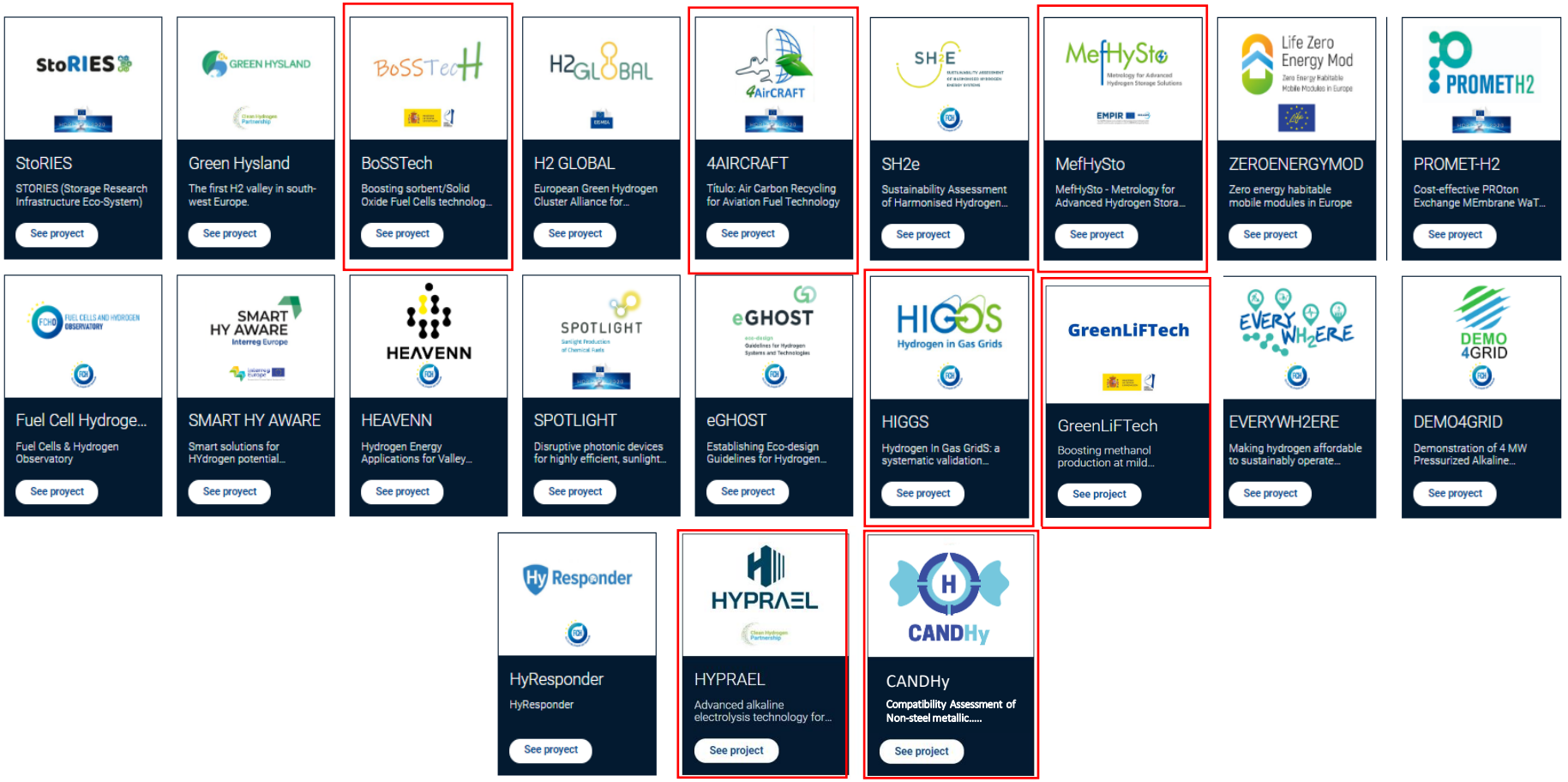
7 kg (4000 L) @35 bar

23 kg (900 L) @350 bar

HIGGS - R&D Blending H2/GN

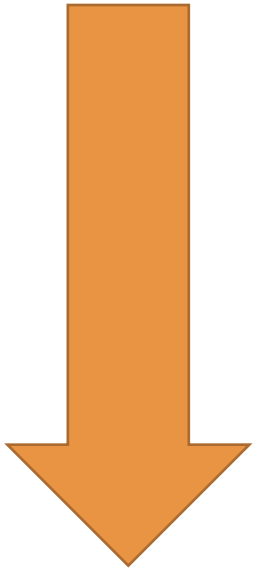
Hyundai Nexo & Kangoo ZE

Active Projects



R&D Department activities

- **Hydrogen production, storage, transport & distribution, applications**
- **Proof of concepts**
- **Water electrolyser stack testing**
- **Hydrogen injection**



4AirCRAFT-Air Carbon Recycling for Aviation Fuel Technology

- **Funding Programme:** H2020-EU.3.3.3. – Alternative fuels and mobile energy sources
- **Topic:** LC-SC3-RES25-2020 – International cooperation with Japan for Research and Innovation on advanced biofuels and alternative renewable fuels – Mission Innovation Challenge

Coordination: Aragon Hydrogen Foundation (FHa, Spain)

Dr. Vanesa Gil

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101022633. This work is supported by Japan Science and Technology Agency (JST) (Grant Agreement No JPMJSC2102) and São Paulo Research Foundation (FAPESP) (Grant number 2022/04751-0).

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Advisory Panel group

Sustainable fuels producers
Petro-chemical industry
Chemical industry
CO_2 producers
Logistics, Ports, etc.

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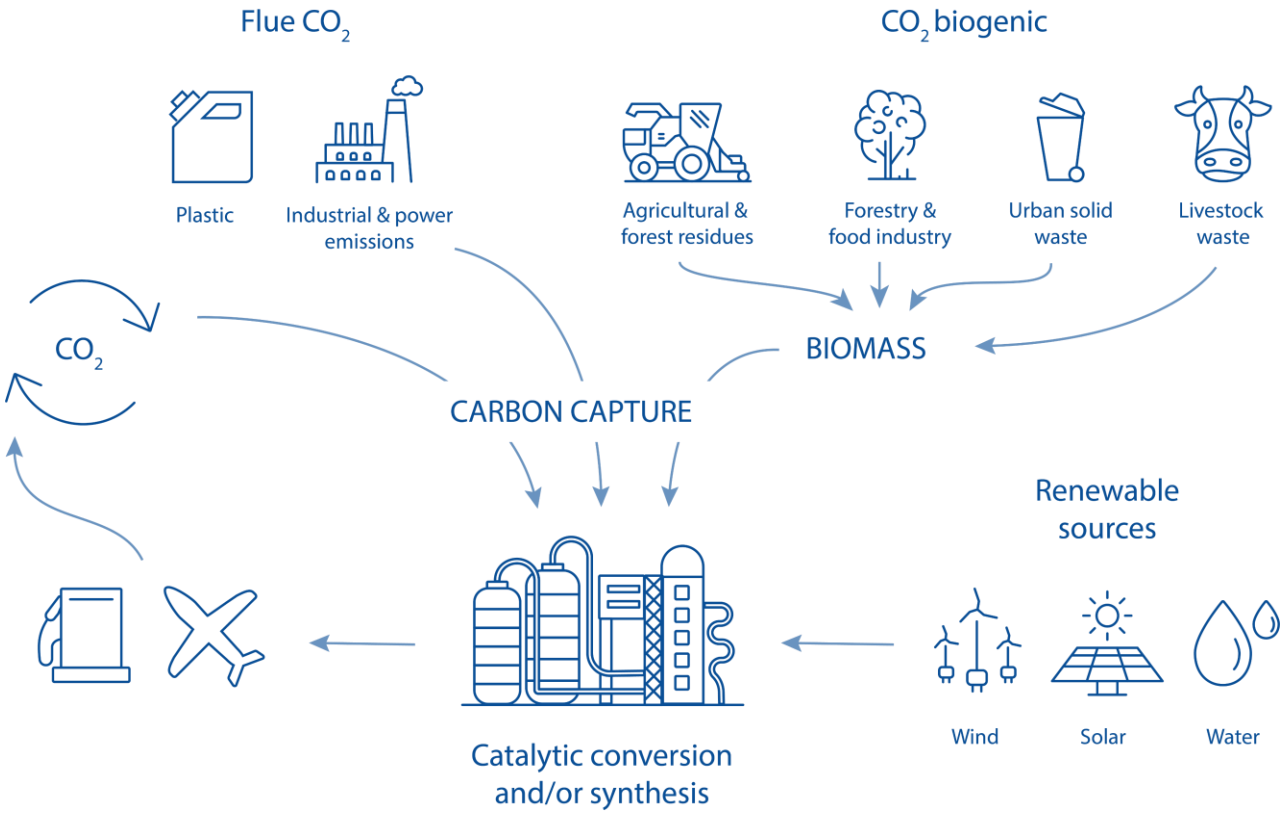
4AirCRAFT

What is our motivation?



Unfortunately, **conventional technologies** often suffer from **low selectivity** and **conversion** while **lacking energy efficiency**.
Therefore, **new technology** solutions are required, in which the **rational design of catalytic materials** is a must.

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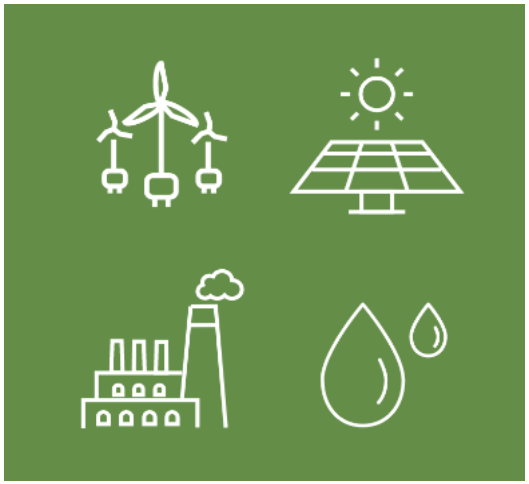
What about the approach?



Water and carbon dioxide from biomass and industrial sources

Greener, milder and intensified liquid fuel production routes

Direct aviation use, storage and distribution in the existing infrastructures

Hybrid cascade reactor technology - CO_2 conversion to long-chain hydrocarbons at mild conditions
Proof of the concept → TRL3

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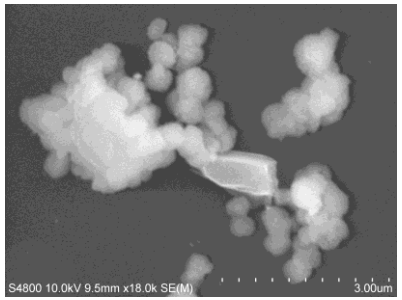
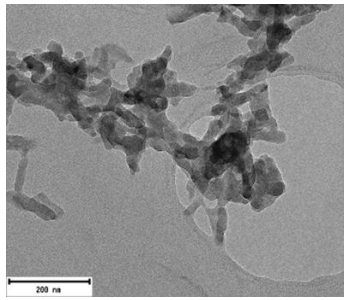
Research Activities

Materials

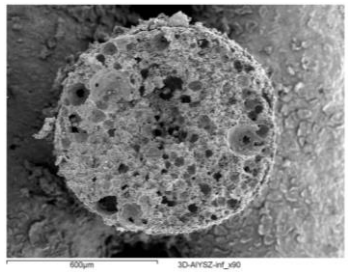
- Electrocatalyst
- Chemocatalysts
- Biocatalysts and Biomimetic catalysts





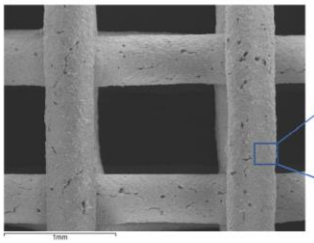
Components

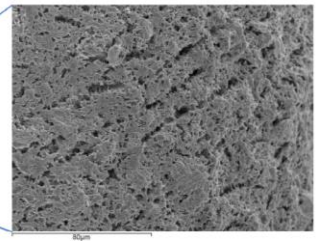
- Membranes and Electrodes
- Advanced Catalysts Carriers
  MOFs and nano→meso→macro
  structured and functionalized scaffolds



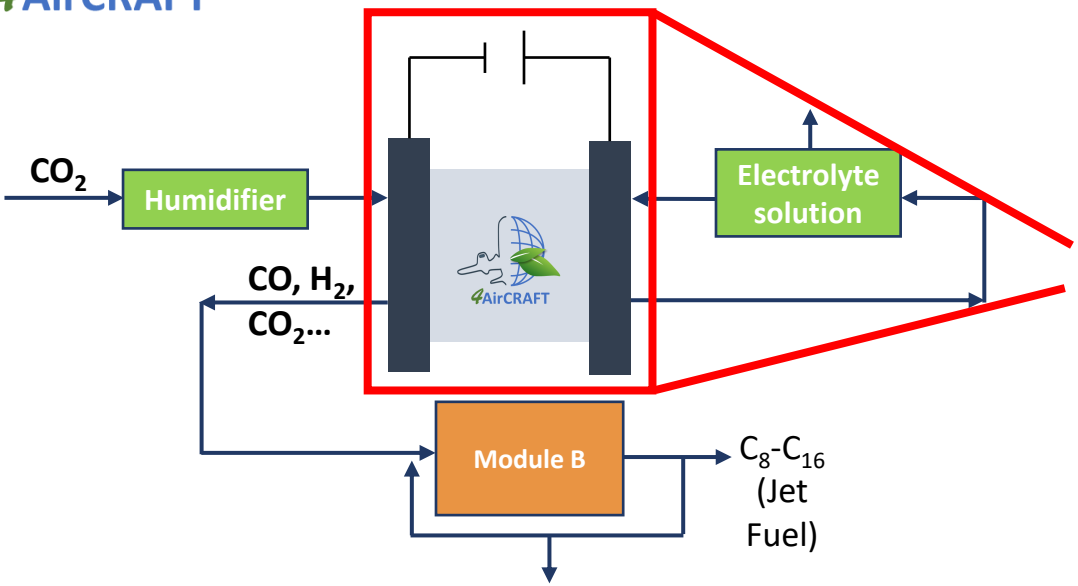
Reactor

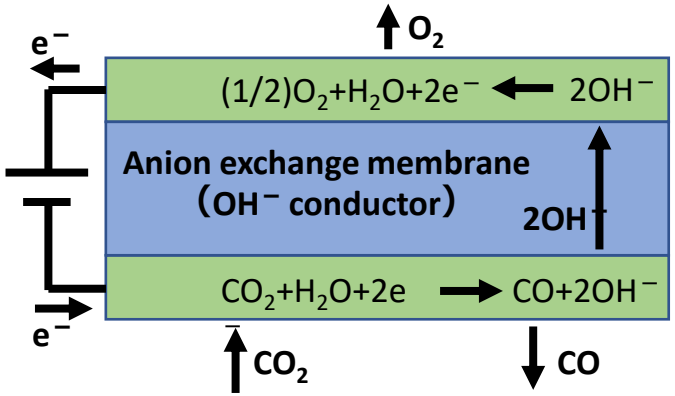
- Reactor design-Process Intensification
- Structural and mechanistic investigations
- Proof of the concept and Life Cycle Assessment (LCA)





Cascade reactor





$CO_2 + H_2O + 2\ e^- \rightarrow CO + 2\ OH^-$ (1)

$2\ OH^- \rightarrow H_2O + 2\ e^- + (1/2)\ O_2$ (2)

$CO_2 \rightarrow CO + (1/2)\ O_2$ (3)

Prof. K. TADANAGA

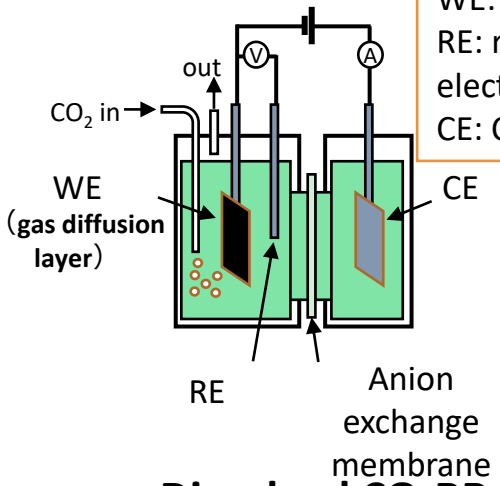
K. Tadanaga et al. J Asian Ceram Soc. **2023**, 11.3, 406

Electrocatalyst performance

Cell configuration for CO_2 reduction reaction (CO_2RR)

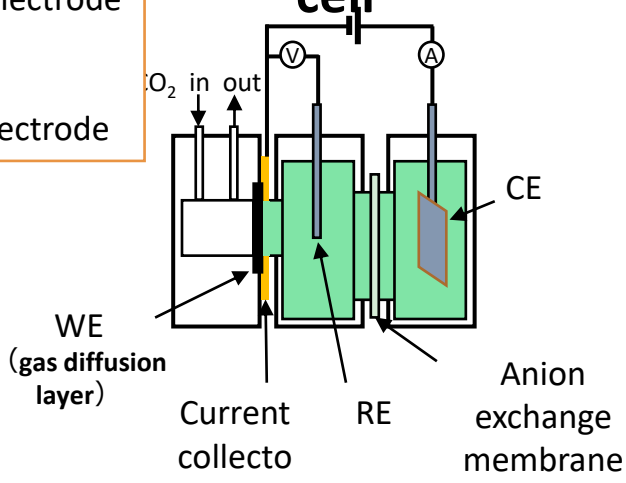
2-compartment cell → **3-compartment cell** → **Zero gap cell**

WE: working electrode
RE: reference electrode
CE: Counter electrode



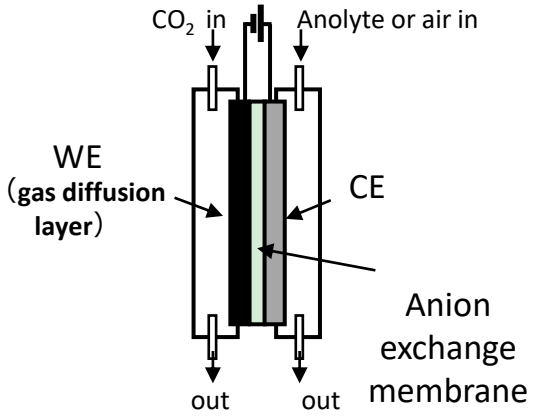
Dissolved CO_2RR

- ✓ **Factors to limit the CO_2RR reaction**
  Saturation concentration of CO_2 (33 mM)
  Diffusion rate of CO_2
  Limit of electrolyte because of dissolution of CO_2



Gaseous- CO_2RR

- ✓ Increase in reaction efficiency using gas
- ✓ Configuration is rather easy



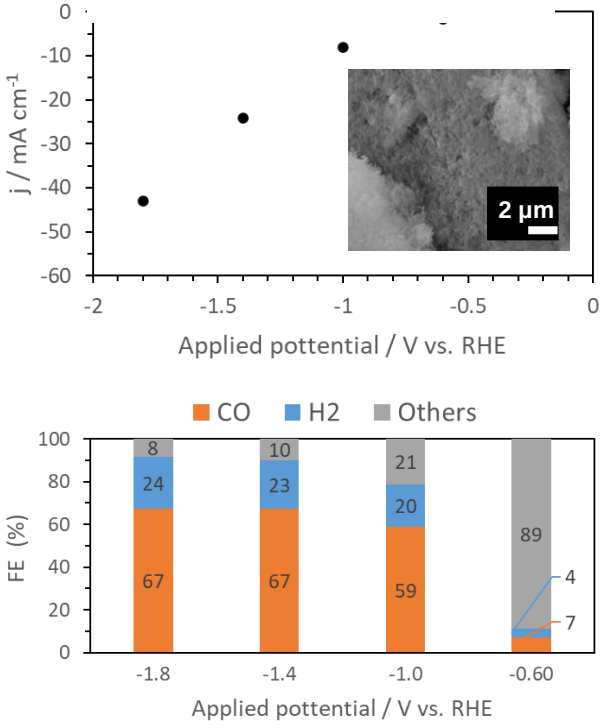
Practical gaseous CO_2RR

- ✓ Reduction of cell resistance using MEA (membrane electrode assembly)

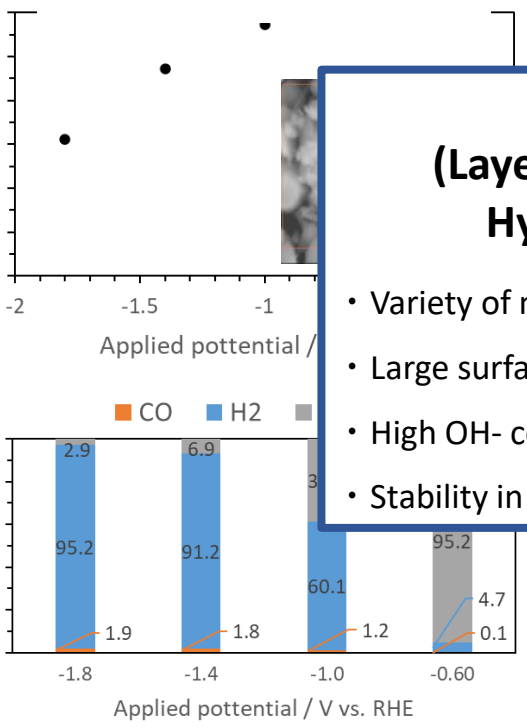
Gaseous CO_2RR activity

Current density (***j***) & Faradaic efficiency (**FE**)

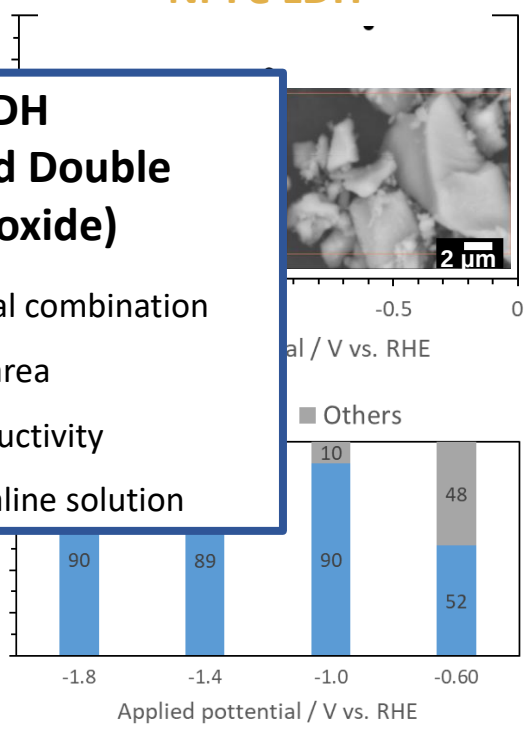
Zn-Al LDH



Ni-Al LDH



Ni-Fe LDH



LDH (Layered Double Hydroxide)

- Variety of metal combination
- Large surface area
- High OH- conductivity
- Stability in alkaline solution

C. I. Ezeh *et al.*, *Ultrason. Sonochem.* **2018**, *40*, 341; K. Tadanaga *et al.*, *Adv. Mater.* **2010**, *22*, 4401; D. Zhou *et al.*, *Chem. Soc. Rev.* **2021**, *50*, 8790; M. Li *et al.*, *J. Mater. Sci.* **2019**, *54*, 9034; K. Iwase *et al.*, *ChemSusChem* **2022**, *15*, e202102340.

CO2RR Test bench

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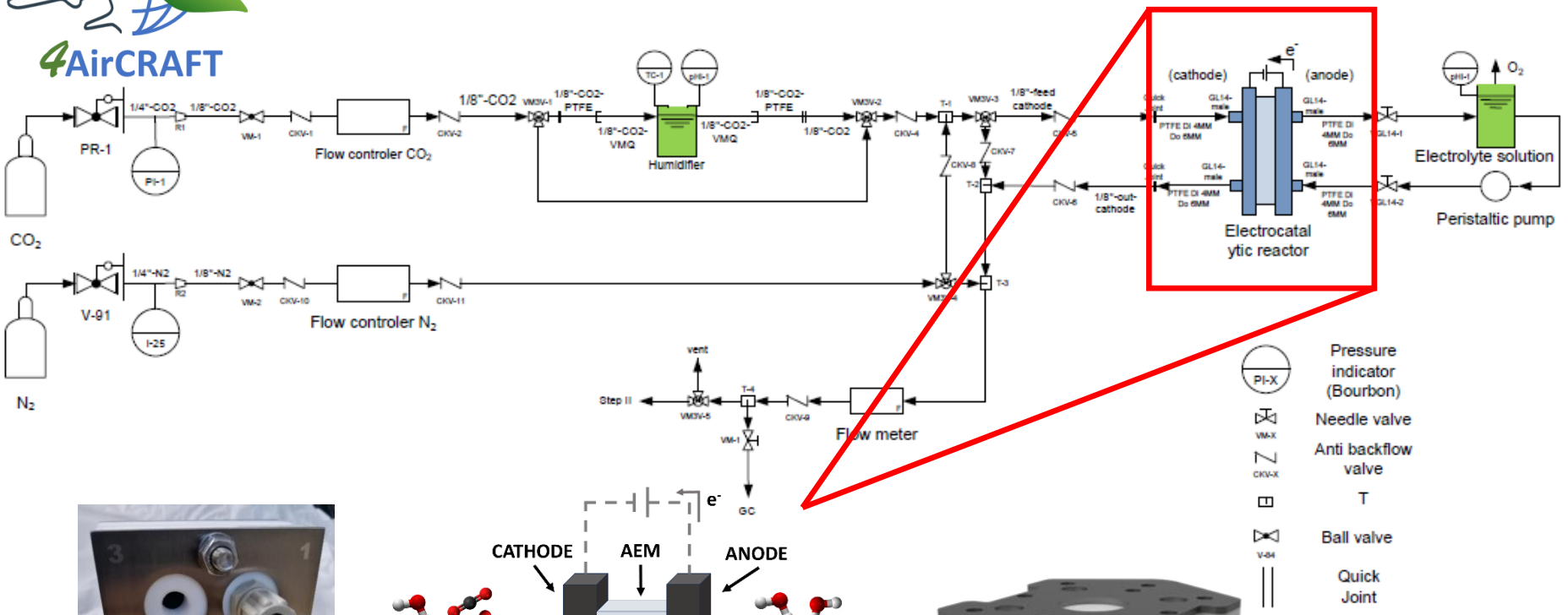
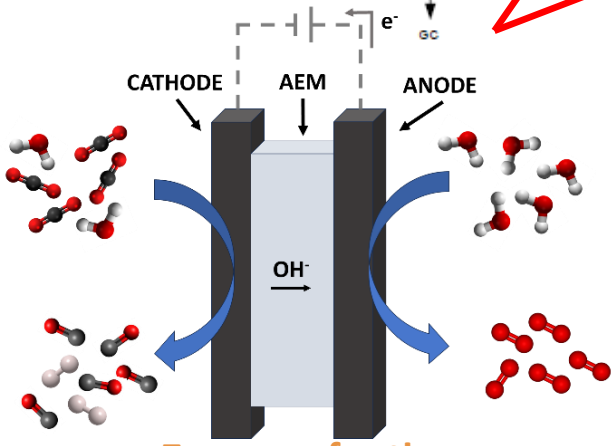
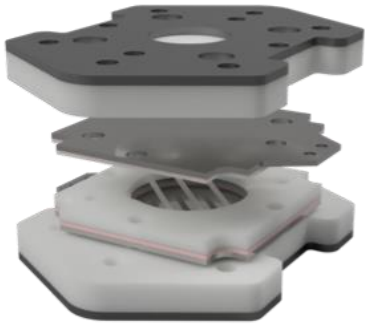


Commissioning module – single cell



Zero-gap for the CO2RR



Initial module design – single cell

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CO2RR Test bench

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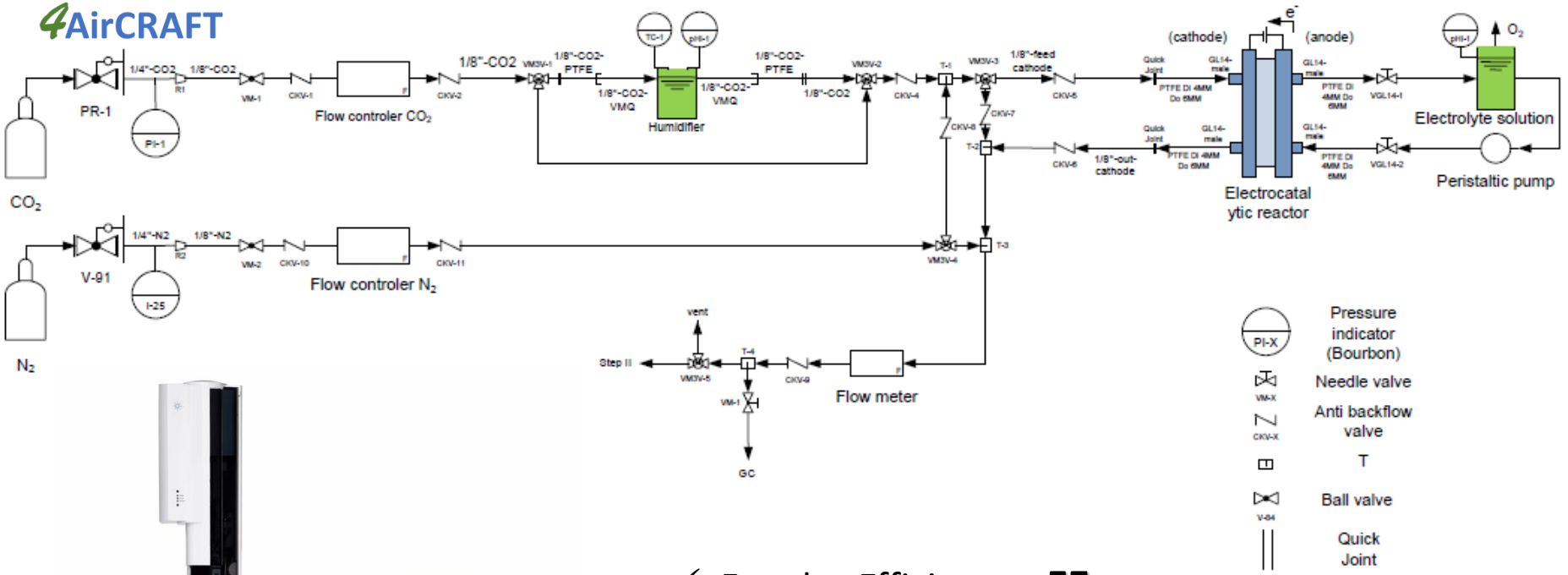

- ✓ Faraday Efficiency **FE**
- ✓ Lifetime
- ✓ LCA

Conclusions

- ✓Design and construction of a test bench to carry out tests and monitoring carbon dioxide flues.
- ✓Use of non-precious metal as catalysts.
- ✓Development of a stage with great potential for the synthesis of industrial chemical processes.

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Acknowledgement

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Eduardo Bernad Quílez

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PhD Candidate, Research & Development Department

Thank you for your attention!