Next generation of hydrogen storage solutions based on innovative materials

MAST3RBoost Project – Carlos Sanchís ENVIROHEMP

November 9th, 2023

MAST3RBoost updates

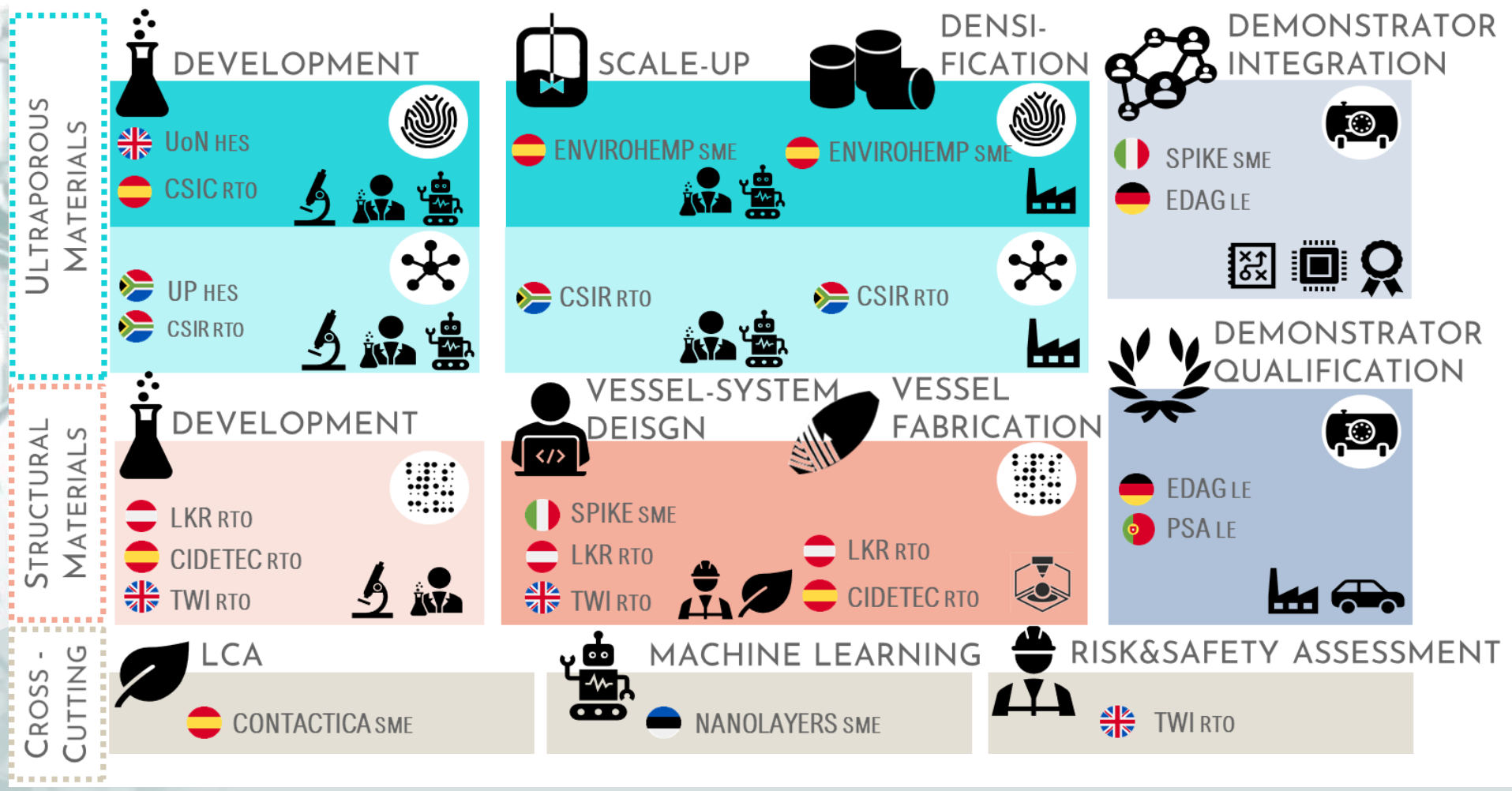
1. Scope of the Project
2. Overview of Key Results Achieved and Future Milestones
3. Technical Challenges Encountered During Project Execution

MAST3RBoost

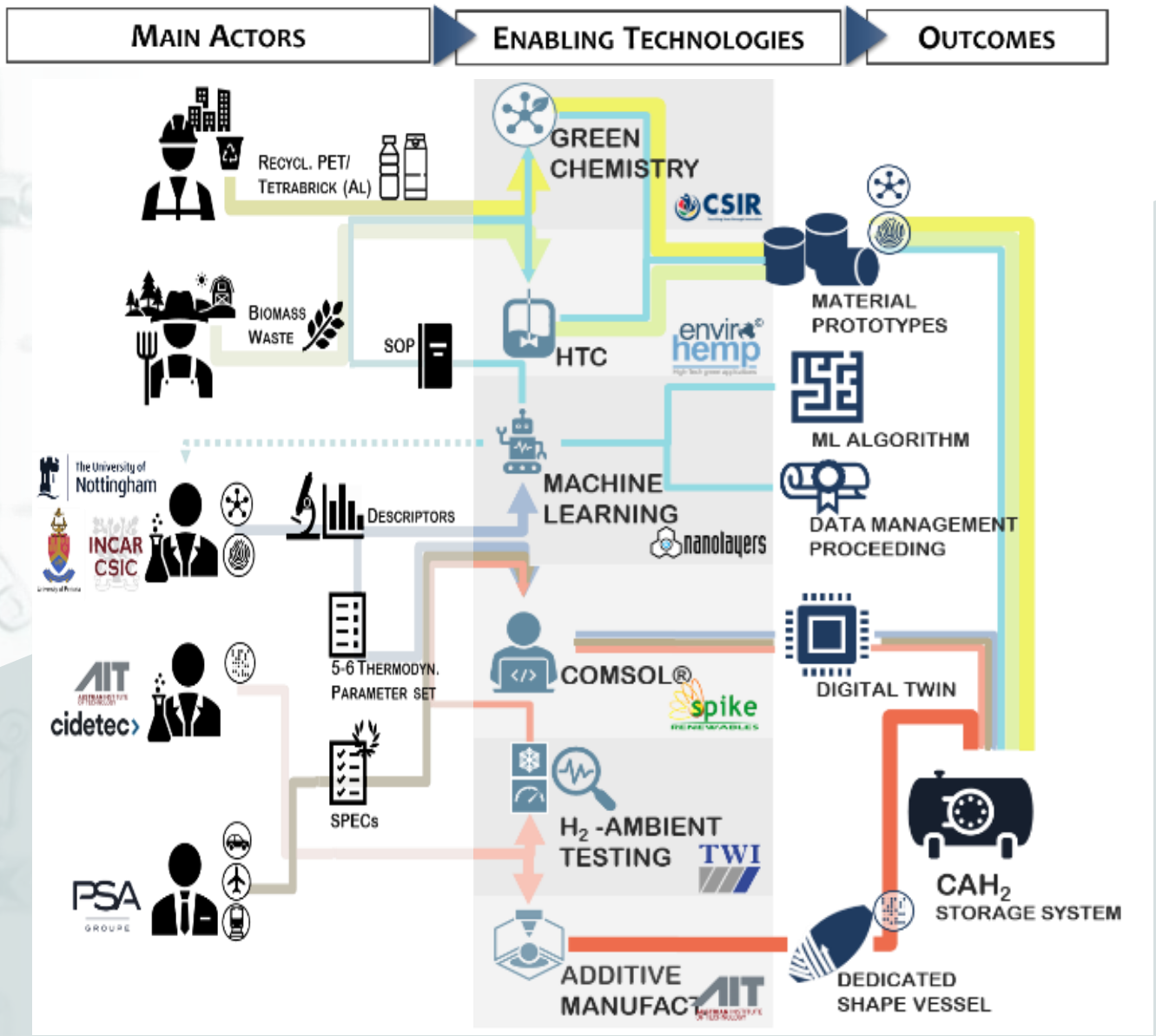
1. Scope of the Project

- The Concept
- The Technologies
- The Goals

THE CONCEPT


ULTRAPOROUS MATERIALS
STRUCTURAL MATERIALS
CROSS - CUTTING
DEVELOPMENT
UoN HES
CSIC RTO
UP HES
CSIR RTO
SCALE-UP
ENVIROHEMP SME
CSIR RTO
DENSI-FICATION
ENVIROHEMP SME
CSIR RTO
DEMONSTRATOR INTEGRATION
SPIKE SME
EDAG LE
DEVELOPMENT
LKR RTO
CIDETEC RTO
TWI RTO
VESSEL-SYSTEM DEISGN
SPIKE SME
LKR RTO
TWI RTO
VESSEL FABRICATION
LKR RTO
CIDETEC RTO
DEMONSTRATOR QUALIFICATION
EDAG LE
PSA LE
LCA
CONTACTICA SME
MACHINE LEARNING
NANOLAYERS SME
RISK&SAFETY ASSESSMENT
TWI RTO

THE TECHNOLOGIES



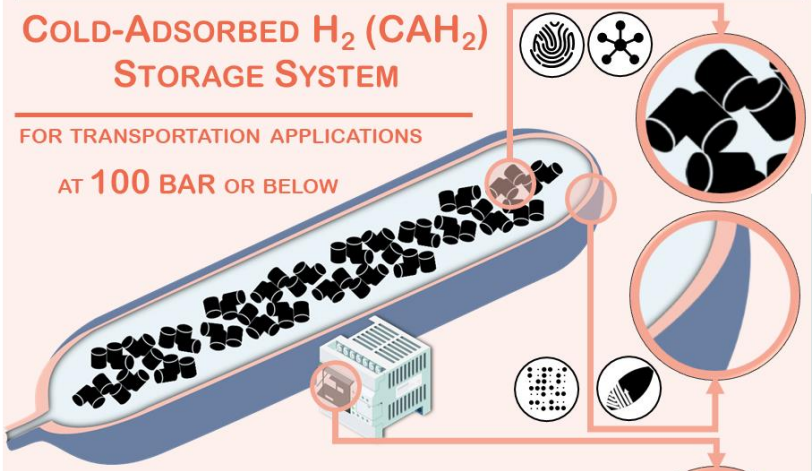
THE GOALS

THE DEMONSTRATOR

COLD-ADSORBED H_2 (CAH_2) STORAGE SYSTEM

FOR TRANSPORTATION APPLICATIONS

AT 100 BAR OR BELOW



UNITS OF DEVELOPMENT

- Carbon
- MOF
- Al/Mg - AM
- Vessel
- Controls
- Storage system

>10 kg densified ultraporous materials	20+ litre scale dedicated vessel shape	Built-in active temp. swing $\Delta T > 80$ K	1 kg CAH_2 33 g/l_{sys}

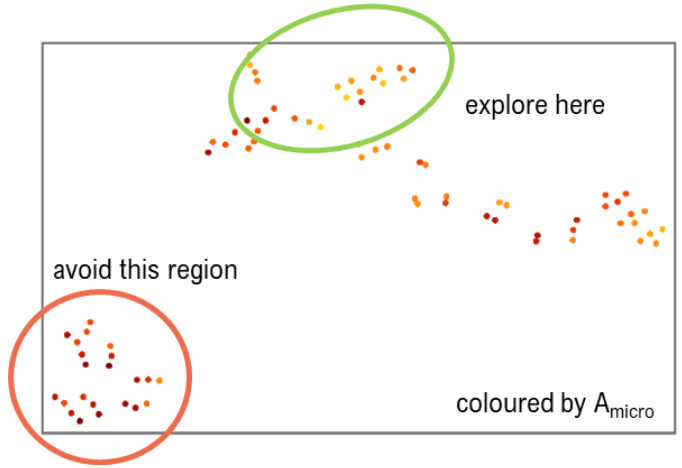
2. Overview of Key Results Achieved and future Milestones

- Results on adsorbent materials
- Results on structural materials & system design
- Timeline of Milestones

Results on adsorbent materials

Machine Learning

- Preliminary database - ca. 180 AC materials
- Promising areas in 2D maps



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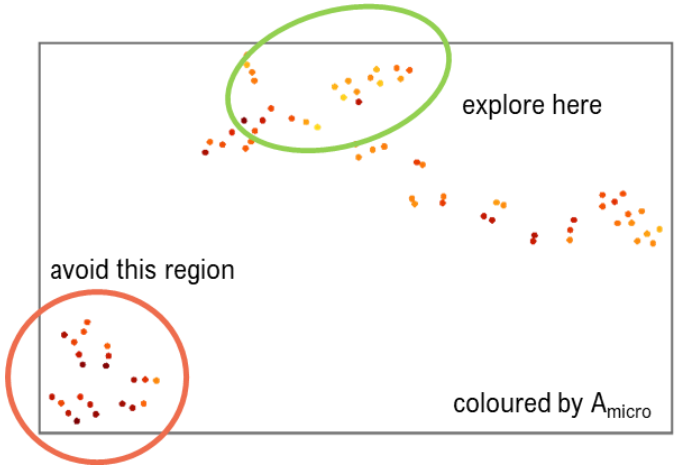
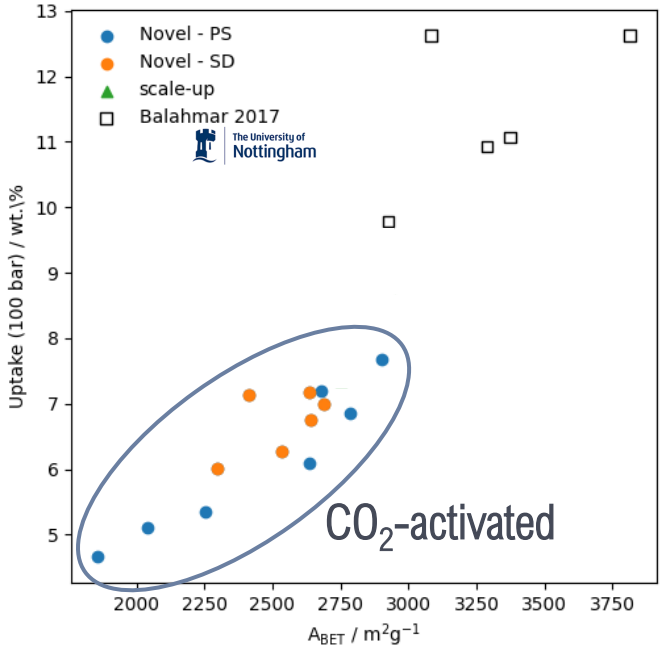


Activated Carbons

- 50 new CO_2-activated ACs
- 16 scale-up ACs (300 g) - 3 fully tested



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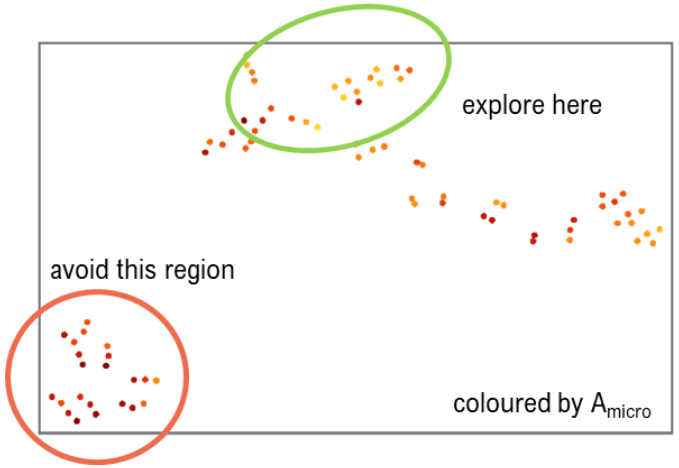

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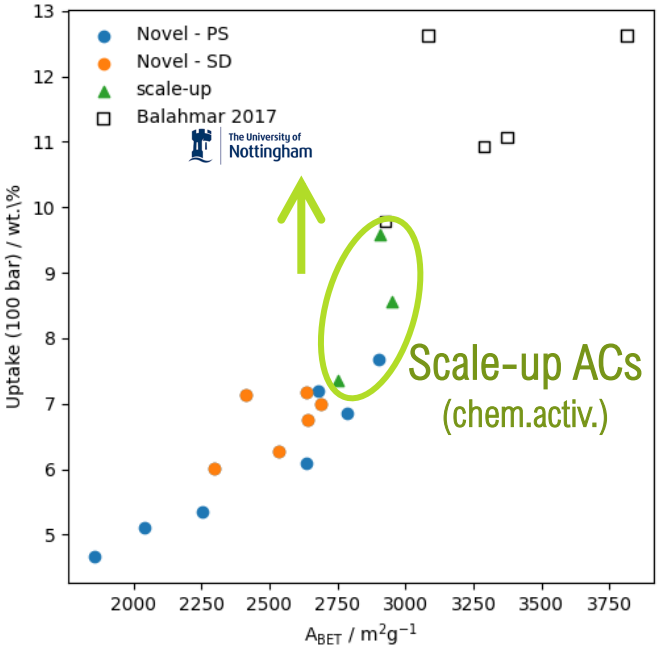
for AC: 2910 m^2/g – 1.41 cm^3/g



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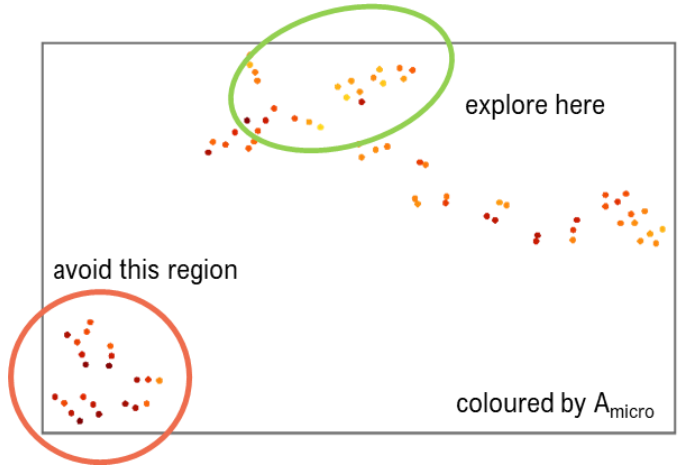

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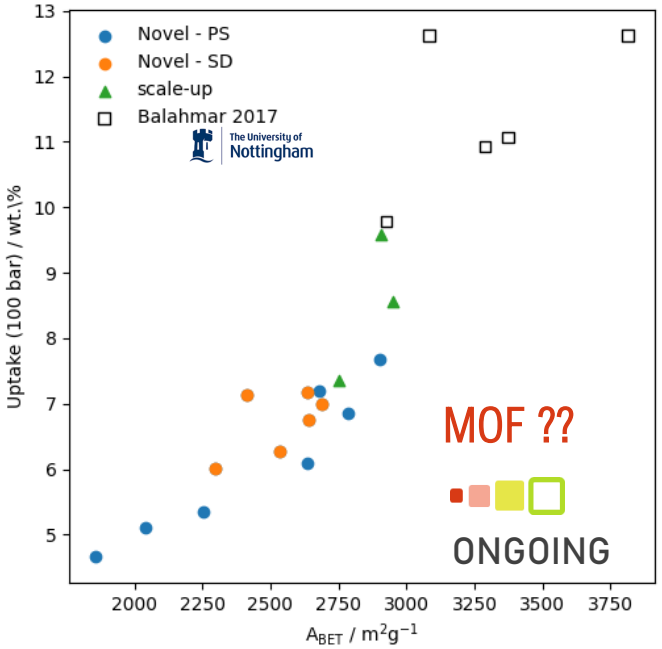

MOFs

- 30 samples of Al-fumarate, MIL-88B, MIL-101
- Validating Acid Mine Drainage and waste polyAlu as metal source (Fe, Al)
- Systematic study of trace metals in synthesis of Fe-based MOF

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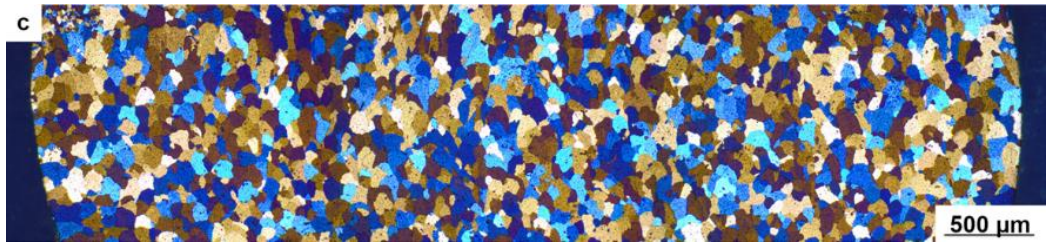
Results on structural materials & system design

Wire Arc Additive Manufacturing

(Al alloy MA-5183)

- 20% increase in yield strength and slight increase in ductility at 77K
- Equiaxed grain morphology – Low porosity



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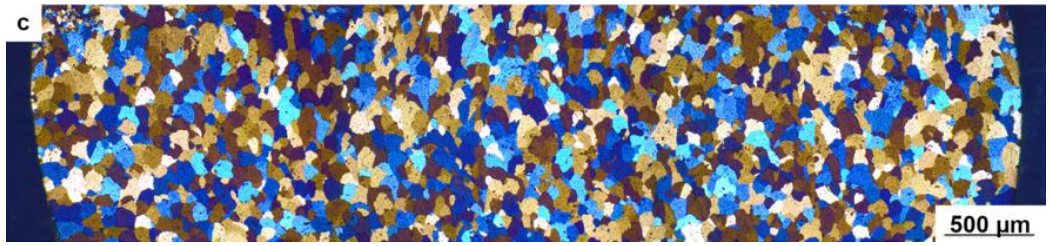

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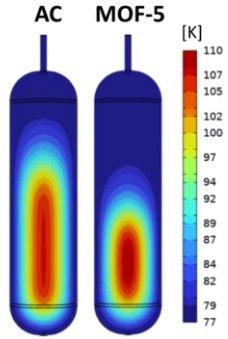
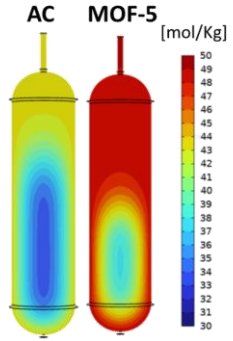
Design of vessel & balance of plant

- CFD model for MOF and ACs adsorption (COMSOL Multiphysics)
- Numerical simulations for refilling cold ads. H_2



Temperature

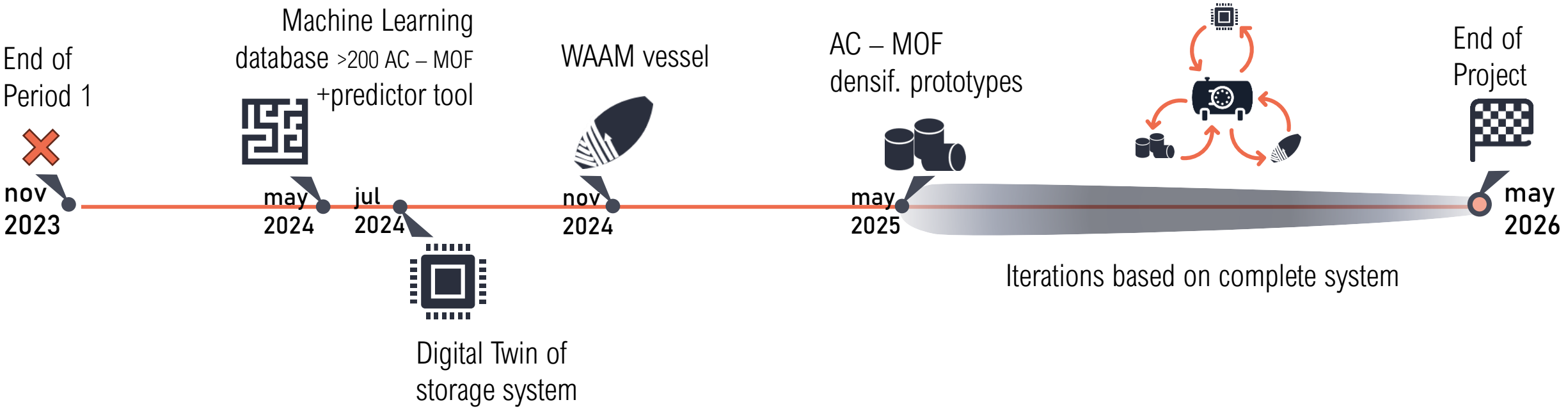


Absolute adsorption

- 3D design & instrumentation

ONGOING

Timeline of Milestones



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3. Technical Challenges Encountered During Project Execution

- Main technical challenges

Main technical challenges

Bottlenecks

- H_2 uptake tests (>>100 samples)
- Material aging under cycling (thermal/loads stress)
- Feeding the ML database for consistent predictions

Missing capacities

- Mechanical testing @H_2 @77K
- Risk assessment (burst testing)
- No skills on complete storage systems (OEM missing)

Standardisation / Harmonisaiton

- MOF inputs/outputs for ML
- Data gaps in existing literature (few studies @100 bar / no data @160 K)
- Final 3D design of vessel – Operational parameters?

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“Maturing the production standards of ultraporous structures for high density hydrogen storage bank operating on swinging temperatures and low compression”

101058574 — MAST3RBoost – Horizon Europe
HORIZON-CL4-2021-RESILIENCE-01