Bologna: un hub di ricerca per lo sviluppo dell'idrogeno - 9 ottobre 2024

Progetto NICOLHy

Storage di idrogeno liquido

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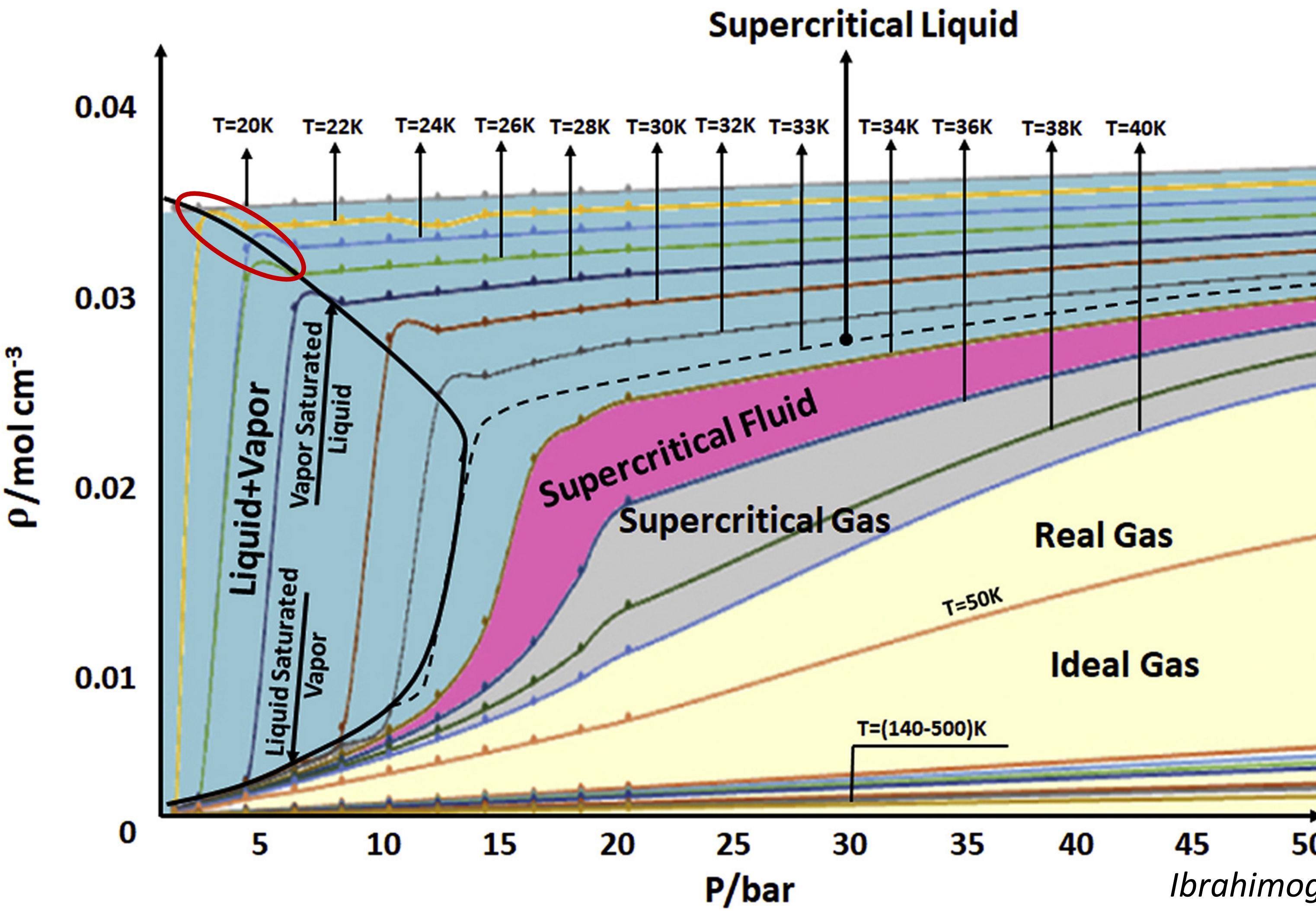
ORGANIZZATO DA

BOLOGNAFIERE WATER&ENERGY

BolognaFiere 9-11 ottobre

Liquid Hydrogen (LH2)



Ibrahimoglu et al., 2021

The markets for LH2

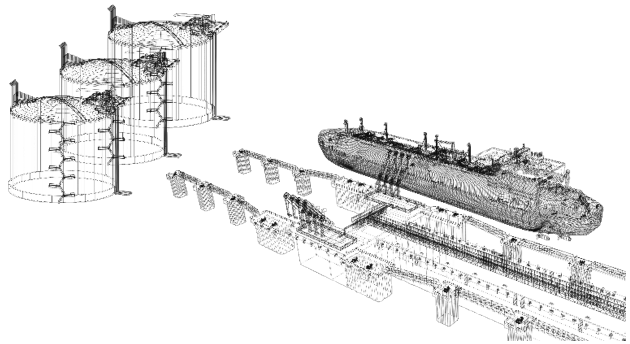
Mobile energy intensive applications

Daimler Truck AG

NORLED

Aribus

Large-scale transport which requires also storage



Adobe Stock 617871536; 640219726

Large-scale and long-term storage

Adobe Stock 135344948; 651330108

Expected size for storage

		LH2 Industry	LNG Industry
Ship tank	In application	1.250 m³	65.000 m³
	In design	40.000 m³	
Storage tank	In application	5.000 m³	180.000 m³
	In design or construction	40.000 m³	220.000 m³

Two times the volume of an LNG tank is required to store the same amount of energy with LH2

Iveco

DB

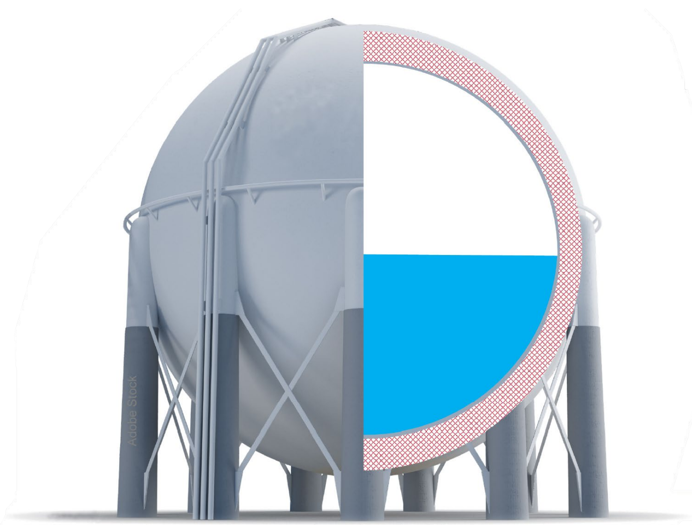
GTT

TGE

Current LH2 storage technology

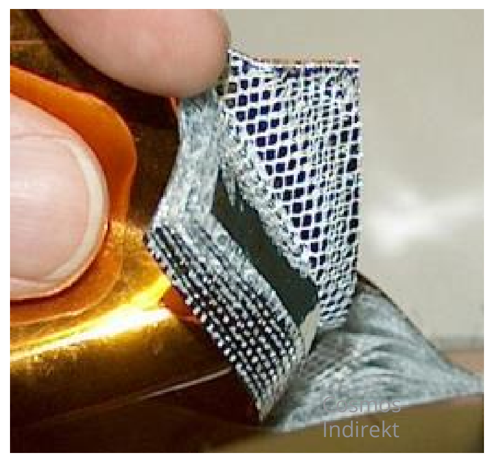
Small-scale tank

Large-scale tank

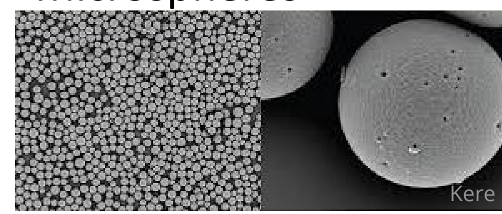


Double wall + **Vacuum** + **Fill material**

MLI



Microspheres

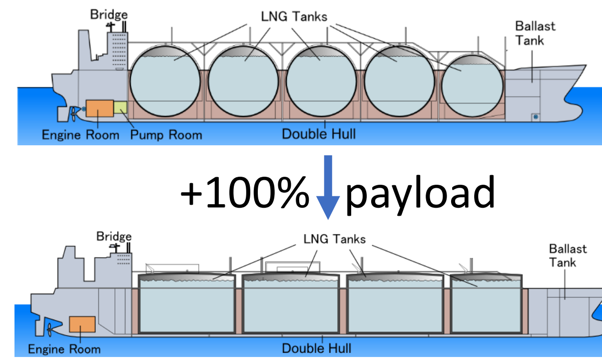


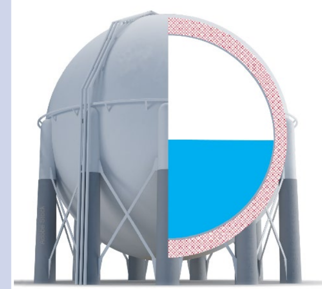
Perlites

Limits of current technologies in LH2 storage

Advantages	Disadvantages

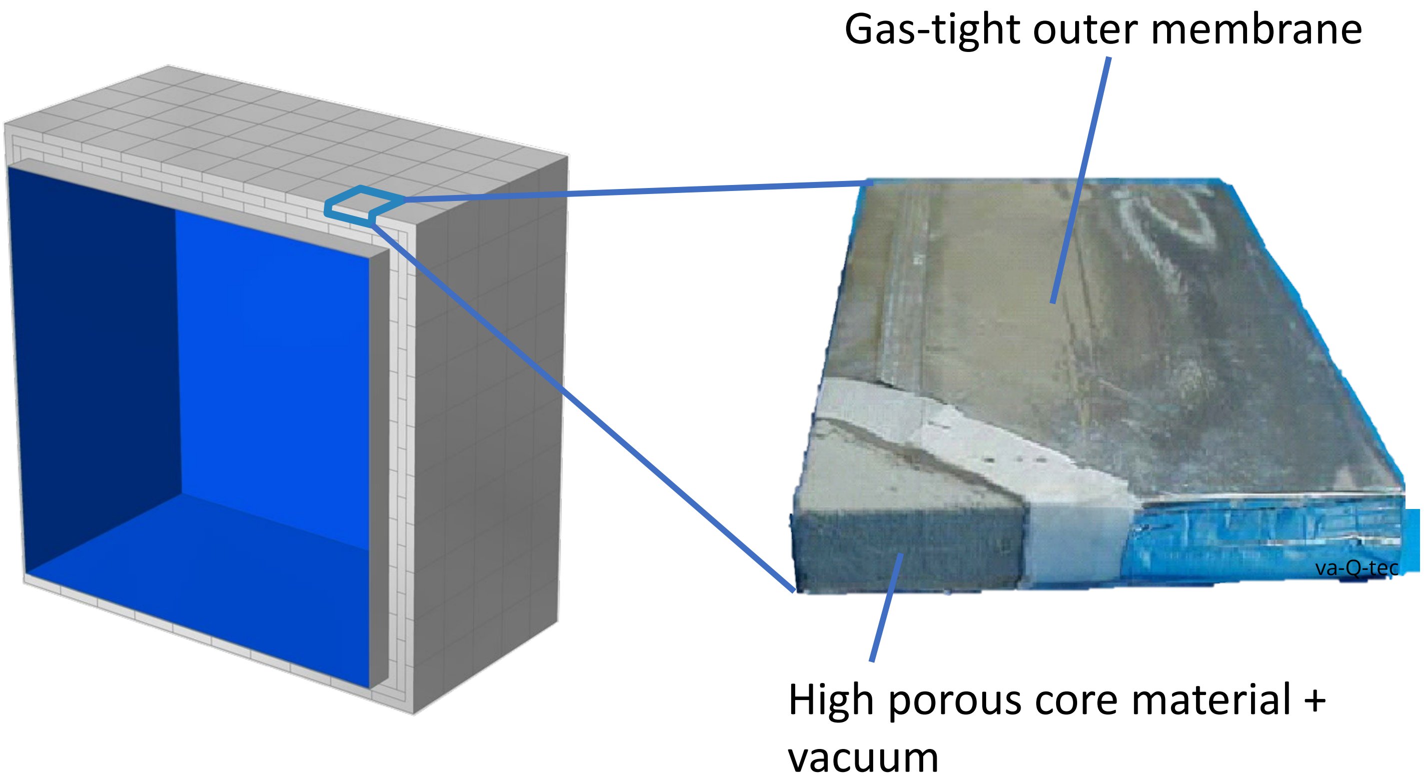
✓ Lowest surface / volume ratio
✓ proved manufacturability and process chain
✓ In use since > 50 years
	❖ Bad to install in technical applications
	❖ Bad Process chain within production:
	    ❖ Time intensive (>36 Month)
	    ❖ Difficult for automation and parallelization or processes
	    ❖ High manpower fluctuations
	    ❖ Quality assurance is limited
	❖ In case of an insulation failure:
	    ❖ Non multi-failure tolerance
	    ❖ Payload is lost
	    ❖ Long service time
	❖ Upscaling is expensive as known from LNG industry




Adobe


NASA

Proposal: tanks insulated by Vacuum Insulation Panels (VIP)



VIP advantages

Insulation

- ✓ Industrial manufacturing in an industrial environment,
- ✓ Excellent quality control during the manufacturing process,
- ✓ Automation of manufacturing and quality control,
- ✓ Lower vacuum requirements of VIP (1 to 10^2 Pa) than e.g. MLIs (10^{-5}Pa),
- ✓ Parallelization of tank constructions.

Tank

- ✓ Flexibility in the selection of the tank shape due to the inherent stability of the insulation,
- ✓ Reduction of construction time and increase of plannability,
- ✓ Improved planning of manpower requirements during tank installation,
- ✓ Increased fault tolerance of the entire insulation system due to the high number of partial insulation elements (VIPs).

Technology Readiness Level (TRL) of VIP applications

Building industry (TRL9)

Transport of:
- Covid vaccines (TRL9)
- Human organs (TRL9)
- Large goods (TRL6)

Barriers and scope

Recent construction principles for VIP‘s don‘t fulfill the requirements:

- Temperature resistents up to – 253°C,
- Long-life performance,
- Handling of thermal displacements,
- Safety?

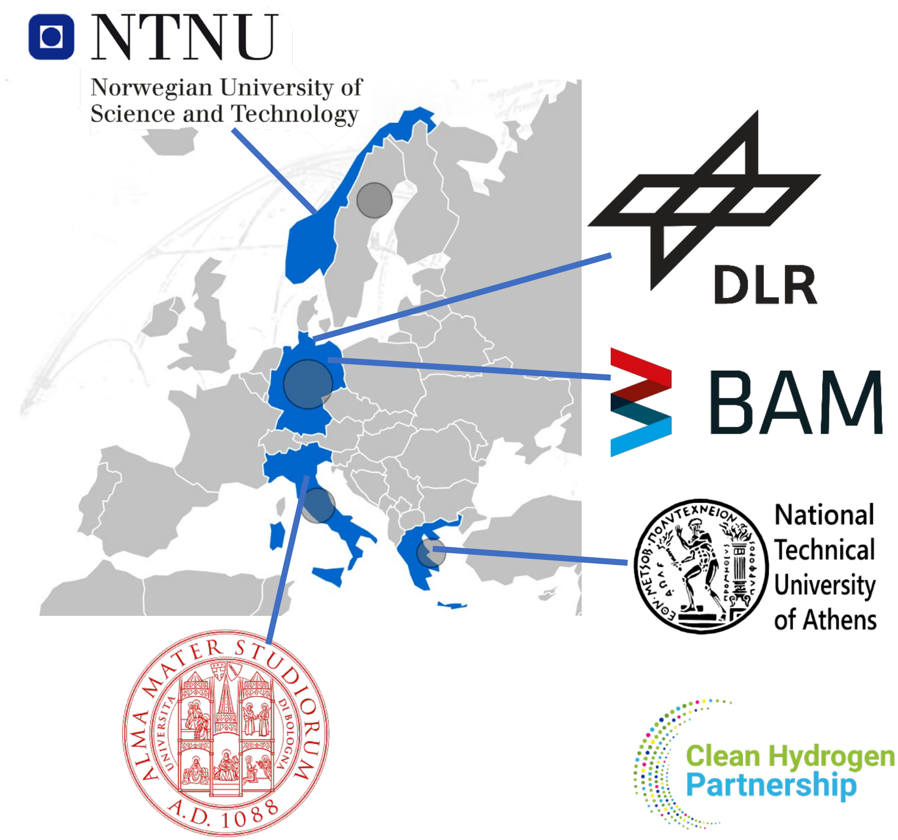
↓

Need for research and new design principles to apply VIP‘s on LH2 storages with capacities of 40.000 m³ to 200.000 m³ LH2

Project consortium

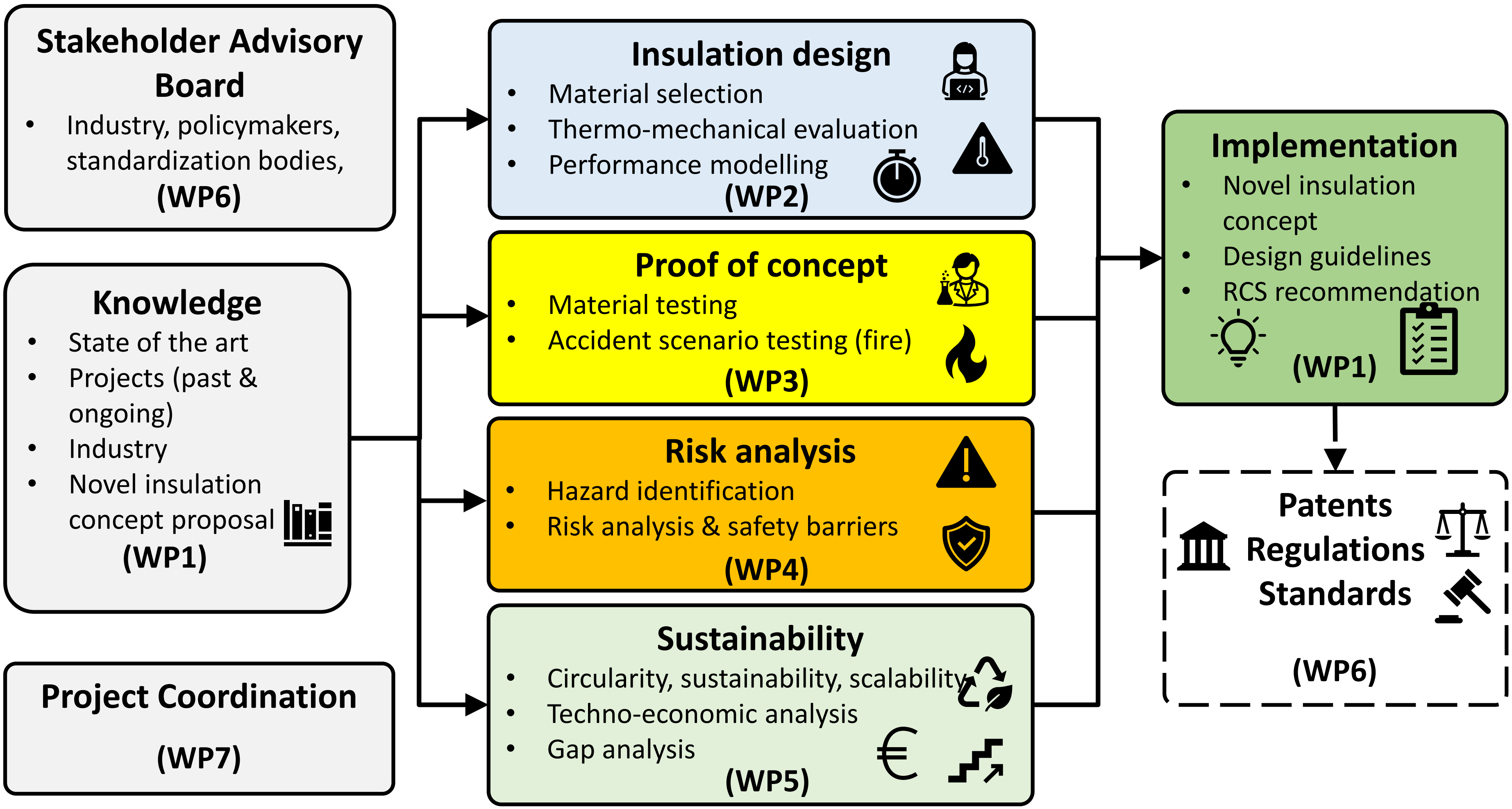
NICOLHy

Partner	✓ BAM ✓ UniBo ✓ DLR ✓ NTNU ✓ NTUA
Theoretical and practical expertise in	✓ Construction ✓ Thermodynamics ✓ Safety ✓ Manufacturing ✓ Integration ✓ Economics ✓ Sustainability



Clean Hydrogen Partnership

Project structure



Design
Identification of reference schemes

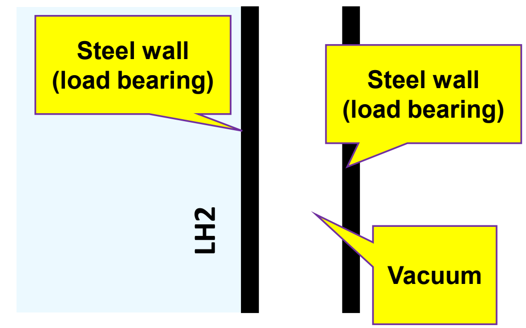
Reference schemes

CONVENTIONAL SYSTEM

SHAPE: Spherical tank

SIZE: 4'700 m^3 (approx. D=22m)

INSULATION SYSTEM: vacuum gap

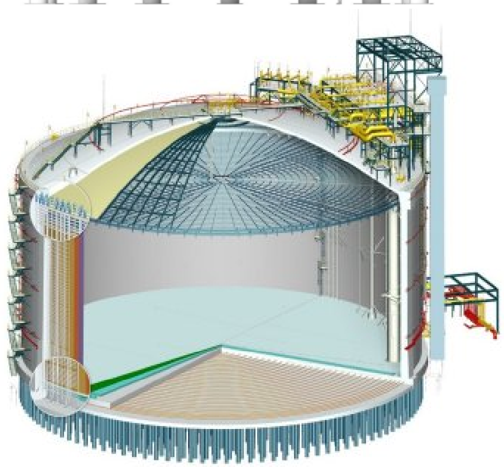


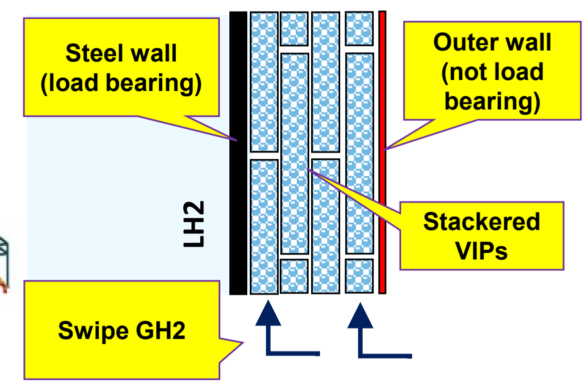
"NOVEL" SYSTEMS

SHAPE: Cylindrical vertical axis

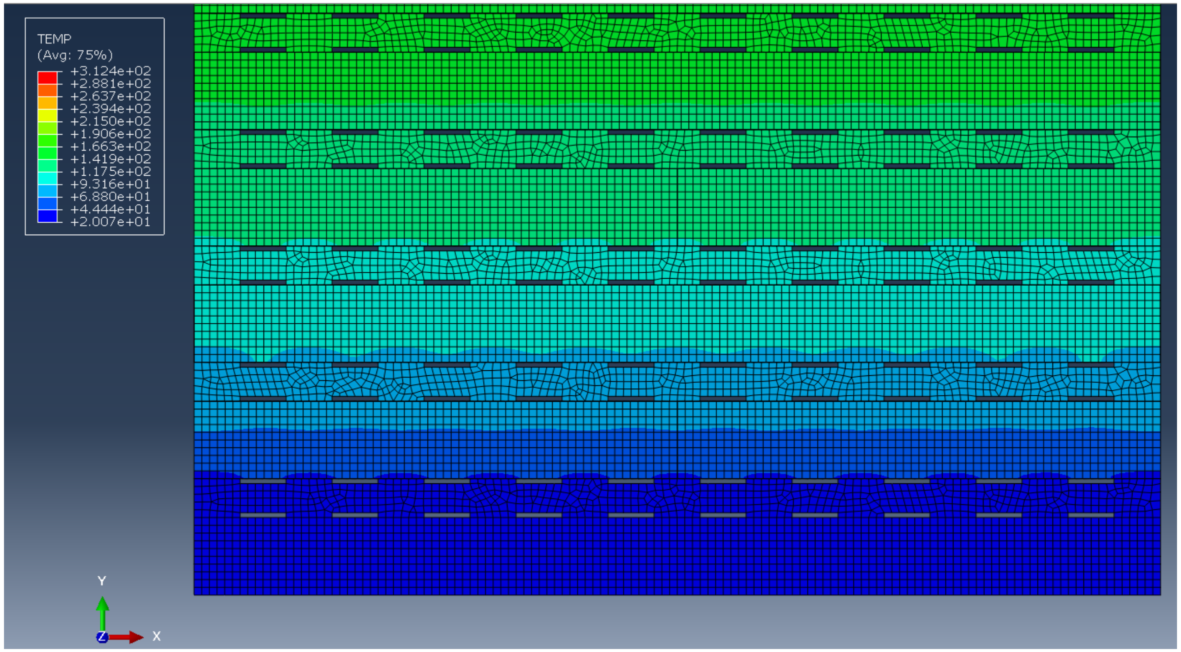
SIZE: 200'000 m^3 (D=75m, H=60m)

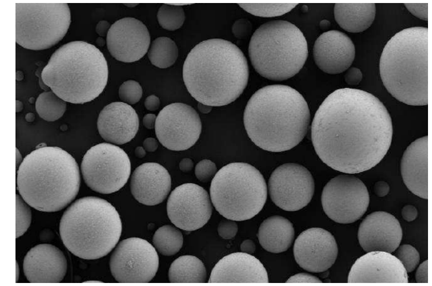
INSULATION SYSTEM: stackered VPIs

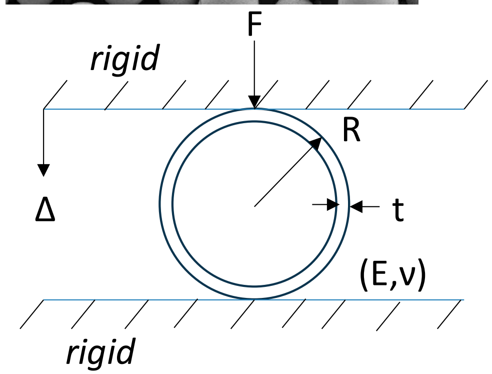


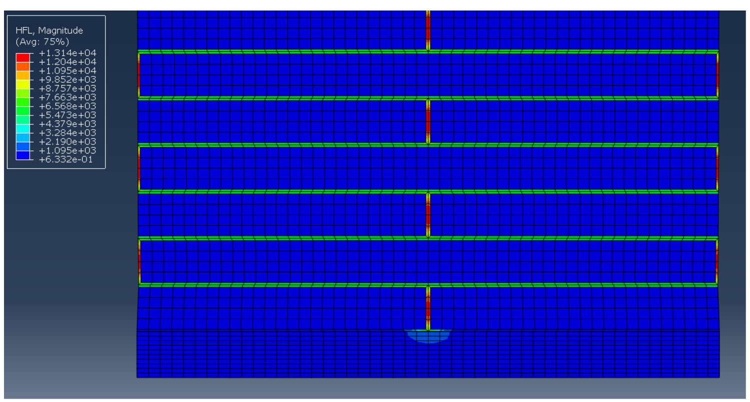


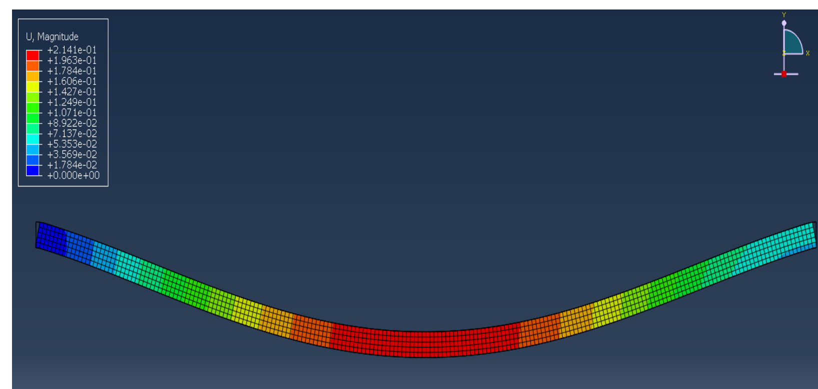
Thermal and Mechanical Modeling



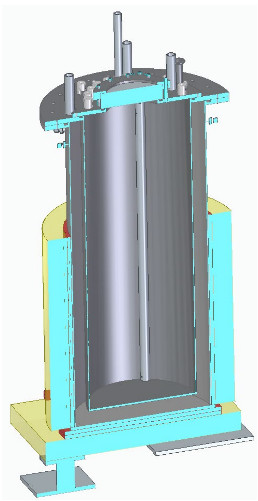




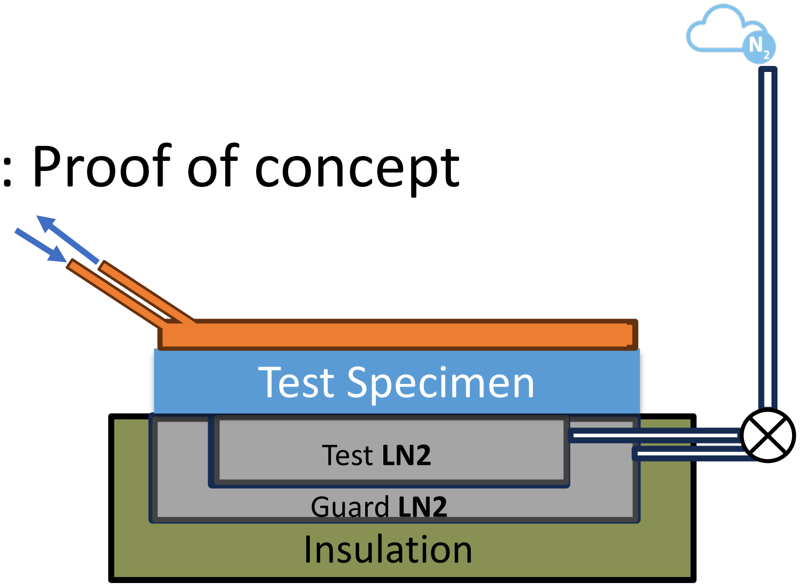


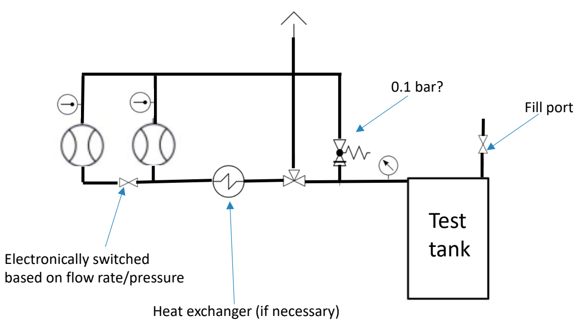


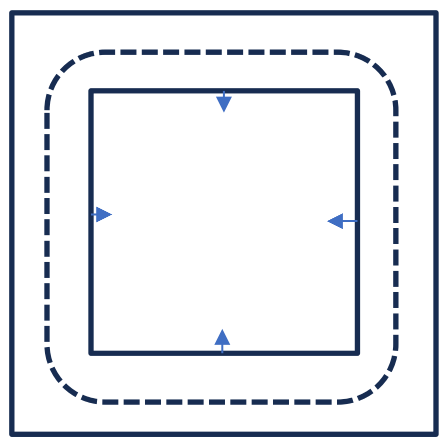
Experimental tests

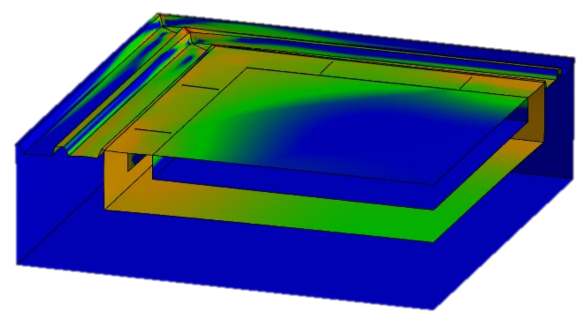


System level: Proof of concept



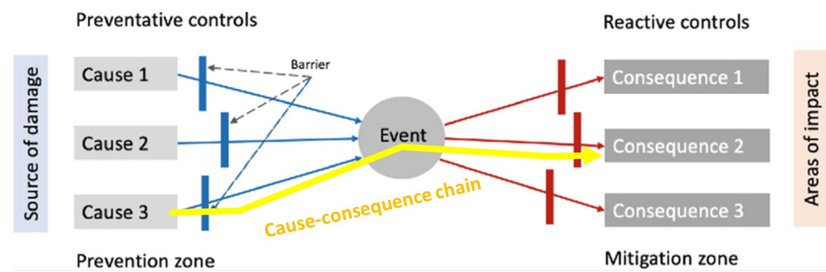






Risk analysis
Identification of reference hazardous scenarios

Approach followed for preliminary hazard identification (bow-tie generation)



Input		*Output*
LH2 tank design concept	**MIMAH** *Methodology for the Identification of Major Accident Hazards*	**Generic safety scenarios**
Preliminary P&ID	**HazOp** Hazard and Operability analysis	**Specific contribution of tank design**
Preliminary design of insulation	**FME(C)A** Failure Mode, Effects, and Criticality Analysis	**Specific contribution of insulation design**

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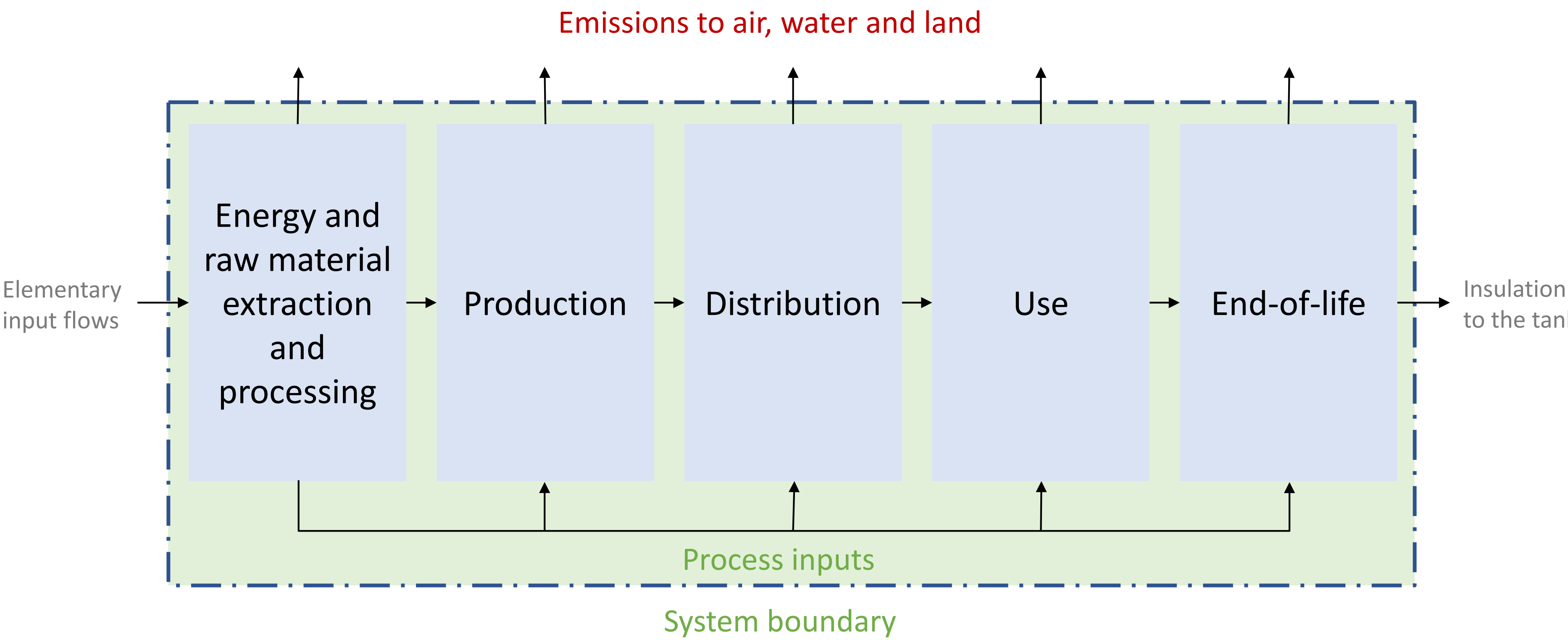
Life Cycle Assessment

Scope: Cradle-to-cradle LCA, assessing the potential environmental impacts associated with the use of VIPs for liquid hydrogen tank insulation over the full life cycle.



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Credits:

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