Hydrogen Research & Innovation Days

24-25 November 2025

Clean Hydrogen Partnership

Co-funded by the European Union

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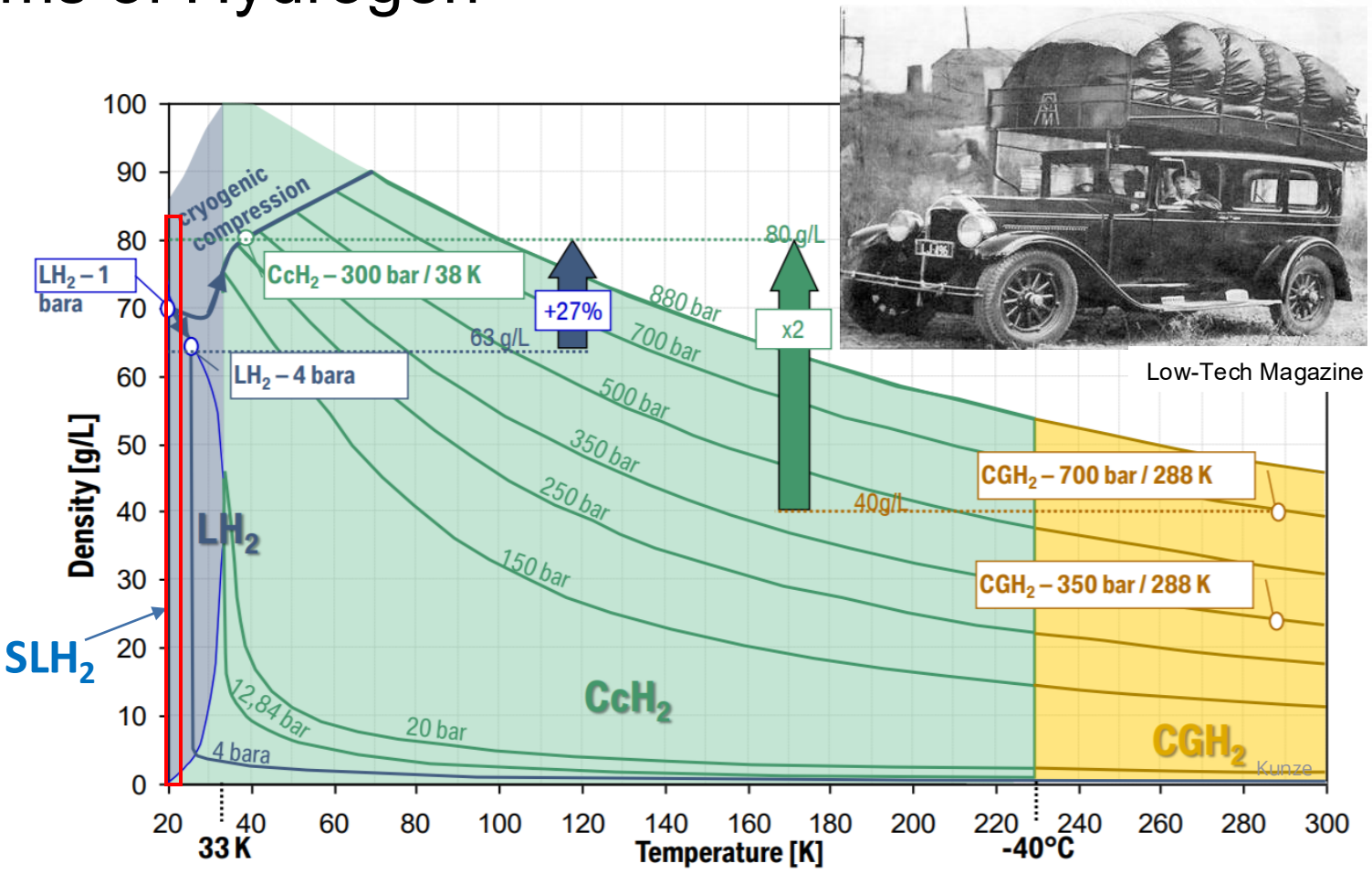
ENERGY TRANSPORTATION AND STORAGE WITH LIQUID HYDROGEN

Dr.-Ing. Robert Eberwein

Clean Hydrogen Partnership

Co-funded by the European Union

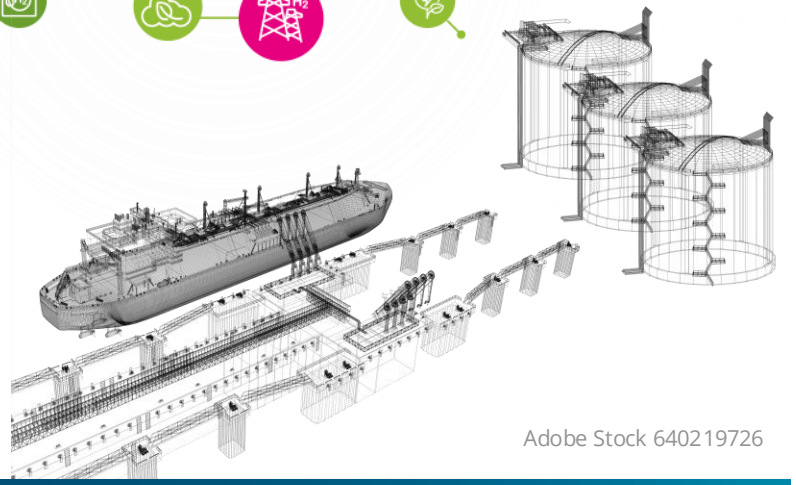
Storage Forms of Hydrogen



Low-Tech Magazine

Enable Economical Energy Imports by LH_2

- Bulk transportation and bulk storage enable the implementation of a flexible, large-scale energy market, and tanks can be built where they are needed.
- First studies indicate LH_2 could be more cost-effective and lower risk than H_2 derivatives for energy import
- First national plans for LH_2 terminals and transfer lines routes
- Acceptance and confidence are increasing thanks to LNG infrastructure
- NICOLHy and other studies show that the existing LNG infrastructure could be adapted for LH_2



Adobe Stock 640219726

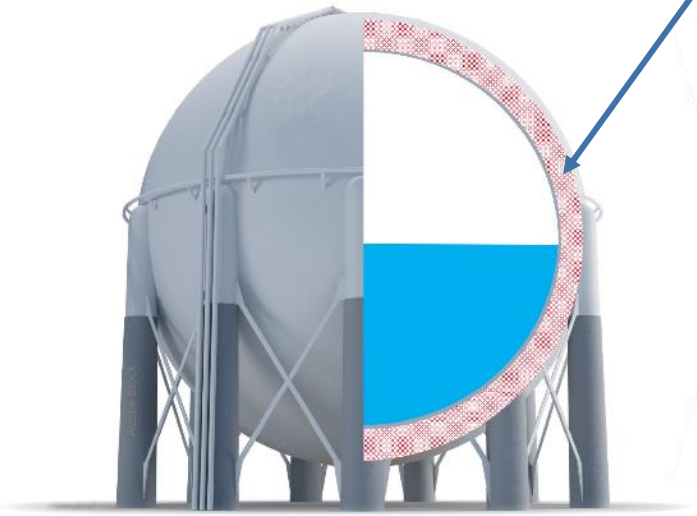
Fraunhofer

State of the Art: Tank Design and Insulation

Small-scale tank

DENA

Medium-scale tank



Double wall + Vacuum + Fill material

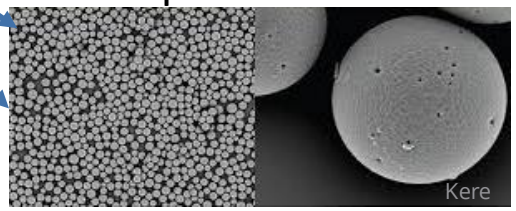
- Technology proven in small and medium-scale

- Low volume compared to prismatic shapes
- Long production time due to process chain (>3 years)
- Low quality assurance possibilities
- Low fault tolerance

MLI

Cosmos Indirekt

Microspheres

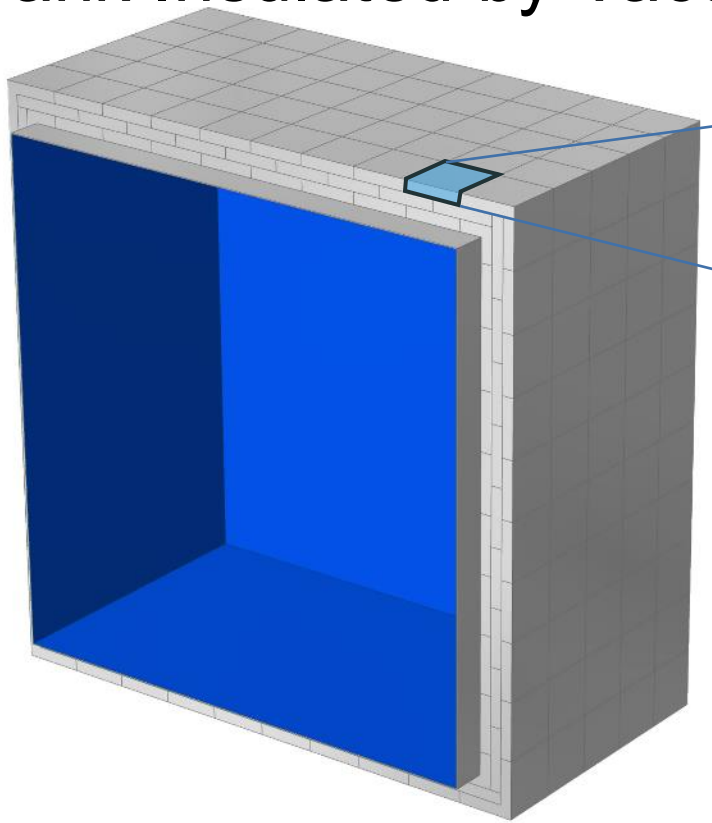


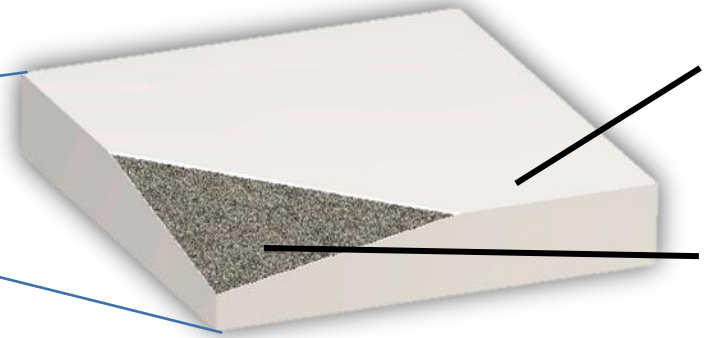
Kere

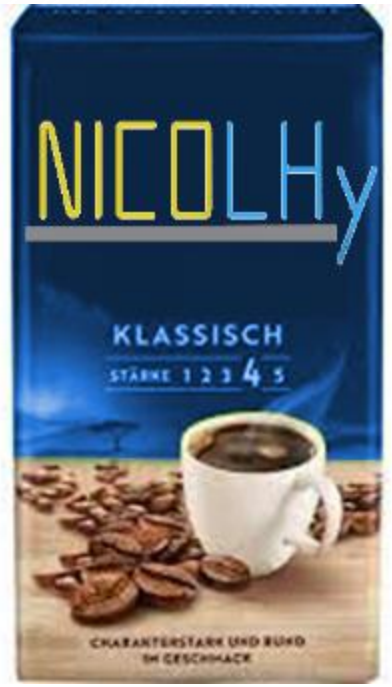
Perlites

Krack

Tank Insulated by Vacuum Insulation Panels (VIP)



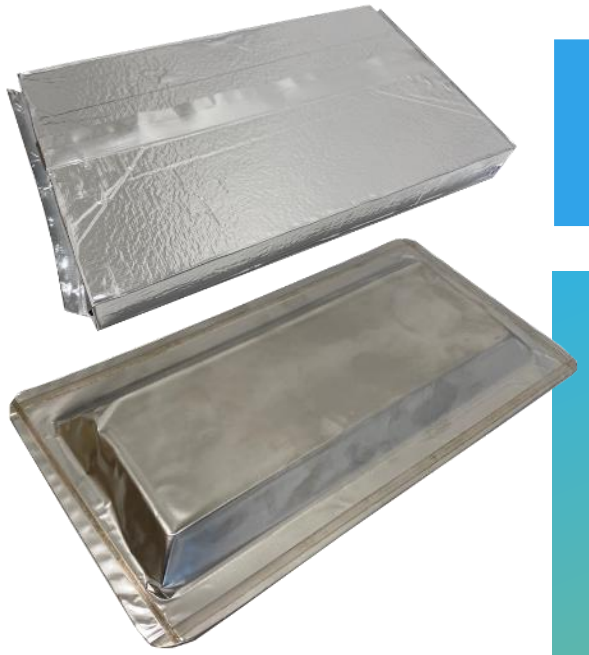




- Scalable
- Low production time due to standardized and partial insulations
- Cost- and energy-efficient
- Very good quality assurance and safety

- Not approved or tested

VIPs as a Concept, at the Heart of the Novel Approach

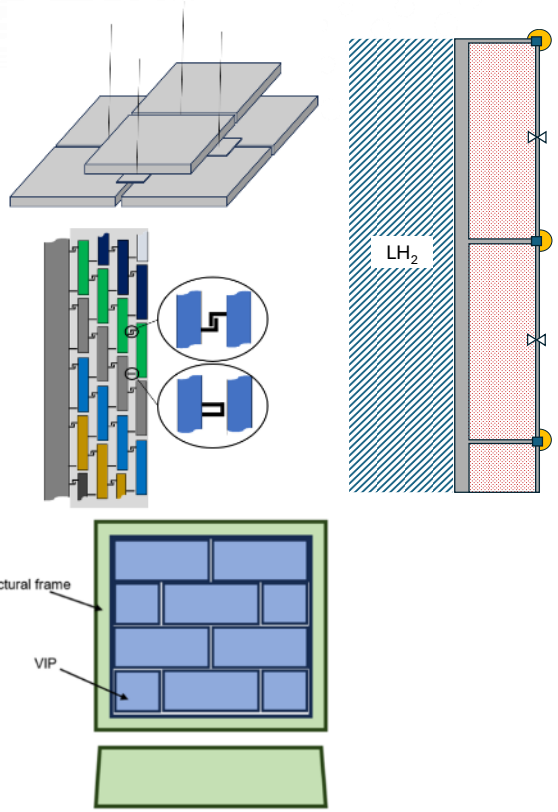


Envelope	+	core material with vacuum	+	Shape, dimensions, mounting

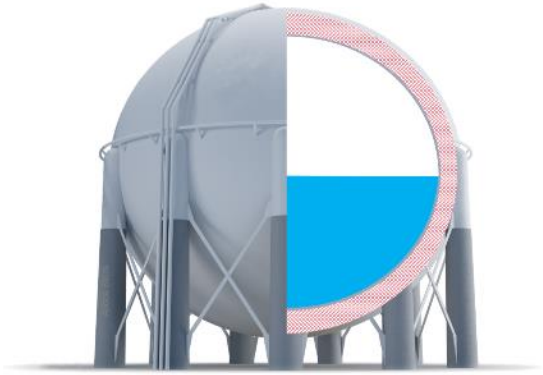
VIPs are established in the packaging and infrastructure industry, but not for cryogenics

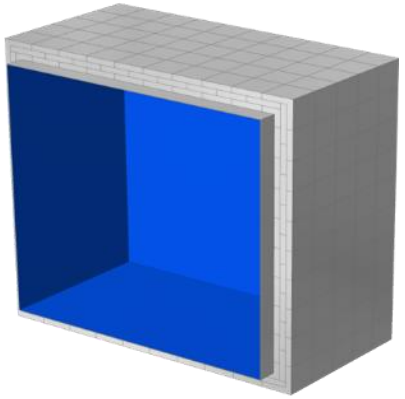
Knowledge gaps:

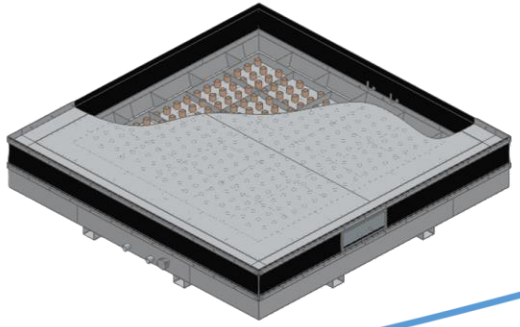
- Resistance and behaviour to temperature changes and cryogenic conditions
- Manufacturing and costs
- Placement and mounting
- …



Progress







SoA

- Methods to evaluate concepts
- Promising and non-promising concepts from the past
- Specification

Concept

- Developing promising concepts
- Benchmark by KPIs from SRIA and others, taking into account

Insulation design | Circularity and sustainability | Safety

Proof of Concept + Material Tests

Demonstrator

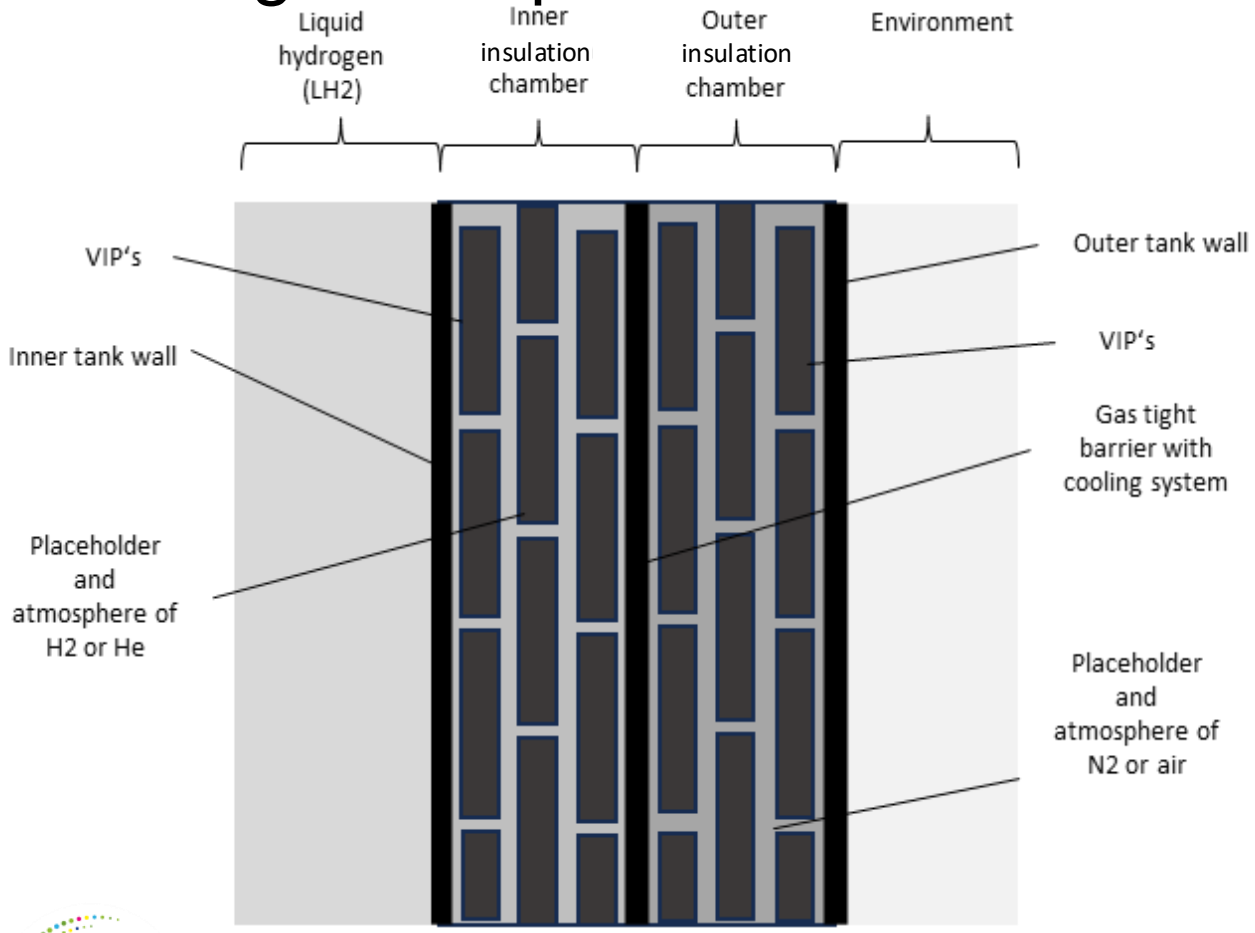
Preparing Implementation

Application

- Promising novel insulation concepts for large-scale LH_2 tanks
- Design guidelines
- RCS recommendation

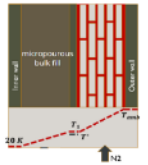
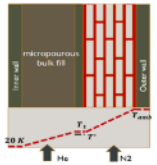
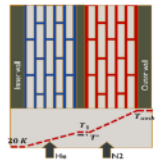
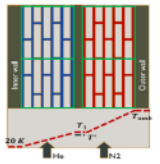
NICOLHy

Promising Concept as an Interim Result



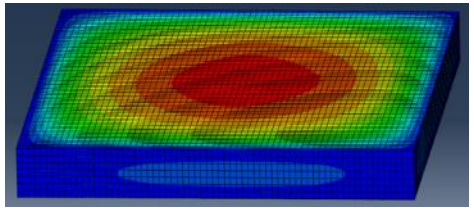
Key Features:

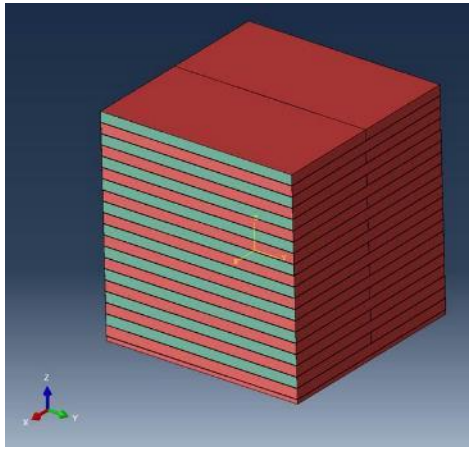
- Non-vacuum-tight tank construction
- Insulation can be parallelized, pre-manufactured
- Cooling elements can be integrated

CONCEPT		REFERENCE	1	2	3	4
SCHEMATIC DESIGN						
INNER LAYER	INSULATION MATERIAL	EVACUATED PERLITE / GLASS MICROSPHERES	EVACUATED PERLITE / GLASS MICROSPHERES	EVACUATED PERLITE / GLASS MICROSPHERES	VIPs	VIPs IN MODULAR STRUCTURES
	SWEEPING GAS / VACUUM	VACUUM	VACUUM	He	He	He
OUTER LAYER	INSULATION MATERIAL	-	VIPs	VIPs	VIPs	VIPs IN MODULAR STRUCTURES
	SWEEPING GAS / VACUUM	-	N2	N2	N2	N2

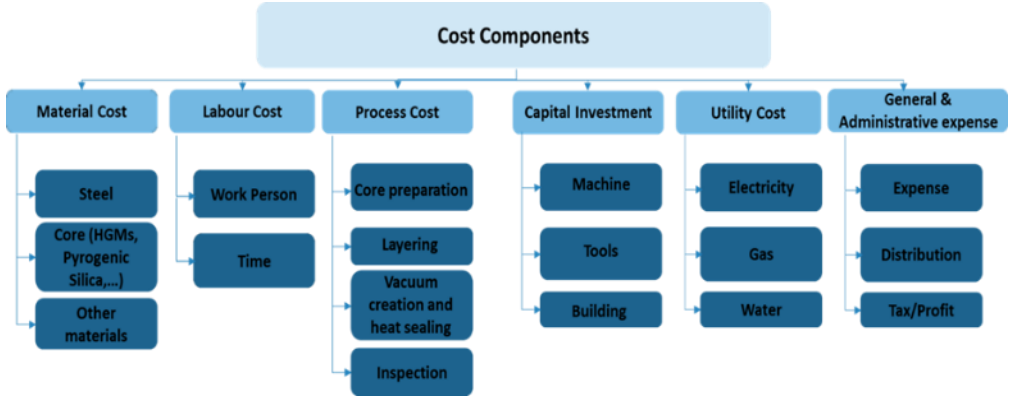
Impressions from Benchmark Supporting Activities

Insulation design





Circularity and sustainability



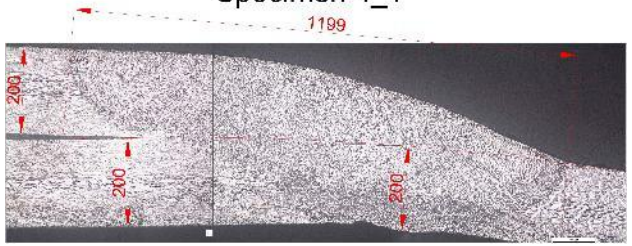
Safety

More frequent

ID	SCENARIO DESCRIPTION / CAUSE	Frequency class				
		A	B	C	D	E
B13	Windborne debris or object impact	0%	36%	29%	29%	7%
B32	Mechanical failure within the gap (e.g. vibration and failure of the panels support structure)	0%	7%	79%	14%	0%
C31	No flow: failure of sweeping gas control loop	0%	13%	80%	7%	0%
C32	Block in sweeping gas supply system	0%	20%	67%	13%	0%
C21	Pressurization of gap: Failure of sweeping gas control loop	0%	29%	57%	14%	0%
D41	Vacuum level degradation in panels	8%	25%	42%	25%	0%
B14	Dopped object (e.g. crane during maintenance work on site)	0%	36%	45%	18%	0%
C41	Vacuum in gap: Failure of sweeping gas control loop	0%	27%	67%	7%	0%

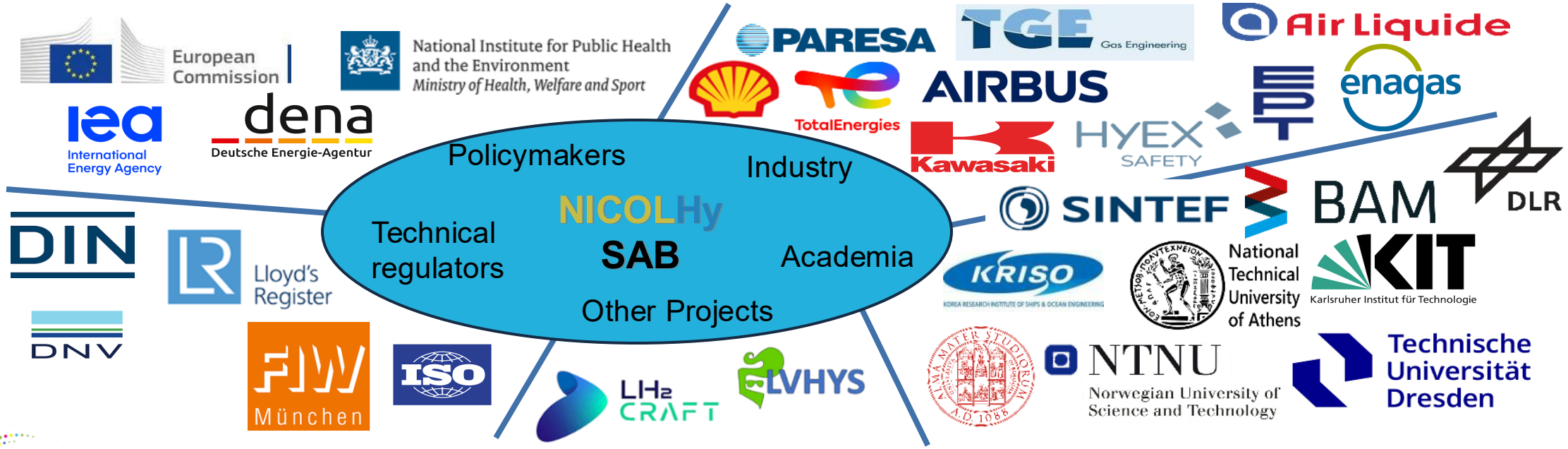
Proof of Concept + Material Tests

Specimen 4_1



Impact and KPI

KPI	Clean Hydrogen JU SRIA KPIs				
	SRIA reference	Unit	SoA (2020)	Target 2024	Targets 2030
11	Onshore LH2 containment tank capex	[€/kg]	100	70	<20
12	LH2 boil-off	[%/d]	<0.3	0.1	<0.1



Thanks for your attention

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