10th Tartu Hydrogen Days

HYCODUQ.

Hydraulic hydrogen compression for refuelling stations, based on a dual-chamber compression unit

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ERI VIRAC | Ventspils University of Applied Sciences | Latvian Hydrogen Alliance

01 — WHO WE ARE

Ventspils University of Applied Sciences

Hydrogen Valley Estonia

State university of applied sciences

Faculties of Economics and Management, Information Technologies, and Translation Studies

ERI VIRAC

Engineering Research Institute “Ventspils International Radio Astronomy Centre”. Full member of EVN European VLBI Network, member of JIV-ERIC, observer of LOFAR ERIC

VENTSPILS AUGSTSKOLA

VIRAC

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TAL TECH

METROSERT

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H2 VALUE

H2CoVE

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02 — THE CHALLENGE

Compression in the hydrogen supply chain

Compression of gaseous hydrogen enables delivery to the end user, and it is generally considered one of the most expensive process units in the supply chain.

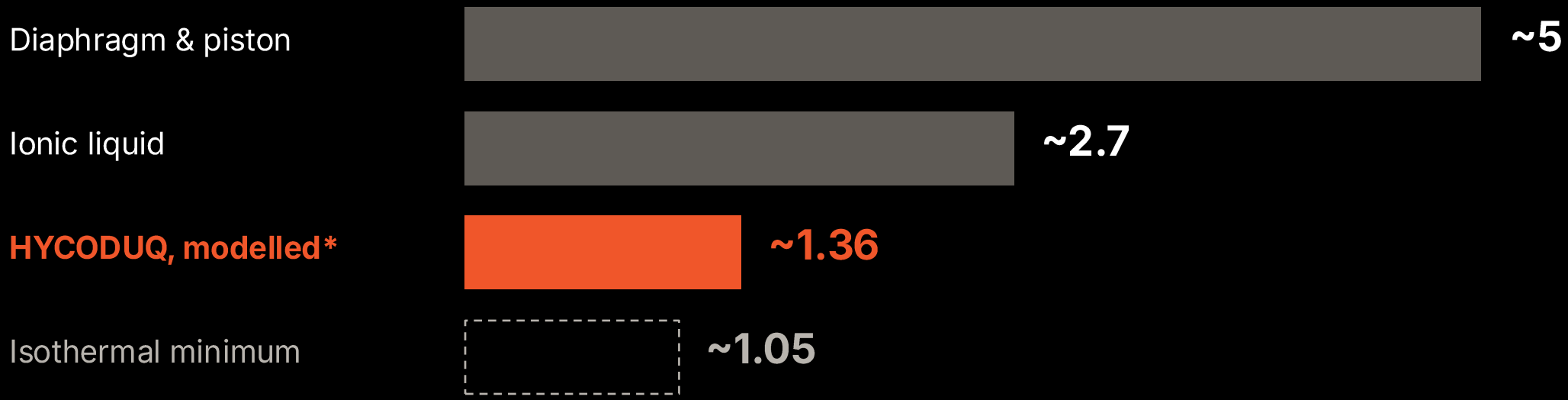
~30%

of refuelling-station CAPEX is compression equipment†

† Team market analysis based on published market reports

02 — THE CHALLENGE

Compression energy at 70 MPa, kWh/kg



* CFD-modelled target, not yet a measured result. Benchmarks per Pereira et al. (2024), Energies 17, 4906.

02 — THE CHALLENGE

Compression technologies today

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Mechanical

Reciprocating piston

Diaphragm

Linear

Liquid piston

Non-mechanical

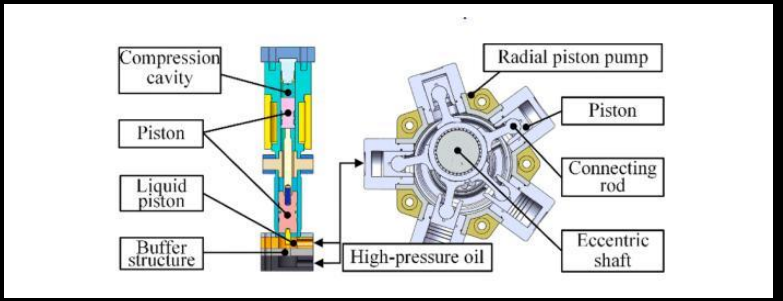
Cryogenic

Metal hydride

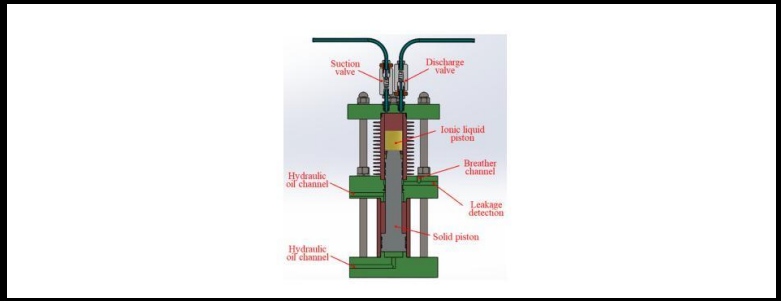
Electrochemical

Adsorption

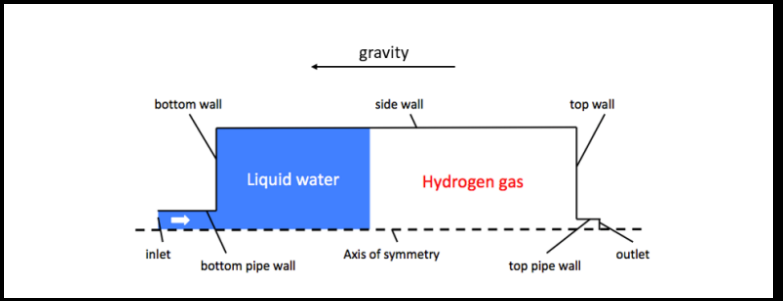
Linde: pioneer of compression for fuel cell vehicles



Ionic liquid compressor, refuelling station (China)



Ionic liquid piston cross-section (China)



Liquid-piston compressor for hydrogen (France, UK)

03 — OUR APPROACH

Dual-chamber hydraulic compression

01 Intake

Low-pressure hydrogen enters a vertical dual-chamber unit; an internal container separates the gas from the working fluid

02 Compress & cool

Tangentially injected working fluid acts as a liquid piston and cools the gas during the stroke

03 Deliver

Cooled high-pressure hydrogen is displaced to storage; compression ratio controlled via fluid flow and valve switching

03 — OUR APPROACH

System layout at a refuelling station

Hydrogen Valley Estonia

1 Hydrogen source

Delivered by truck in tubes, or produced on site by electrolyser (34) from renewable power (35)

2 Low-pressure storage

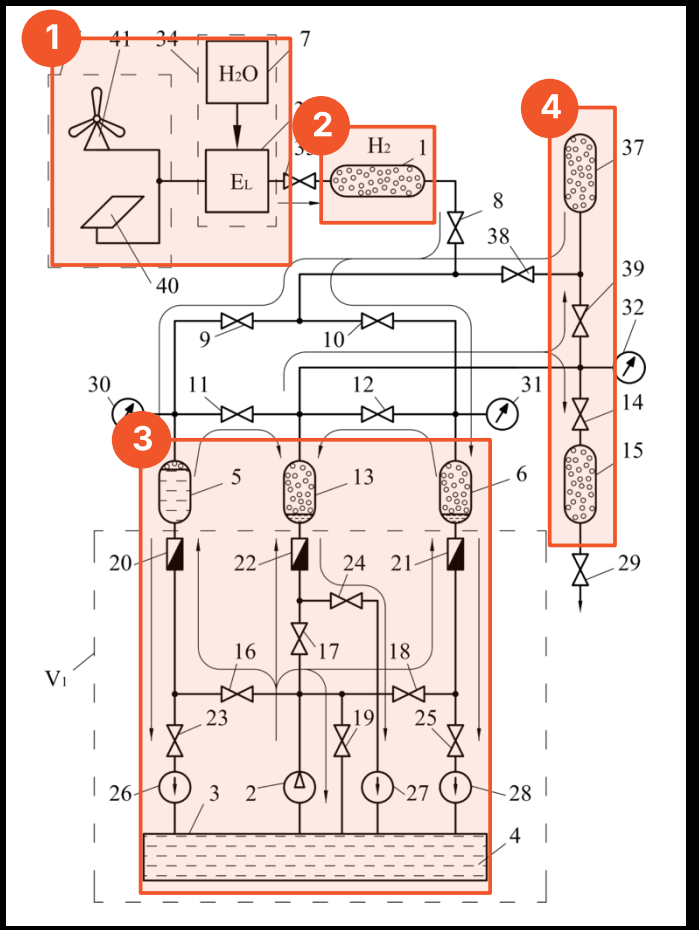
Tank (1) feeds the working cylinders

3 Hydraulic compression

Pump (2) drives working fluid (4) into cylinders 5, 6 and 13 in turn; flow meters 20–22 control each stroke

4 High-pressure delivery

Buffer cylinder (15), topped up by an additional booster container (37)



03 — OUR APPROACH

Design features

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01

Scalable Compression Architecture

Liquid-piston design capable up to 100 MPa (1,000 bar)

02

Wide Inlet-to-Outlet Pressure Range

Variable inlet pressure with controllable compression ratio

03

Easy Service & Maintenance

No piston, diaphragm, rings or seals in the hydrogen path

04

Efficient Thermal Management

Tangential injection drives convective cooling along the chamber

05

Reduced Energy Consumption

~1.36 kWh/kg at 70 MPa, CFD-modelled target

06

Standalone and Booster Ready

For hydrogen delivered by tube trailer or produced on site by electrolysis

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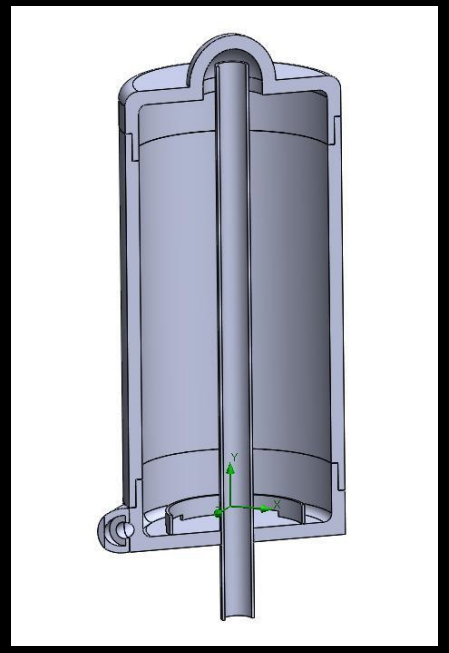
03 — OUR APPROACH

Working fluid movement in the chamber

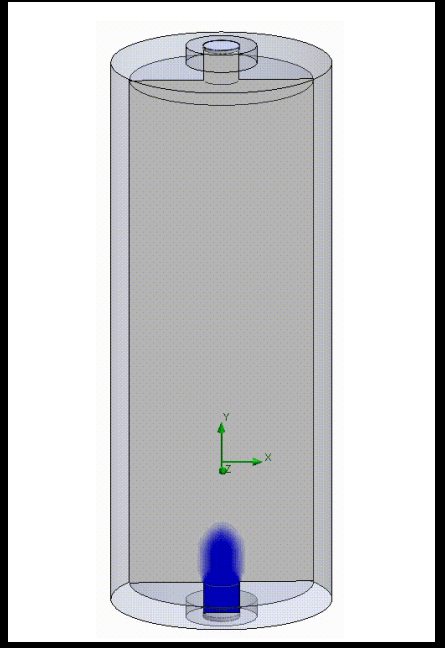
Hydrogen Valley Estonia

01



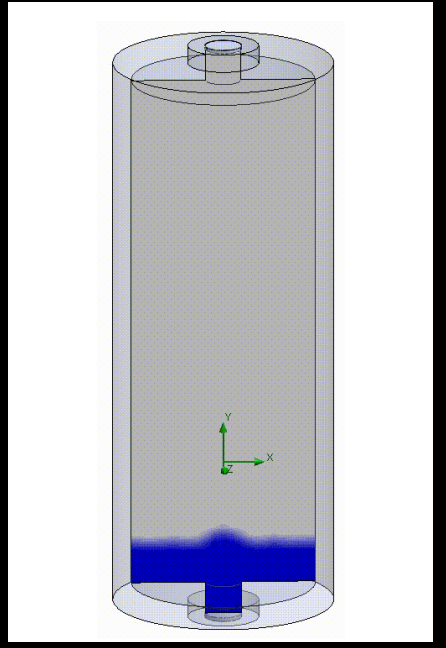
V2 model, section view

02



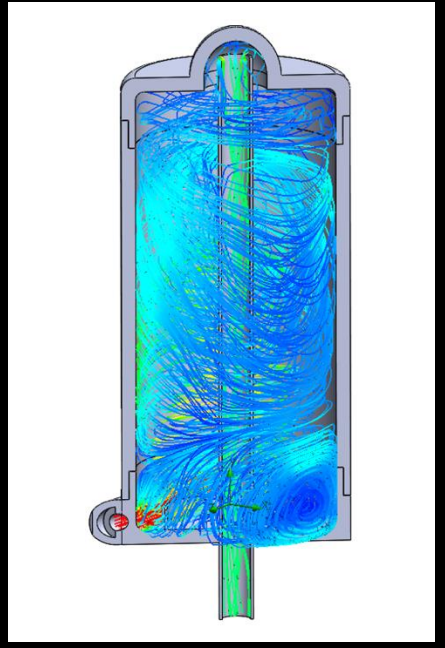
Tangential injection begins

03



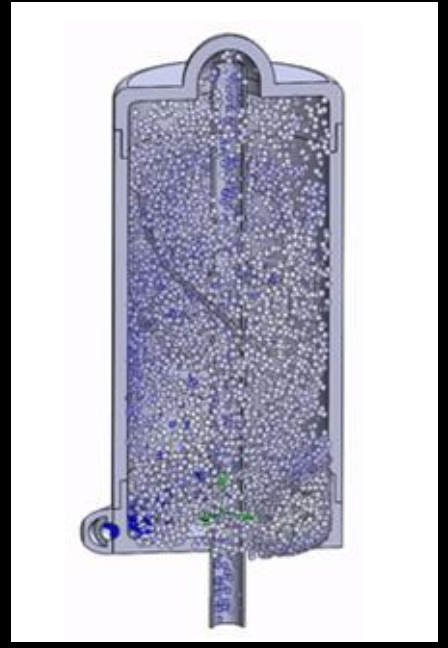
Fluid layer forms at the base

04



Flow trajectories, V2 model

05



Fluid flow (animation)

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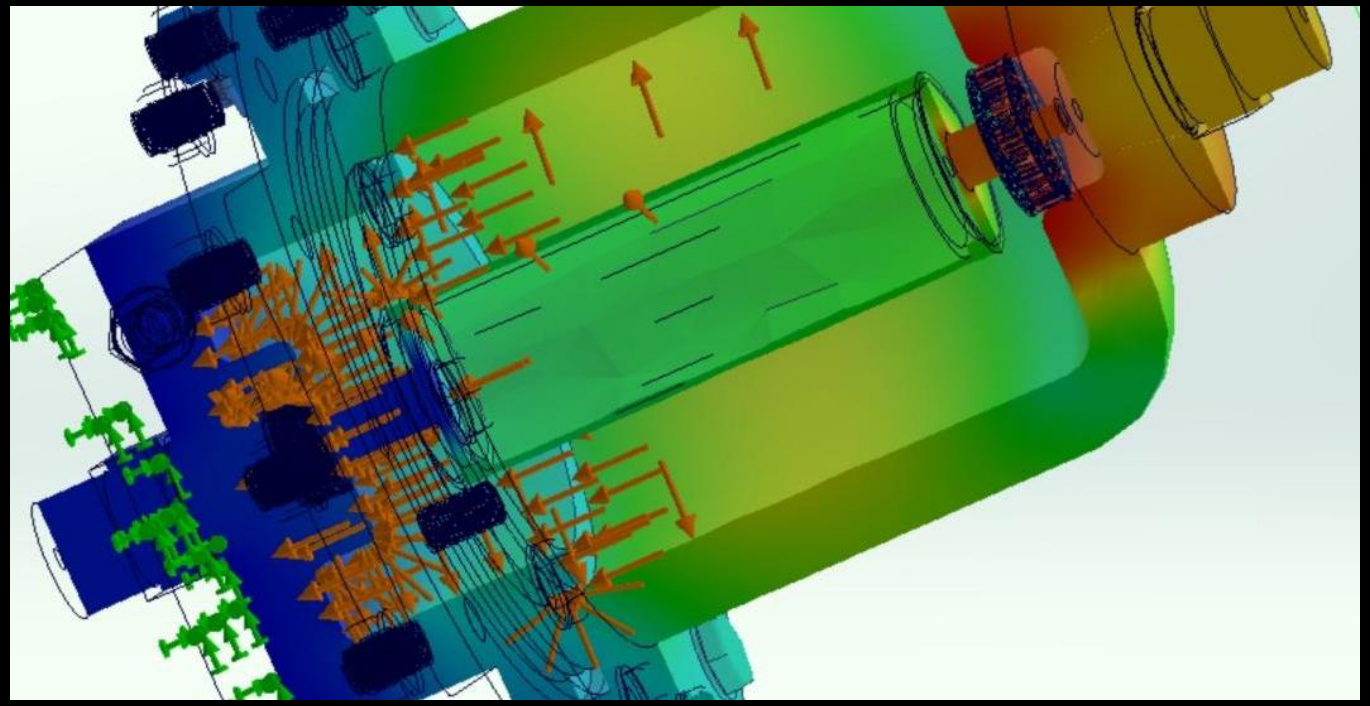
04 — RESEARCH RESULTS

CFD modelling of the working fluid flow



Working fluid flow in the compression cylinder for different injection modes

+188.6 K

Average fluid temperature rise in one 20 s stroke, single-chamber baseline (3.0 MPa inlet, ratio 5.0)

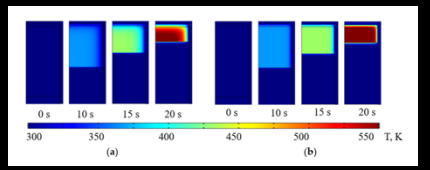


Fig. 6 Gas, 300–550 K

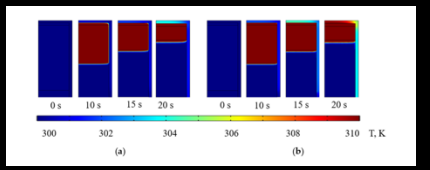


Fig. 7 Wall, 300–310 K

Working fluid

Silicone oil with carbon nanomaterials: lower viscosity, higher thermal conductivity

04 — RESEARCH RESULTS

From design to workshop

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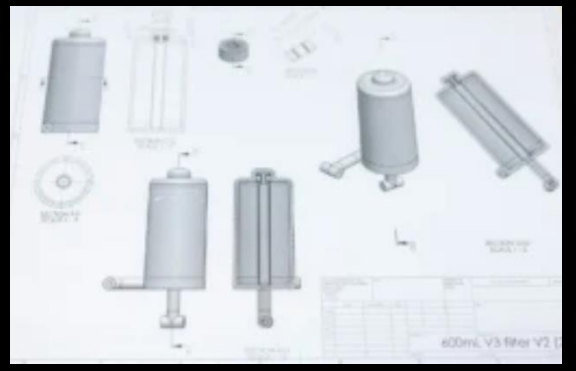
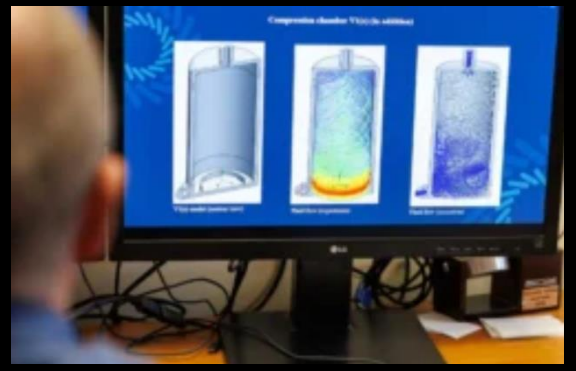
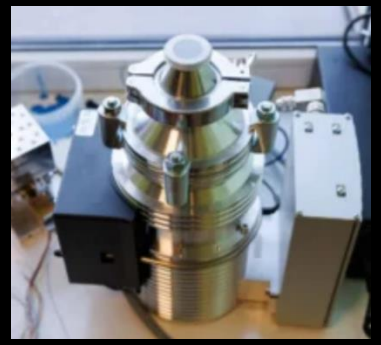
DESIGN & SIMULATION

MANUFACTURING



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04 — RESEARCH RESULTS

Experimental test bench

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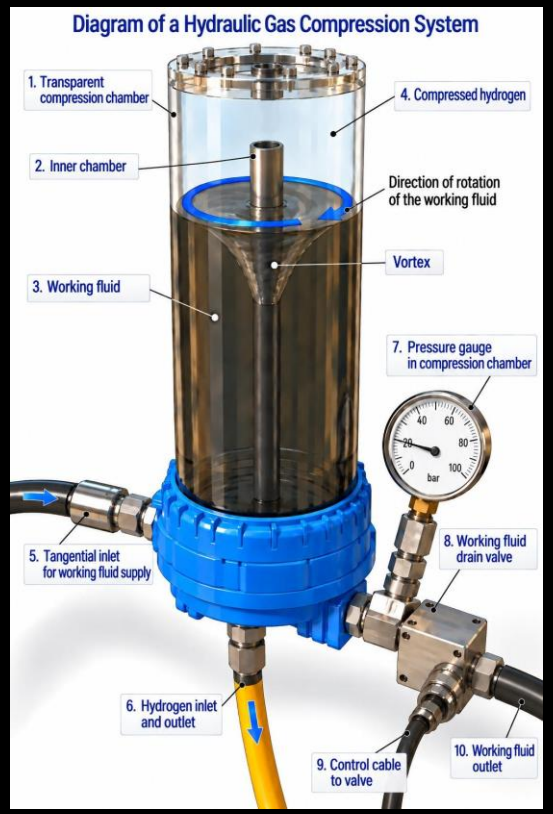

1–10 L

Lab prototypes

Transparent chambers

Flow and heat observation

20 MPa

Metallic chamber, modified for dual-chamber tests

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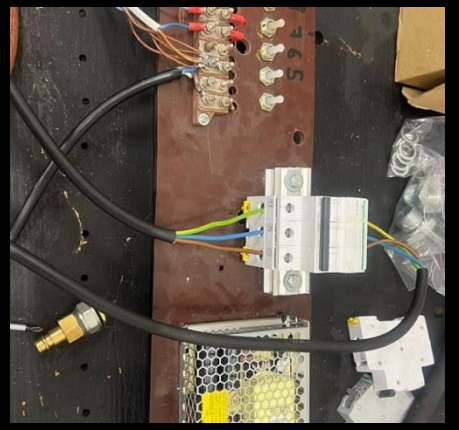
04 — RESEARCH RESULTS

Test rig assembly and commissioning



04 — RESEARCH RESULTS

Technology comparison

TECHNOLOGY	ENERGY, 70–90 MPA	MOVING PARTS IN H_2 PATH	KEY LIMITATION
Reciprocating piston	~5 kWh/kg	Piston, rings, seals	Heat, wear, embrittlement risk
Diaphragm	~5 kWh/kg	Diaphragm, valves	Diaphragm fatigue, downtime
Ionic liquid	~2.7 kWh/kg	Liquid piston	Low flow rates, complex design
HYCODUQ	**~1.36 kWh/kg***	**None, the fluid is the piston**	TRL 2→3, lab validation in progress

* CFD-modelled target, not yet a measured result. Benchmarks per Pereira et al. (2024), Energies 17, 4906.

04 — RESEARCH RESULTS

Intellectual property

6

LV and EU patents and PCT applications

2 prior-generation patents

acquired by Atawey (FR) in 2024

Ūdeņraža hidrauliskās kompresijas ierīce	LVP2022000071 · 2022
Cylinder for hydraulic compression of hydrogen with limited foam formation	LV15782 · 2023
Hydrogen hydraulic compression device	PCT/IB2022/058904 · 2022
Hydrogen hydraulic compression device	EP 22793460.1 · 2023
Ierīce ūdeņraža hidrauliskai saspiešanai	LVP2026000042 · 2026
Device for hydraulic compression of hydrogen	PCT/IB2026/056179 · 2026

05 — OUR TEAM

HYCODUQ team

Dr. Valērijs Bezrukovs

Project Leader

Dr. Marina Konuhova

Project Process Modeling Lead

M. sc. ing. Vladislavs Bezrukovs

Project Engineer | TTO and Software Developer

M. sc. ing. Agris Bērziņš

Project Designer, Production and Testing Lead

Vitālijs Petkevičs

Head of Science & Development

Kaspars Liepiņš

Commercialisation Lead

Linda Ūdre

Project Administrator

06 — NEXT STEPS

Roadmap and industry input

Hydrogen Valley Estonia

2026 · now

Lab validation

TRL 2→3, benchmark criteria defined with industry

2027

Pilot design

With industry partners

Next

Field testing

Eurostars / Horizon Europe consortium formation

Help shape the benchmark criteria.

A 30-minute conversation about your duty cycles, pressure envelopes and integration constraints

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Thank you.

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Project No IVPP-EM-Innovation-2024/1-0002 “BioPhot” is implemented under the national research programme “Innovation Fund – Long-Term Research Programme”, funded by the Ministry of Economics.