

Einblicke in die luxemburgischen Wasserstoffaktivitäten



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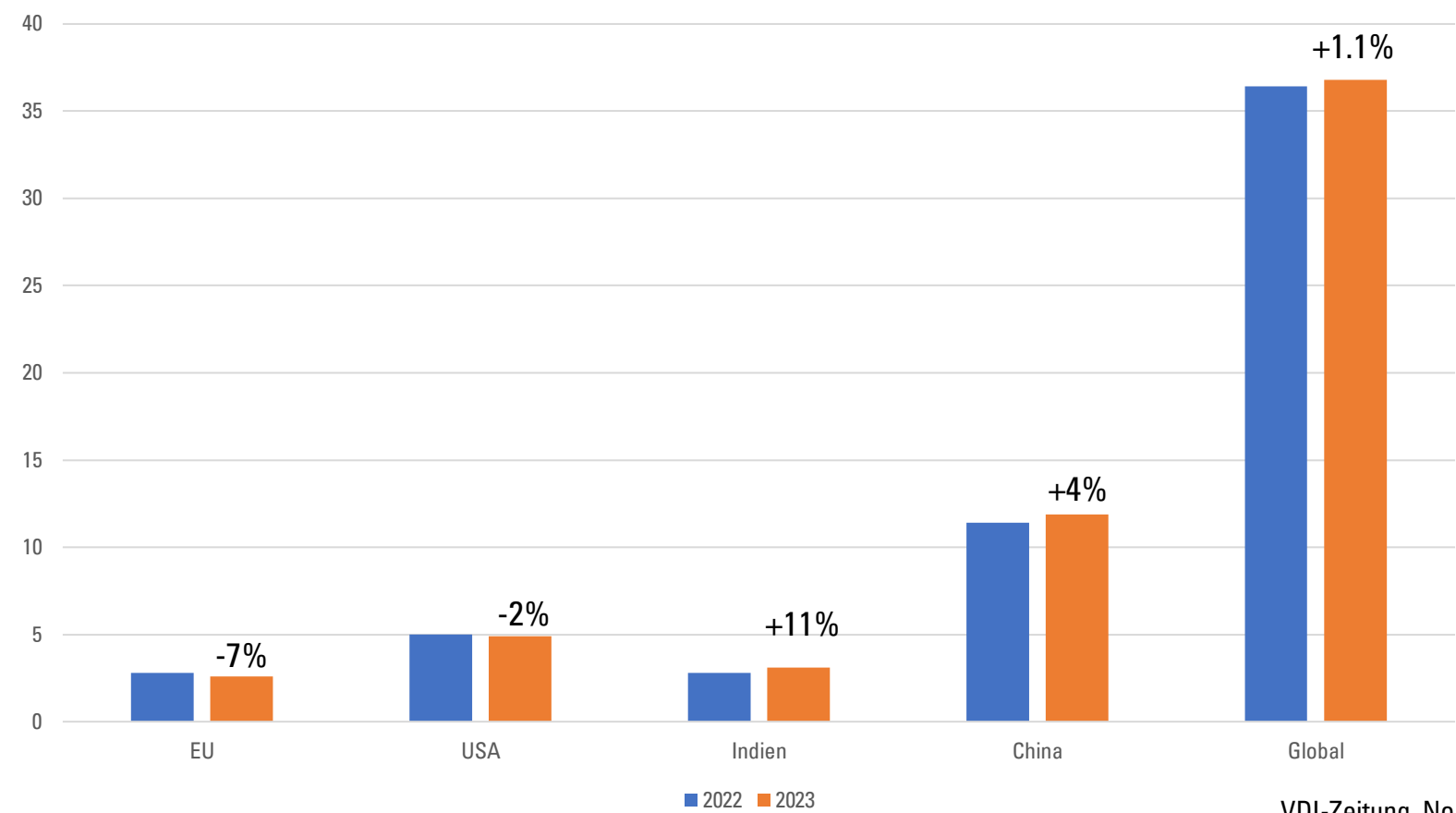


1. Saarländischer Wasserstoffkongress



CO₂-emissions [Mrd. t] in 2022 & 2023

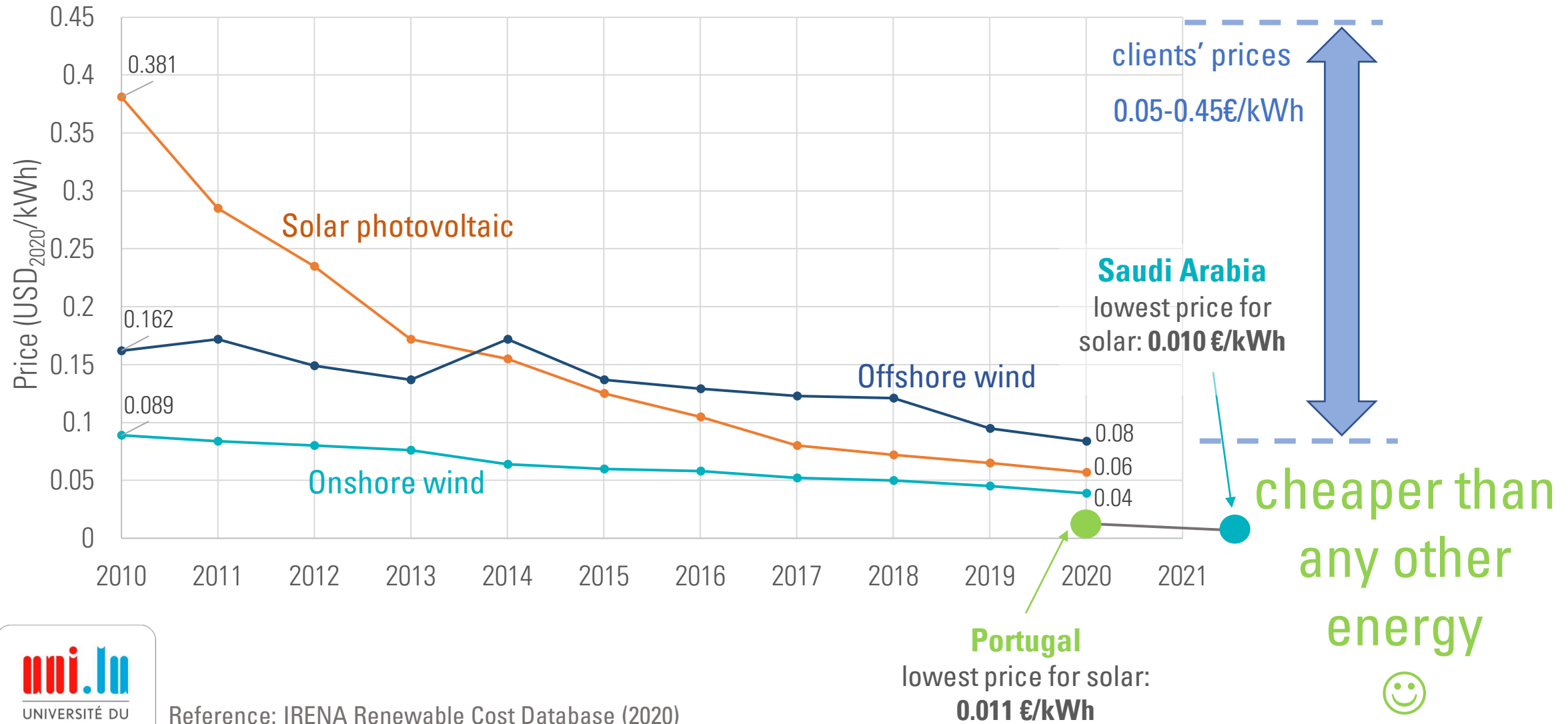
Europe and the world aren't on track? 😞



VDI-Zeitung, No. 25, December 15, 2023

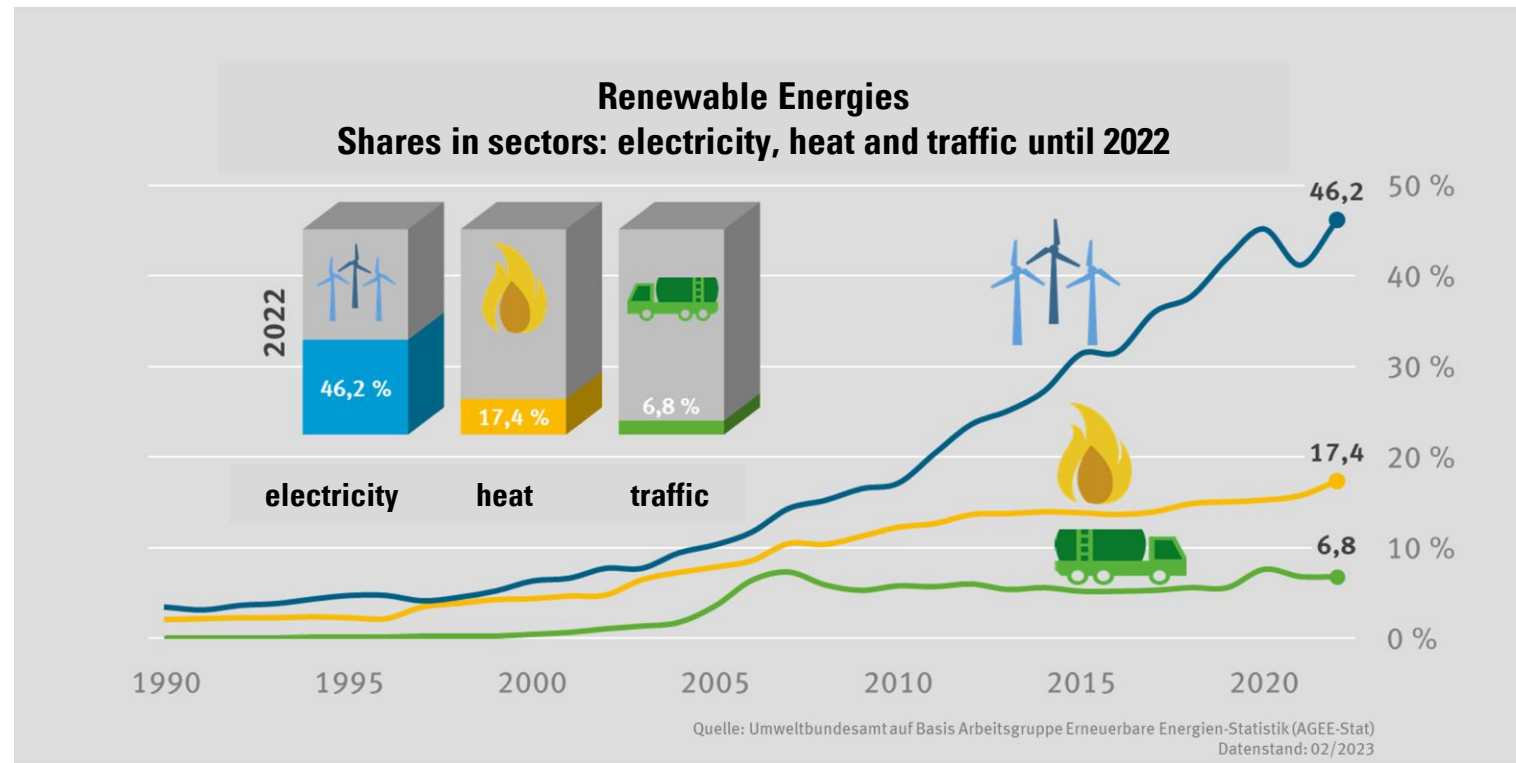
- ➔ highest global emissions per year ever measured in 2023
- ➔ remaining global CO₂-budget for 1.5 °C target is only 275 Mrd.t (7.5 years)
- ➔ we need 0 additional CO₂ emissions asap. = climate neutrality!!!

Production cost of renewable energy the good news 😊



Primary energy is more than electricity...

In 2022, ac. to EU directive to promote renewable energies (RED II, 2018/2001) ~20 percent of German final energy consumption was covered by renewables (Environmental Ministry Umwelt-Bundesamt).



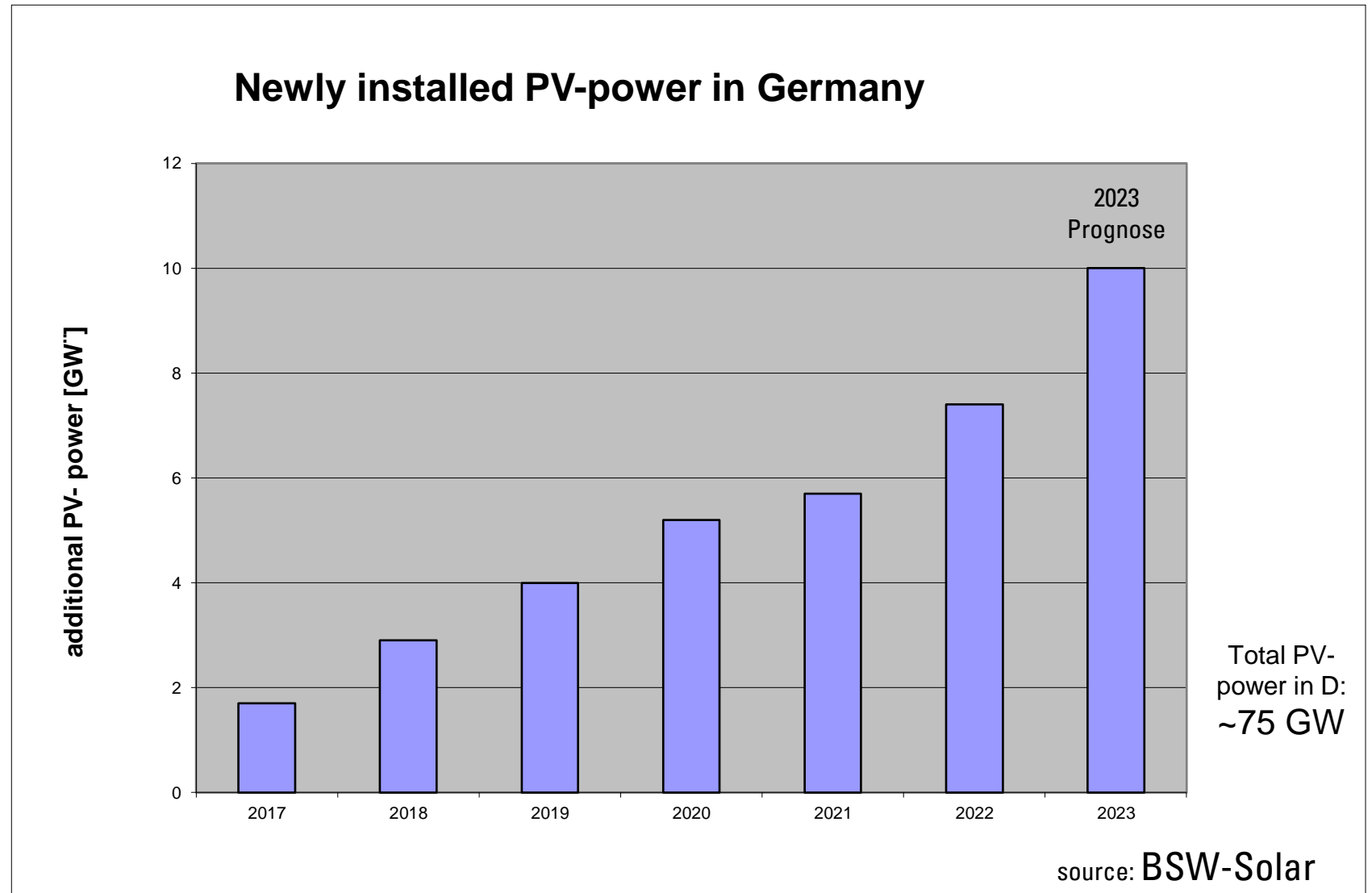
➔ 80% of German Final Energy (=paid energy) is still fossile ☹️

Efficiency: ~ 10% (2000) to ~ **22%** (2023)

Electricity production in D today:
~500 TWh, ~ 50% or **250 TWh** renewable
German PV-Electr.-production ~ 70 TWh

Total primary energy consumption :
EUROSTAT 2022 in D: ~ 3000 TWh
[Statistics | Eurostat \(europa.eu\)](#)

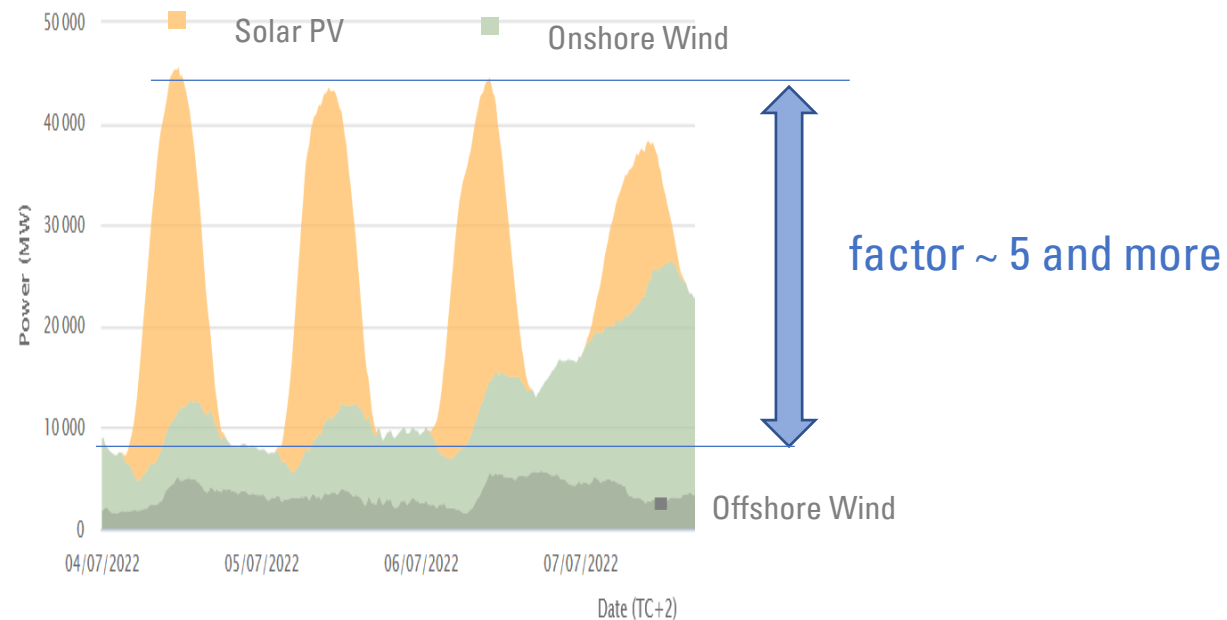
→ though PV-efficiency is «only 22%» PV-electricity is competitive and booming!



Volatility rises with extension of PV & Wind-energy

2022

Only renewables in D « Fraunhofer ISE »



Total annual primary energy consumption in D:
~ 3000 TWh.

Total electricity production in D:
~500 TWh, ~ 50% or 250 TWh renewable

Curtailed renewables: 8 TWh in D

Bundeswirtschaftsministerium estimates:
**100 TWh = 100 Mrd. kWh storage capacity will
be needed !** (VDI_Z., Nr. 23, 2023)

→ Storage and Balancing power is needed more & more !

EU policy: [1 Clean.pdf \(europa.eu\)](#)

from 2024 to 2030

- 6 GW to 40 GW of renewable hydrogen electrolyzers in the EU
- 1 Mio. t to 10 Mio. t of hydrogen production and transportation

after 2030

- renewable hydrogen for all hard-to-decarbonise sectors e.g., energy intensive industries.

→ 100 billion euros invest each year in H2 over the period 2021-2030, i.e. doubling invest of 2011-2020

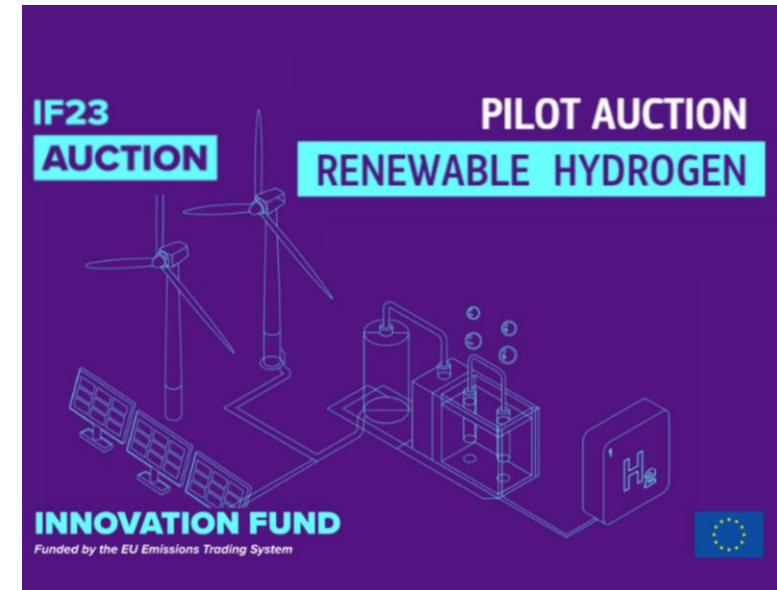
European Hydrogen Bank (EHB-instrument within EU-Commission) to

- launch in November 2023 to 02/2024 the first [EU-wide auction](#) which [attracted 132 bids from renewable hydrogen producers across 17 EEA countries](#) (€800 million from Innovation Fund)

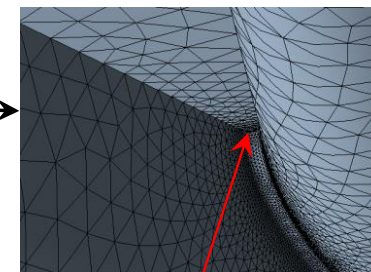
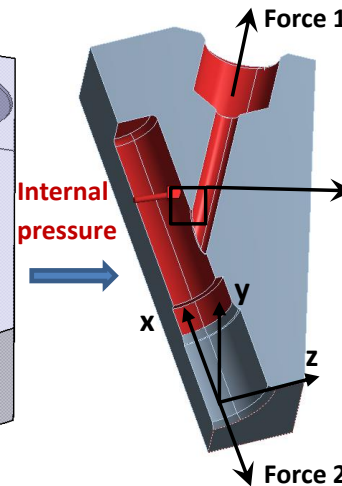
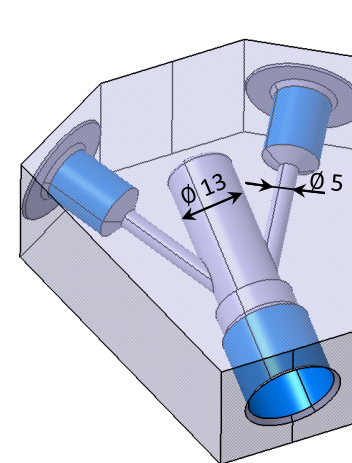
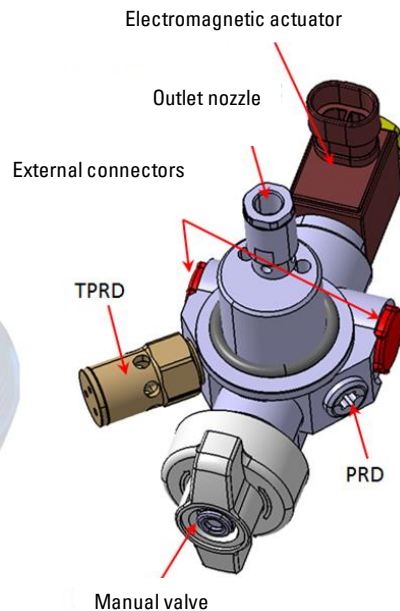
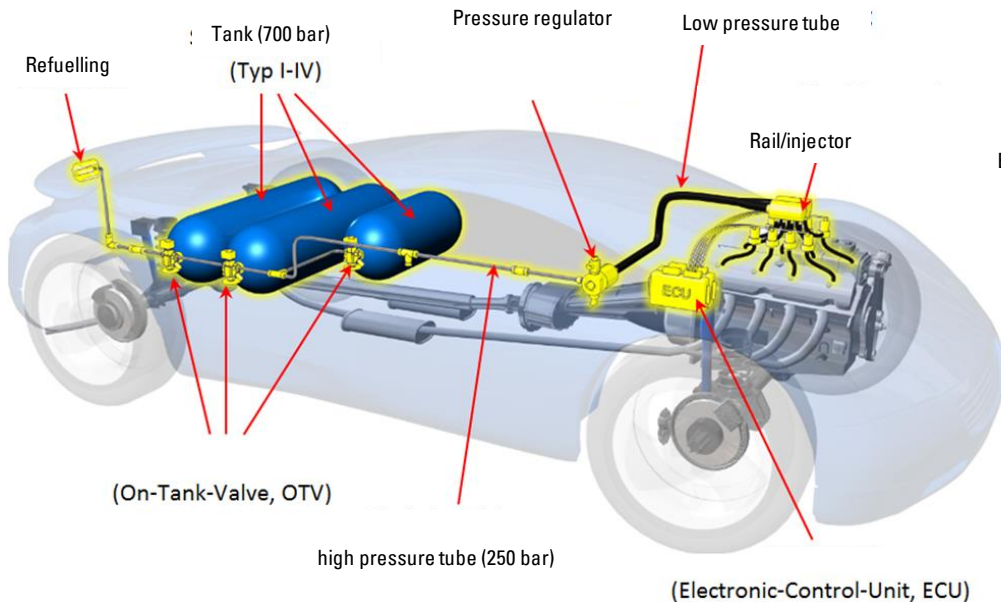
- levelized cost from 6-14 €/kg
- 2nd tender of EHB in preparation with ceiling price ~4€/kg.
- LU Ministry of Energy will also launch a national tender in 2024



Policy Overview



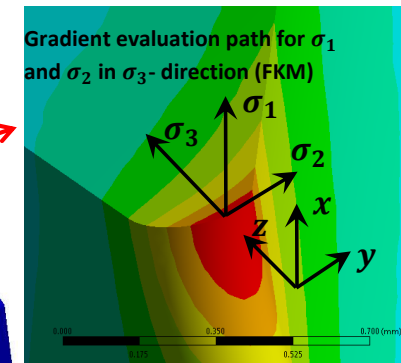
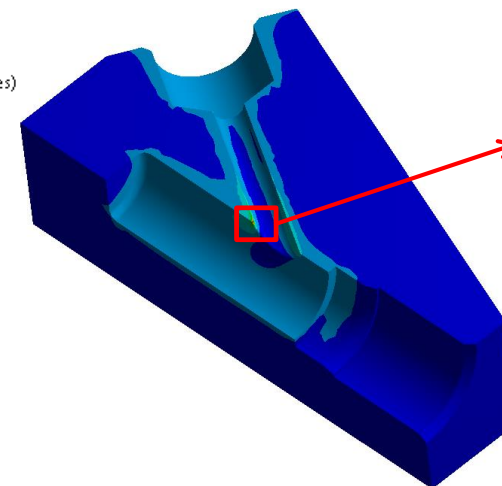
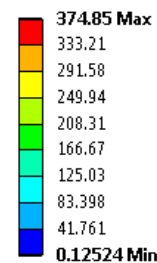
Own project: H₂ -mobility



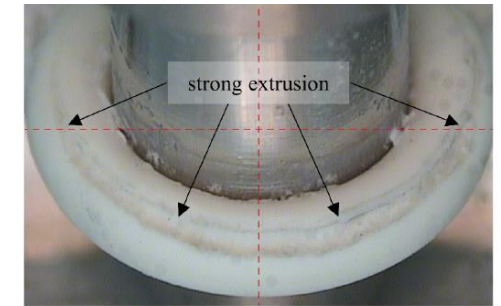
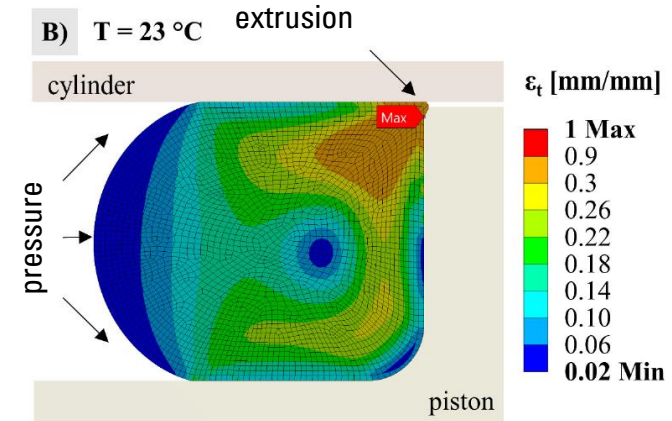
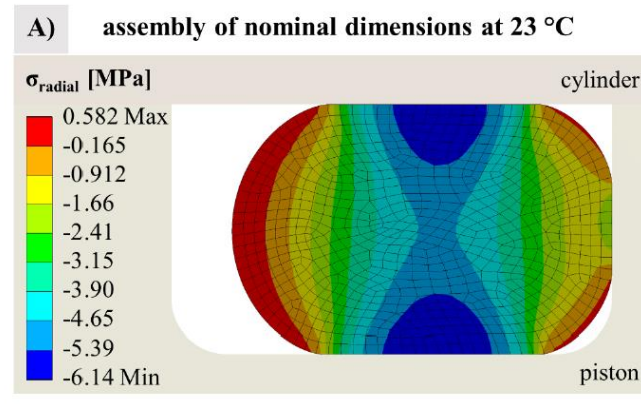
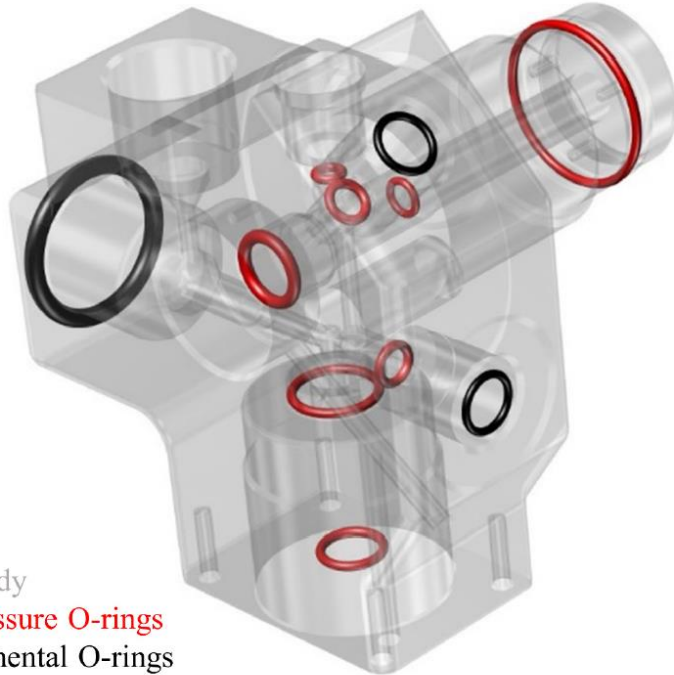
Point of analysis (tip of bore intersection)

cars have H₂-tanks for **700 bar!**
 the pressure varies btw. 0 and 875 bar max.
150.000 pulsating cycles from 0 to 875 bar have to be proven without fatigue indicators or cracks !

A: Static Structural (ANSYS)
 Equivalent Stress
 Typ: Vergleichsspannung (von Mises)
 Einheit: MPa



Own project: car H₂-700 bar valve Gaskets



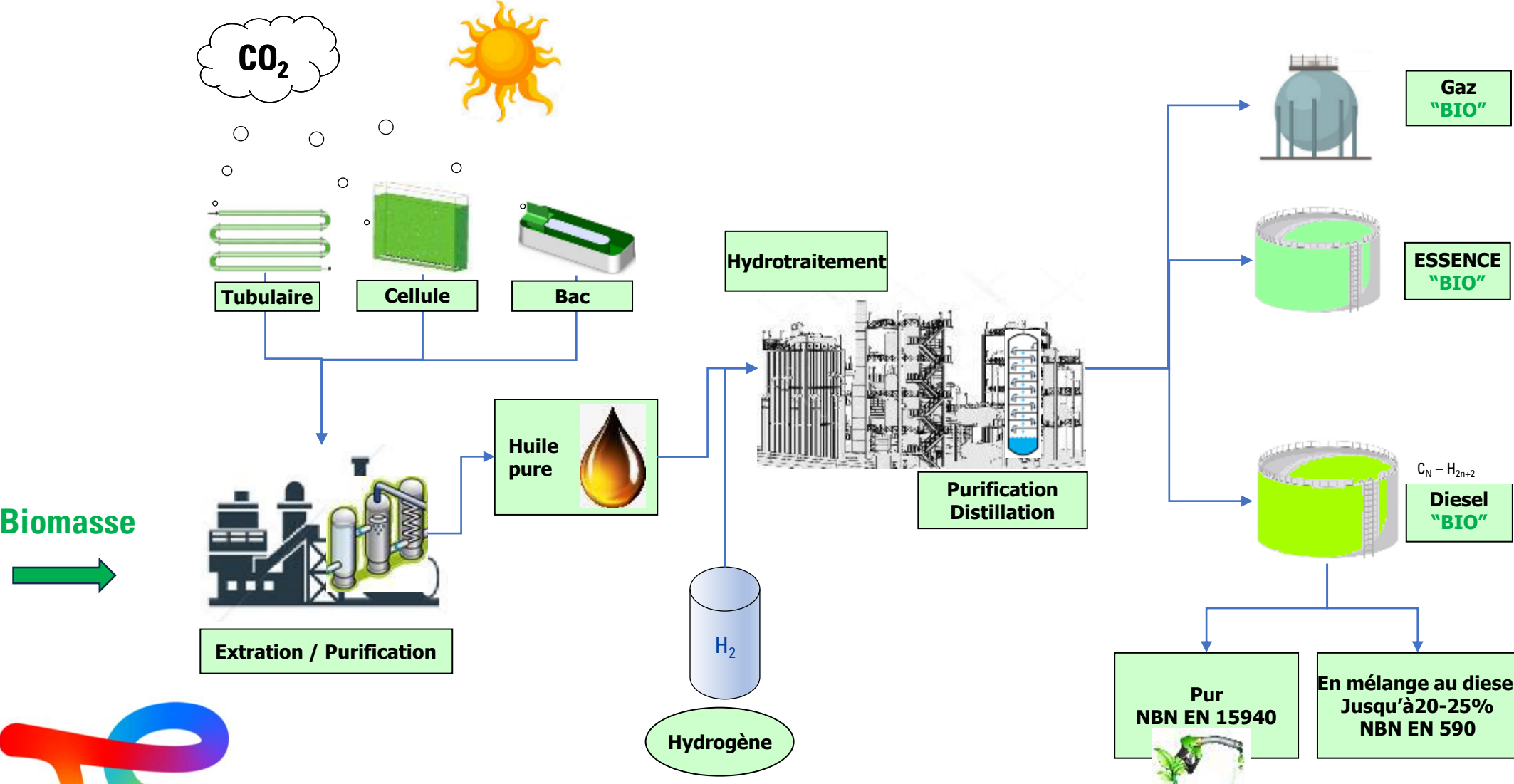
Research questions:

- material of O-rings
- dimensions: diameter & widths
- tolerances of notch & gasket, for instance to avoid extrusion
- temperature-effects in the range of -60°C to + 80°C
- 150.000 cycles of 0 to 875 bar

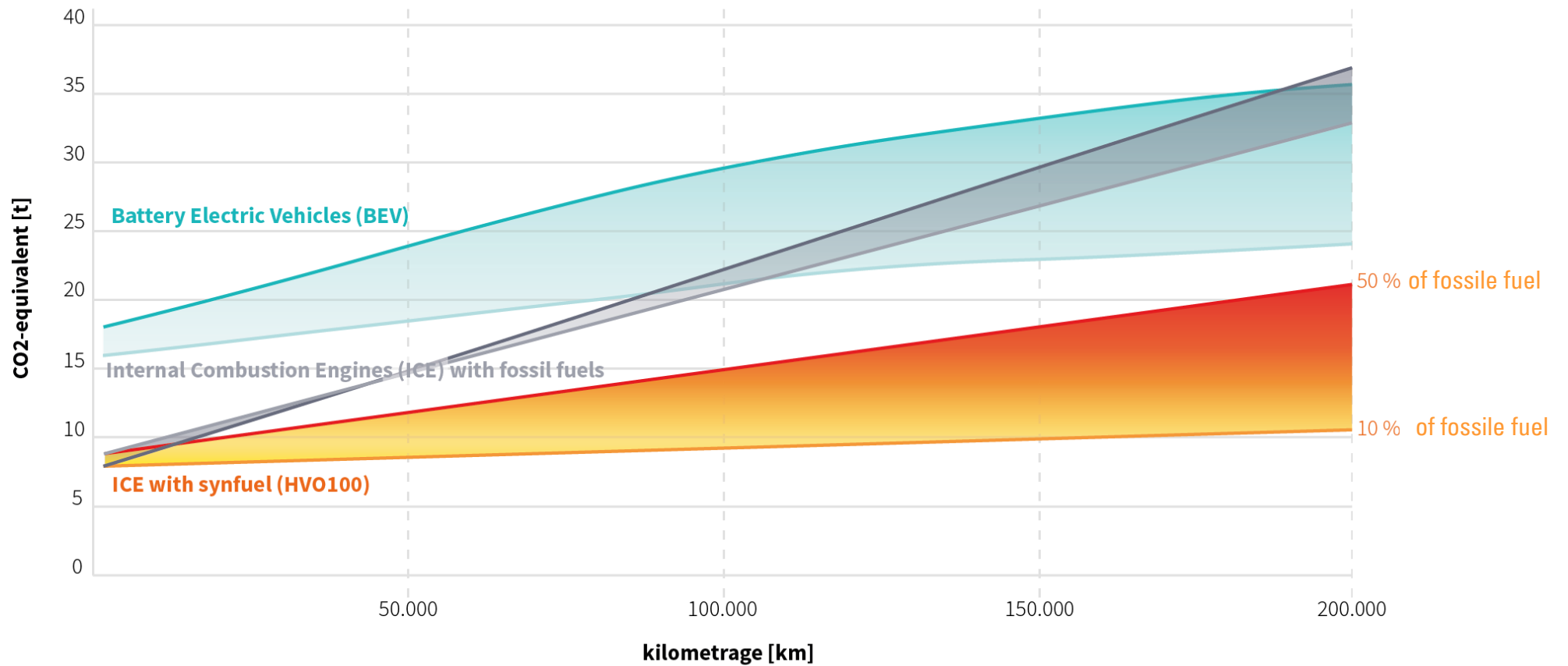
Prototype of the car H₂-700 bar On-Tank-Valve



Hydrotreated Vegetable Oil (HVO100), TOTAL & NESTE



Carbon footprint of typical medium sized vehicle



Reference: VDI-Analyse der CO₂-Emissionen von Pkw mit verschiedenen Antriebssystemen, VDI-Studie Dezember 2023;
doi.org/10.51202/9783949971747

National Policy - Hydrogen Strategy

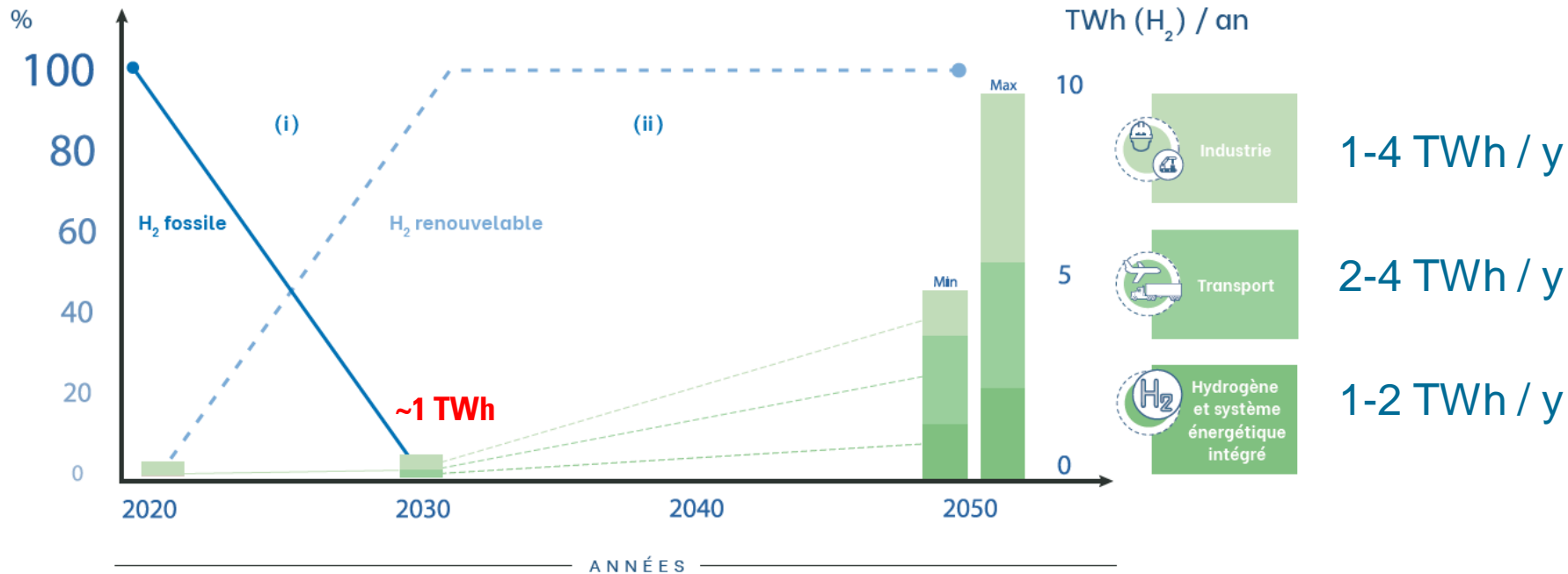


LE GOUVERNEMENT
DU GRAND-DUCHÉ DE LUXEMBOURG
Ministère de l'Énergie et de
l'Aménagement du territoire

Objectif
Neutralité climatique jusqu'en 2050

Priorités pour décarboner le secteur énergétique

1. Efficacité énergétique
2. Électrification renouvelable directe
3. Hydrogène renouvelable



Lower/Higher heating value of H₂
33.3 or 39.4 kWh/kg

H₂ consumption in LU in 2024:
~ 0.01 TWh/a (a few 100 t/a)



Hydrogen Valley & LuxHyVal
Prof. B. Ladewig

~1 TWh equals 28 000t in 2030
~ 10 TWh in 2050

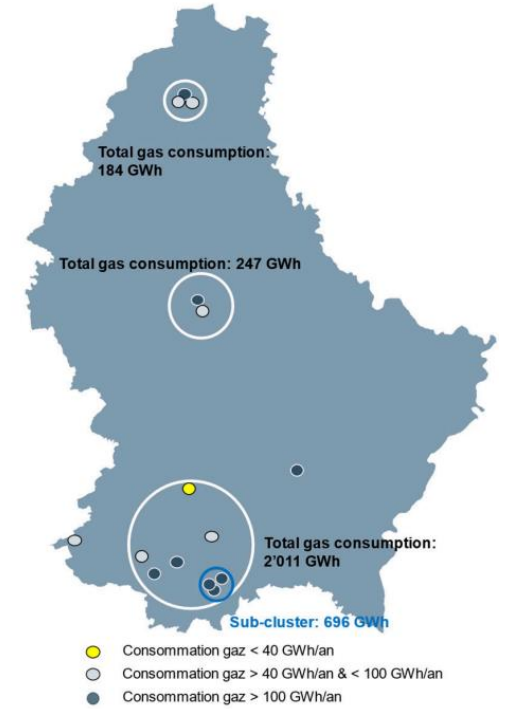


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H₂ transport



The European Hydrogen Backbone (EHB) initiative consists of a group of 32 energy infrastructure operators, big & well-known companies from natural gas



April 17, 2024: Signature of letter of intent on future cooperation for hydrogen pipeline infrastructure



Lex Delles
LU-Minister
Economy/Energy

Laurence Zenner
CEO CREOS-Lu

Pascal De Buck
CEO Fluxys

Tinne Van der Straeten
BE-Minister
Energy

H₂ transport



mosaHyc: moselle-saar-HYdrogen-conversion

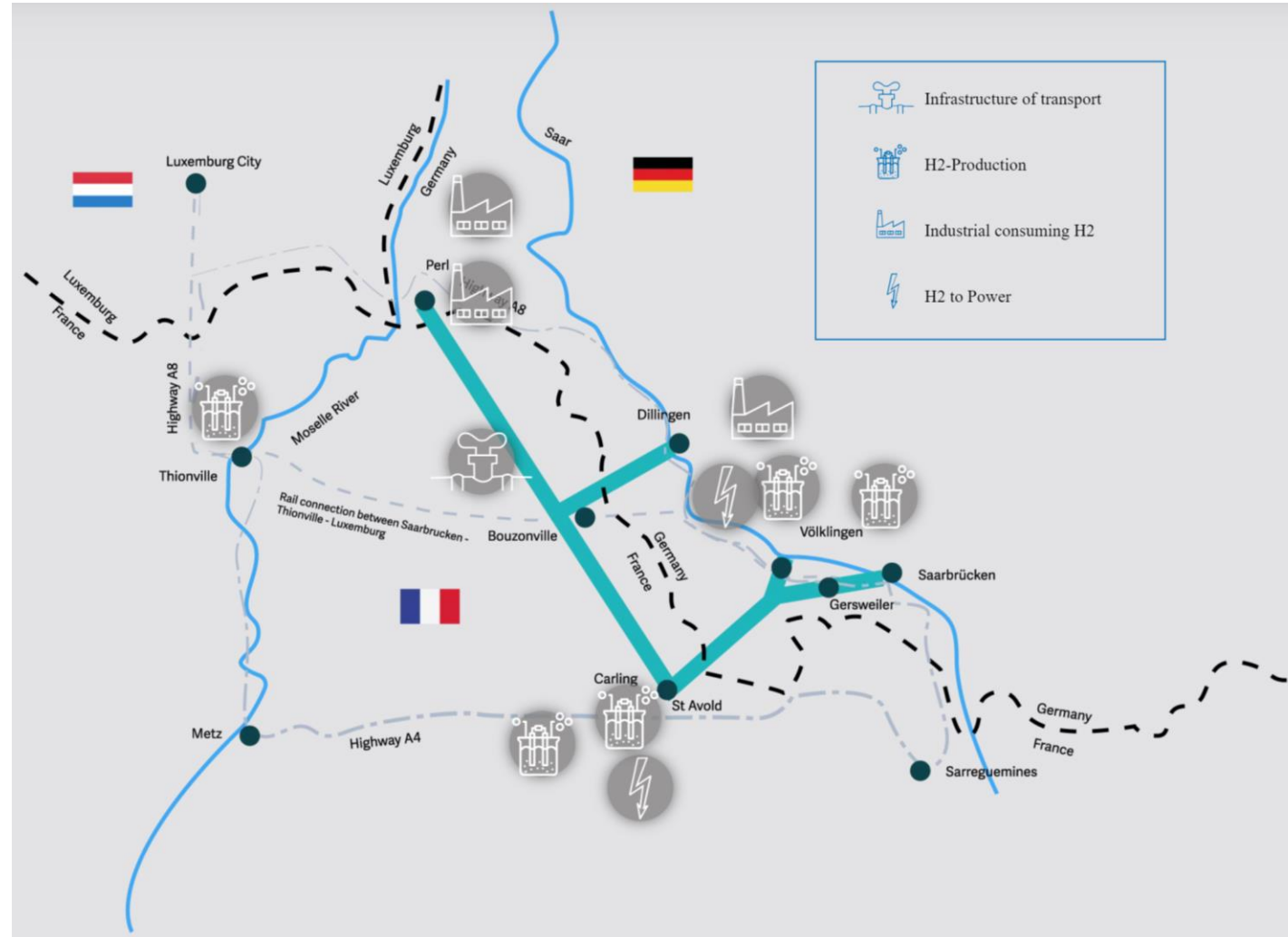


CREOS (Germany)
GRTgaz (France)
ENCEVO (Luxemburg)

Conversion of 70 km from existing natural-gas to H₂-pipeline (certain materials are not compatible, ventils, measuring- and safety technology) & new pipeline of 30 km :

$\dot{V} = 120\,000\text{ m}^3/\text{h}$ or 60.000t/a in 2030!

→ 100 km H₂-pipeline as part of EHB
(cost for new pipeline for DN 500 ~2 Mio€/km)



H₂ transport

transport per trailer (200 bis 300 bar) with truck, train or in future pipeline

density is only 10% of natural gas → high compression, to achieve sufficient density per m³ (energy loss & gr. tanks)

or

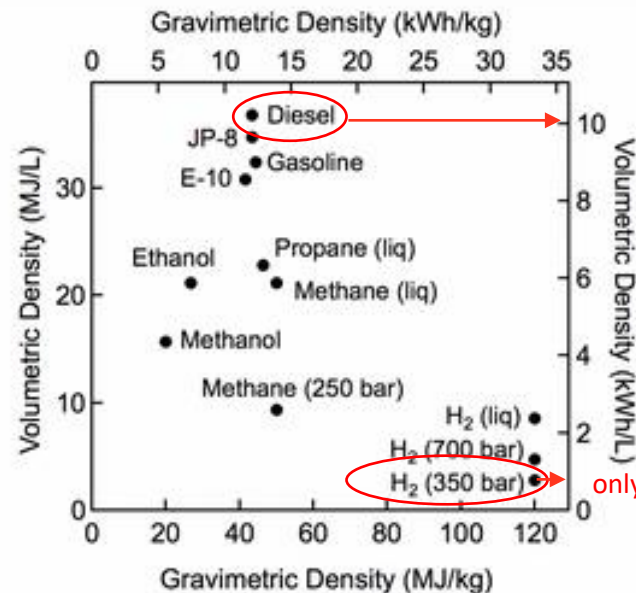
chemical bond for transport (ammonia NH₃, Liquid Organic Hydrogen Carrier –LOHC, Dimethyl-Ether (DME)- Methanol- transformation losses)

or

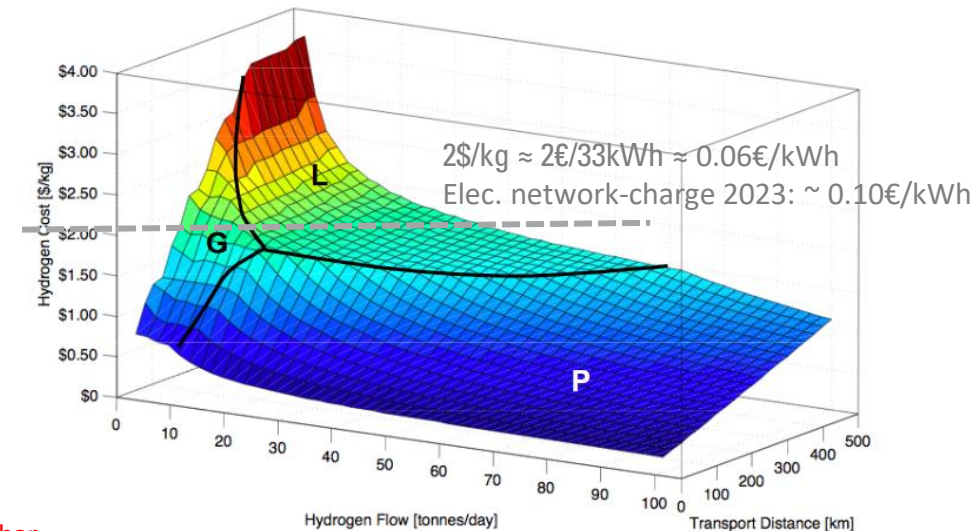
Cryogen, d.h. liquid (T < -253°C -abs. Zero is -273.15 °C-, energy losses to liquify & for permanent cooling)

or

synthetic Methane 4H₂ + CO₂ → CH₄ + 2 H₂O (transformation losses)



only 10%, even at 350 bar



G: compressed H₂ gas truck, L: liquid H₂ truck, P: pipeline

Ch. Yang & J. Ogden. "Determining the lowest-cost hydrogen delivery mode". In: International Journal of Hydrogen Energy 32.2 (2007), pp. 268 ff.

Pilote-project for Intermodality Transport

H₂ Distribution & Storage

Intermodality solution - MEGC

- MEGC: Multiple Element Gas Container
- Type 4 cylinder technology (carbon or glass fibers)
- Modular design at different pressure (300 ~ 600 bars)
- Max H₂ capacity ~ 1.200 kg (tube trailer ~ 400 kg)
- Intermodality & stackability



OR



OR



Credit: Calvera



Luxembourg's hubs for transport and large industrial consumers

Import from Rotterdam (NL) and Antwerp (Be)



CFL multimodal Bettembourg



THANK YOU !

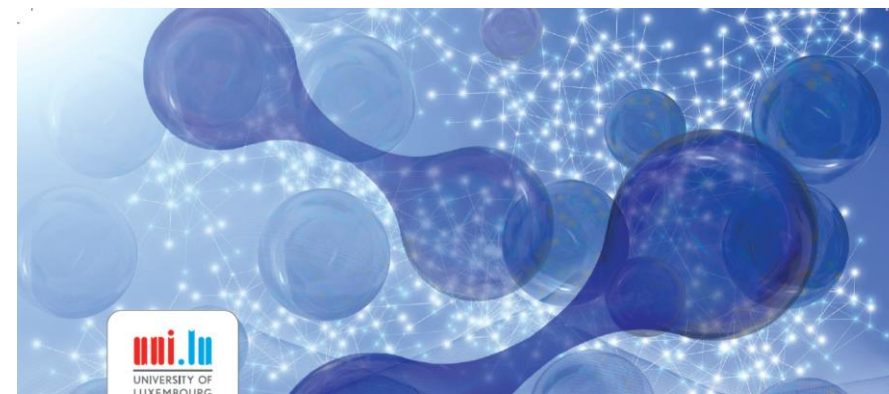
Q&A: Questions, Discussion



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FACULTY OF SCIENCE, TECHNOLOGY AND MEDICINE

IN COLLABORATION WITH:
EUROPEAN INVESTMENT BANK (EIB)
Saarländische H2-Agentur

Energy Innovations and Issues on Ramping-Up European H₂-Economy

Friday 12 July 2024, 14:00h (SAVE THE DATE!)
University of Luxembourg, Campus Kirchberg

H2-Saftey
Siemens-Energy (Haru Oni)
H2-Auctions of EU-H2-Bank
Carbon Border Adjustment Mechanism (CBAM)

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