De rol van waterstof in de energietransitie

Waar is waterstof nuttig en waar is het een hype?

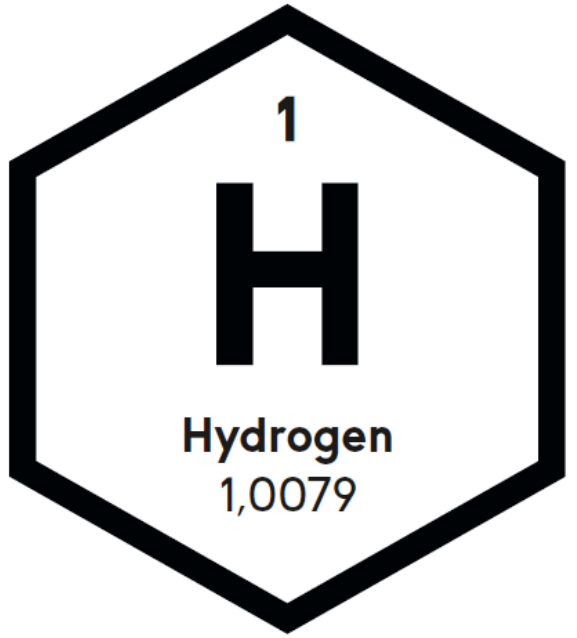
Avondje Best Duurzaam

26 Maart 2026

Gerrit Muller

Iedereen verkoopt Waterstof als **De Oplossing**

Uit:
Hydrogen— study Opportunities, potentials & challenges in the global energy system.
Umlaut, 2020



For aircrafts, no long–term alternatives to traditional propulsion with kerosene via jet engines are fore–seeable because here in particular, high energy densities with respect to the energy carriers are crucial. Rising air passenger numbers, however, are increasing pressure on governments and companies in the sector to find a sustainable alternative to fossil fuels. As a raw material or the production of synthetic fuels, hydrogen will also play a crucial role in this respect.

Enormous potential

Hydrogen technology has enormous potential to reduce costs across the entire energy transition and, like photovoltaic and wind energy, needs start–up financing. Subsidies for these renewable energies mean the technologies today produce energy at competitive prices. Major industrial countries such as China and Japan, as well as the US Federal State of California, plus Canada, are increasingly focusing on the integration of hydrogen in industry and mo–bility. Despite having different approaches, the countries named have two things in common: a roadmap and a clear government position.

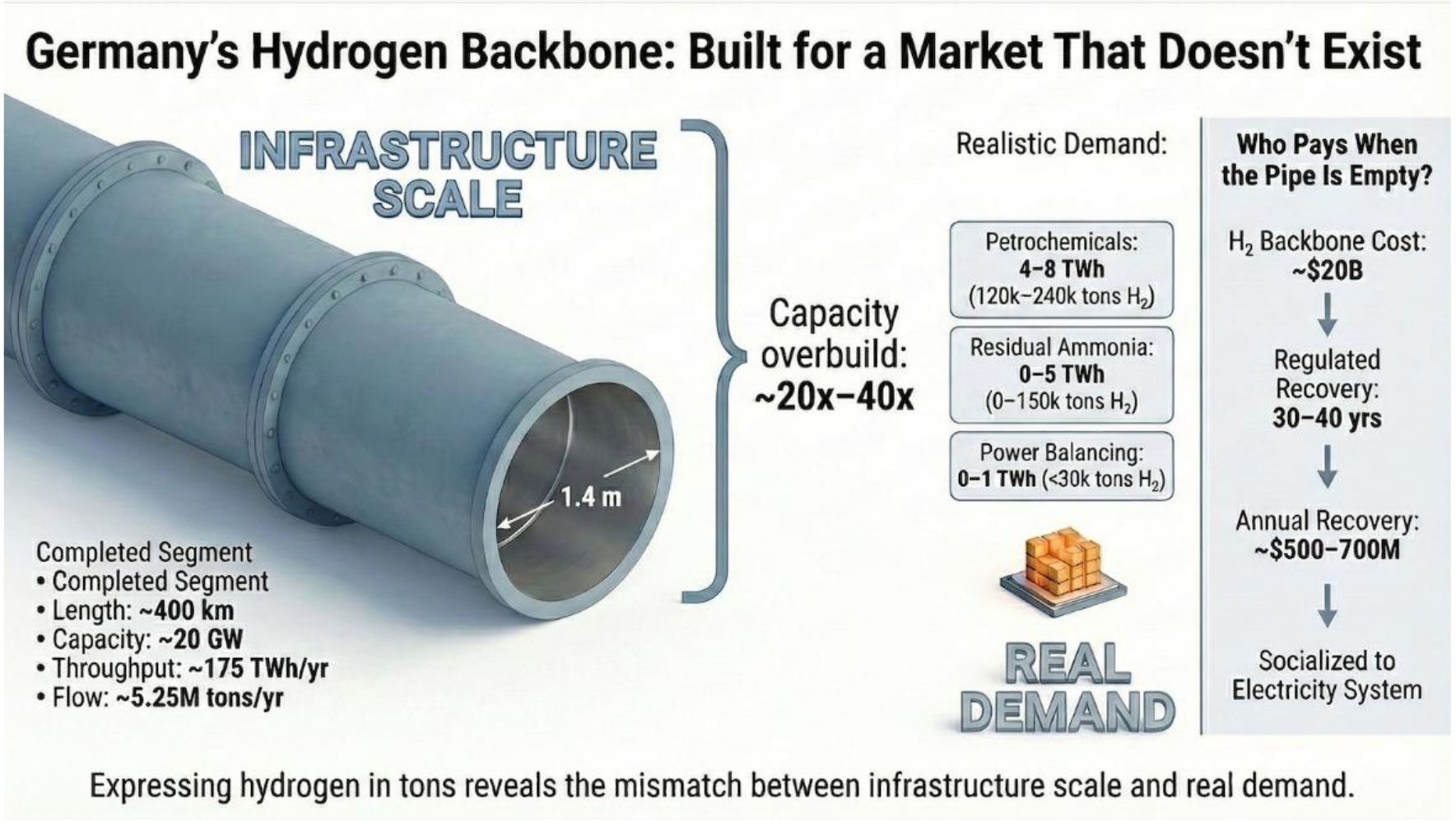
A survey carried out by umlaut among participants in the future hydrogen industry in Germany paints a clear picture. Company representatives agree that sustainably produced hydrogen is unavoidable in the long–term if our energy system is to be transformed in line with the energy transition. The international hydrogen production will fundamentally change dependencies in global energy trade, and support Germany and Europe in meeting their demand for

GasUnie heeft grootse plannen



December 2024,
https://www.h2-tech.com/news/2024/12-2024/gasunie-subsidiary-hynetwork-updates-national-hydrogen-network-roll-out-plan/

Maar, anno 2026: Duitse pijpleiding staat leeg



Google Gemini generated this infographic illustrating the stark mismatch between the massive scale of Germany's planned hydrogen infrastructure and current realistic demand.

400km Hydrogen Pipeline With No Users Will Raise Germany's Electricity Prices

Welke vragen heeft U op dit moment over waterstof?

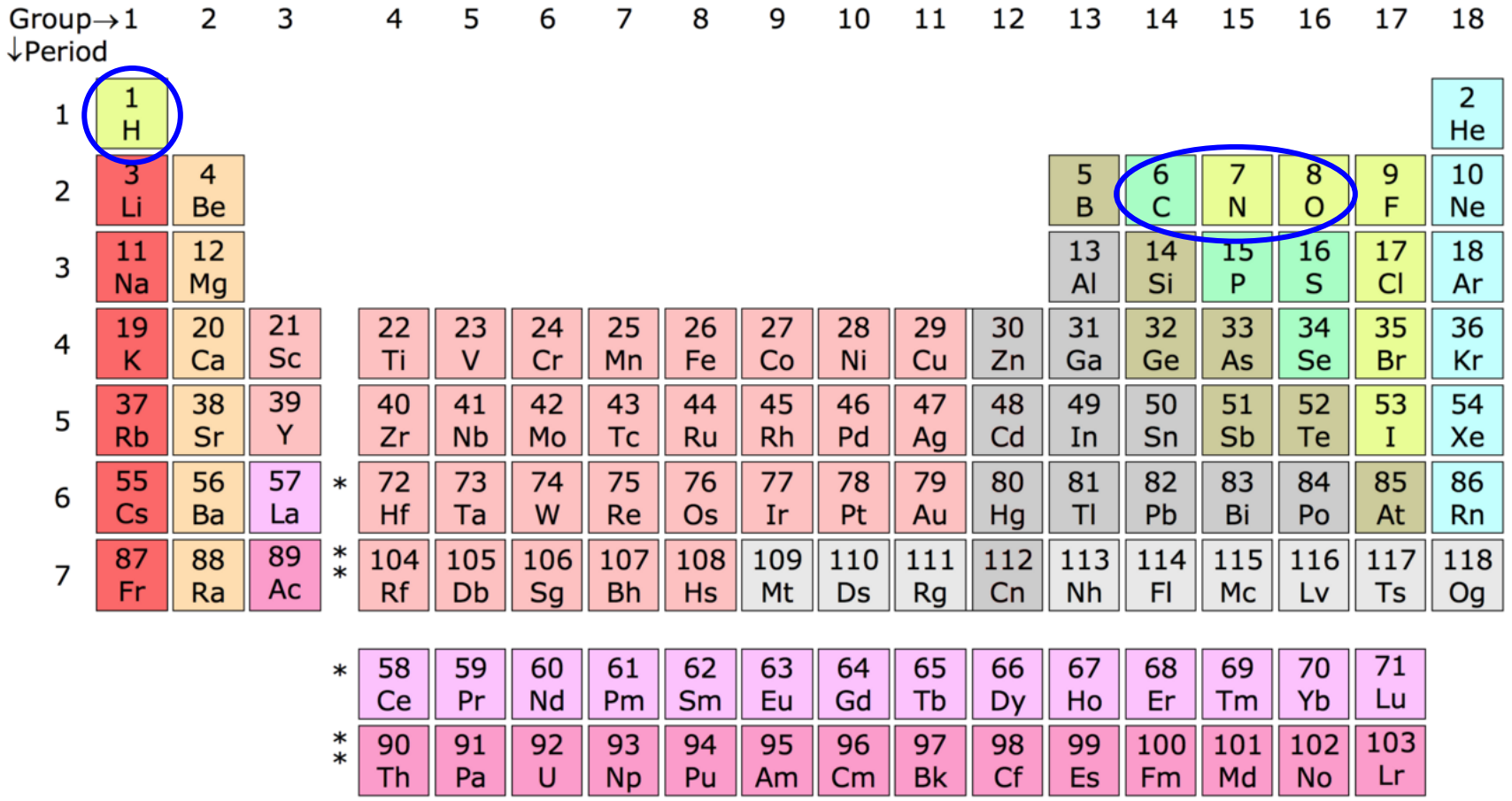
- Schrijf uw vragen op een sticker
- 1 vraag per sticker!
- Hang uw stickers op de flip-over

- Ik ga daarna verder met mijn presentative en zal na afloop deze en andere vragen (proberen te) beantwoorden

Even Opfrissen: Middelbare school scheikunde

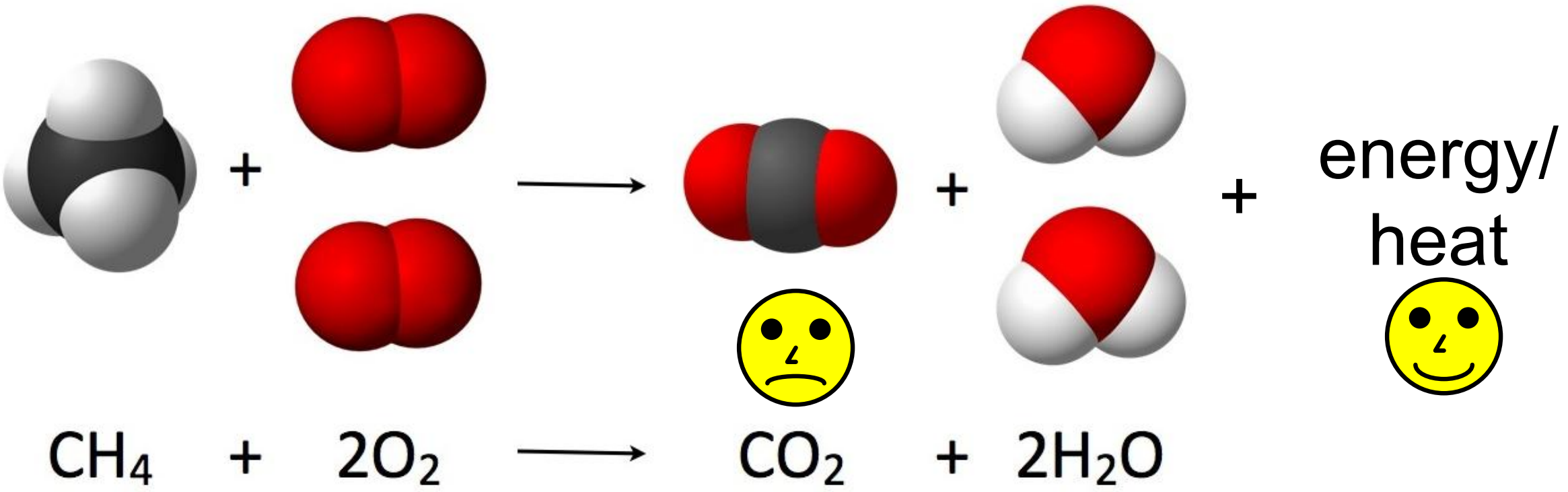
Hoofdrolspelers in het Energiesysteem: 4 elementen

- Waterstof
- Koolstof
- Stikstof
- Zuurstof



from, I added ellipses:
https://upload.wikimedia.org/wikipedia/commons/thumb/9/9d/Periodic_Table_Chart.png/1280px-Periodic_Table_Chart.png

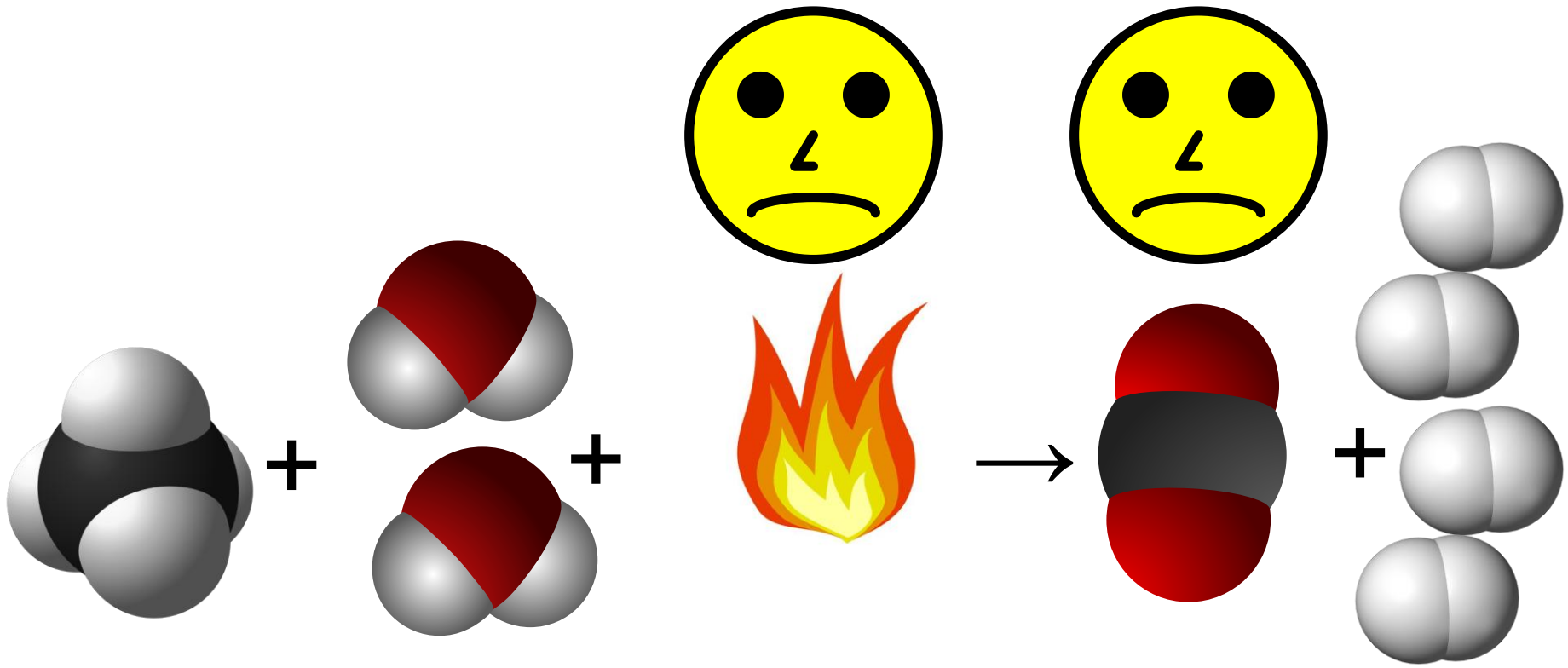
Nu: Het verbranden van aardgas veroorzaakt CO_2



from: https://commons.wikimedia.org/wiki/File:Combustion_reaction_of_methane.jpg I added Smileys and energy/heat.

Grijze waterstof veroorzaakt veel CO_2

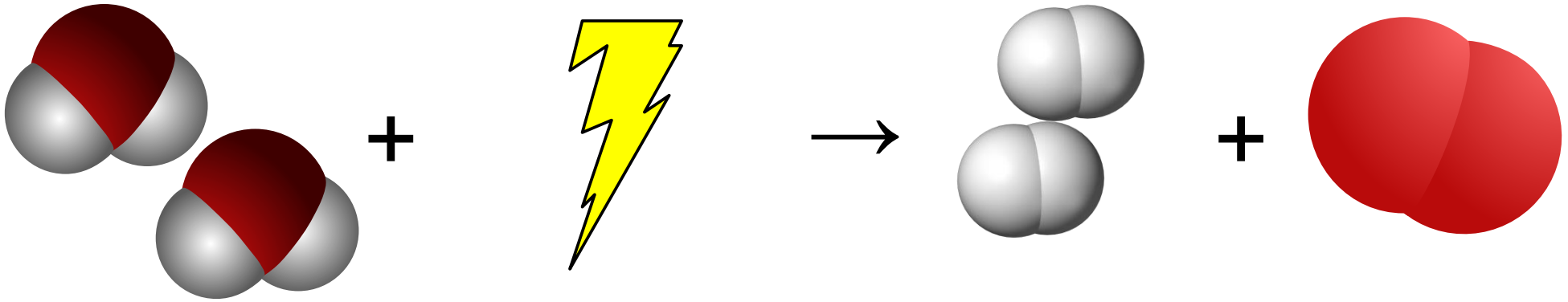
Kunstmestproductie veroorzaakt ook veel CO_2



$$CH_4 + 2\ H_2O + 165\ kJ/mol \rightarrow CO_2 + 4\ H_2$$

https://commons.wikimedia.org/wiki/File:Water_molecule_3D.svg
https://commons.wikimedia.org/wiki/File:Oxygen_molecule.svg
https://commons.wikimedia.org/wiki/File:Carbon-dioxide-3D-vdW.svg
https://commons.wikimedia.org/wiki/File:Methane-3D-space-filling.svg
https://commons.wikimedia.org/wiki/File:Dihydrogen-3D-vdW.png
https://fr.wikisource.org/wiki/Fichier:Fireicon.svg

Productie van **groene waterstof** vraagt **veel electriciteit**



$$2\ H_2O + 286\ kJ/mol \rightarrow 2\ H_2 + O_2$$

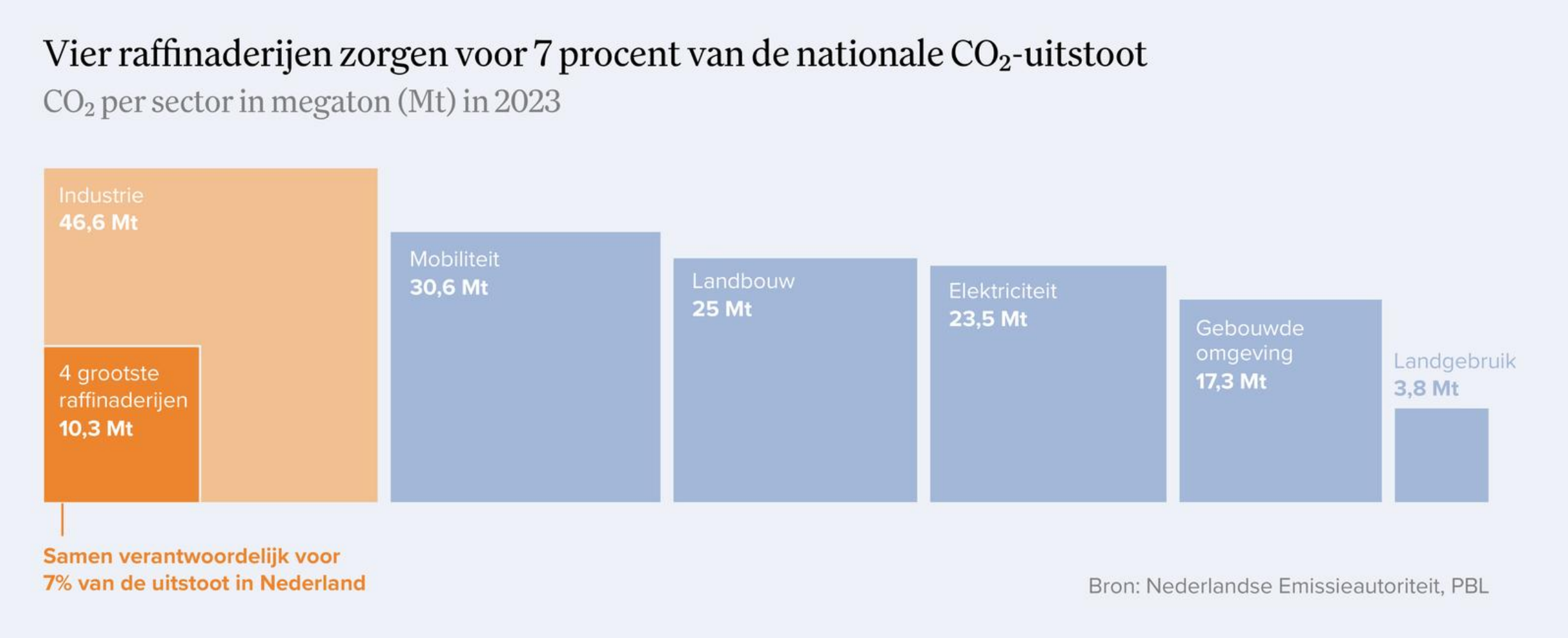
https://commons.wikimedia.org/wiki/File:Water_molecule_3D.svg
https://commons.wikimedia.org/wiki/File:Oxygen_molecule.svg
https://commons.wikimedia.org/wiki/File:Carbon-dioxide-3D-vdW.svg
https://commons.wikimedia.org/wiki/File:Methane-3D-space-filling.svg
https://commons.wikimedia.org/wiki/File:Dihydrogen-3D-vdW.png
https://fr.wikisource.org/wiki/Fichier:Fireicon.svg

Waar is Waterstof goed voor?

toepassingsgebieden

- Procesindustrie
- Water en ruimte verwarming
- Transport
- Lange termijn (seizoens) opslag

CO_2 emissies per sector in Nederland in 2023



Belangrijkste waterstoftoepassingen in procesindustrie

- chemische grondstoffen; raffinaderij, ammoniak, methanol
- staal (hoogovens)
- pulp, papier, voedselverwerking
- glas
- beton

Belangrijkste transport waterstoftoepassingen

- Auto’s
- Scheepvaart over korte afstanden (~250 km)
- Luchtvaart over korte afstanden (~1000 km)
- Lange afstand scheep- en luchtvaart

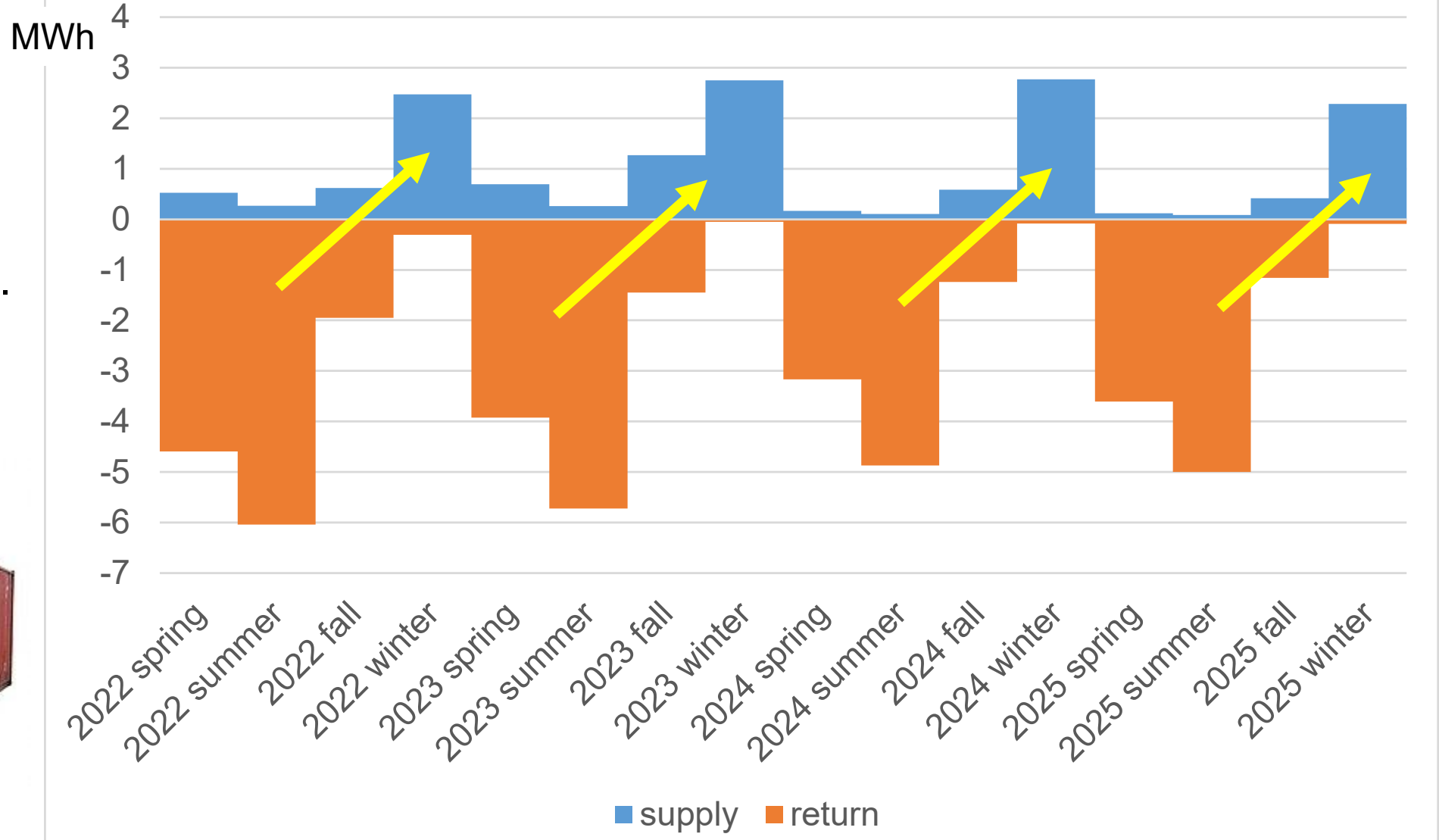
Lange termijn (seizoens) energieopslag
Hoe het zomeroverschot te bewaren voor de winter?

Gerrit's energieverbuik 2022-2025

Dat vraagt om een container vol batterijen.
Kosten: >1 M€
7 * 2.5 * 1.7m
30.000 Kg

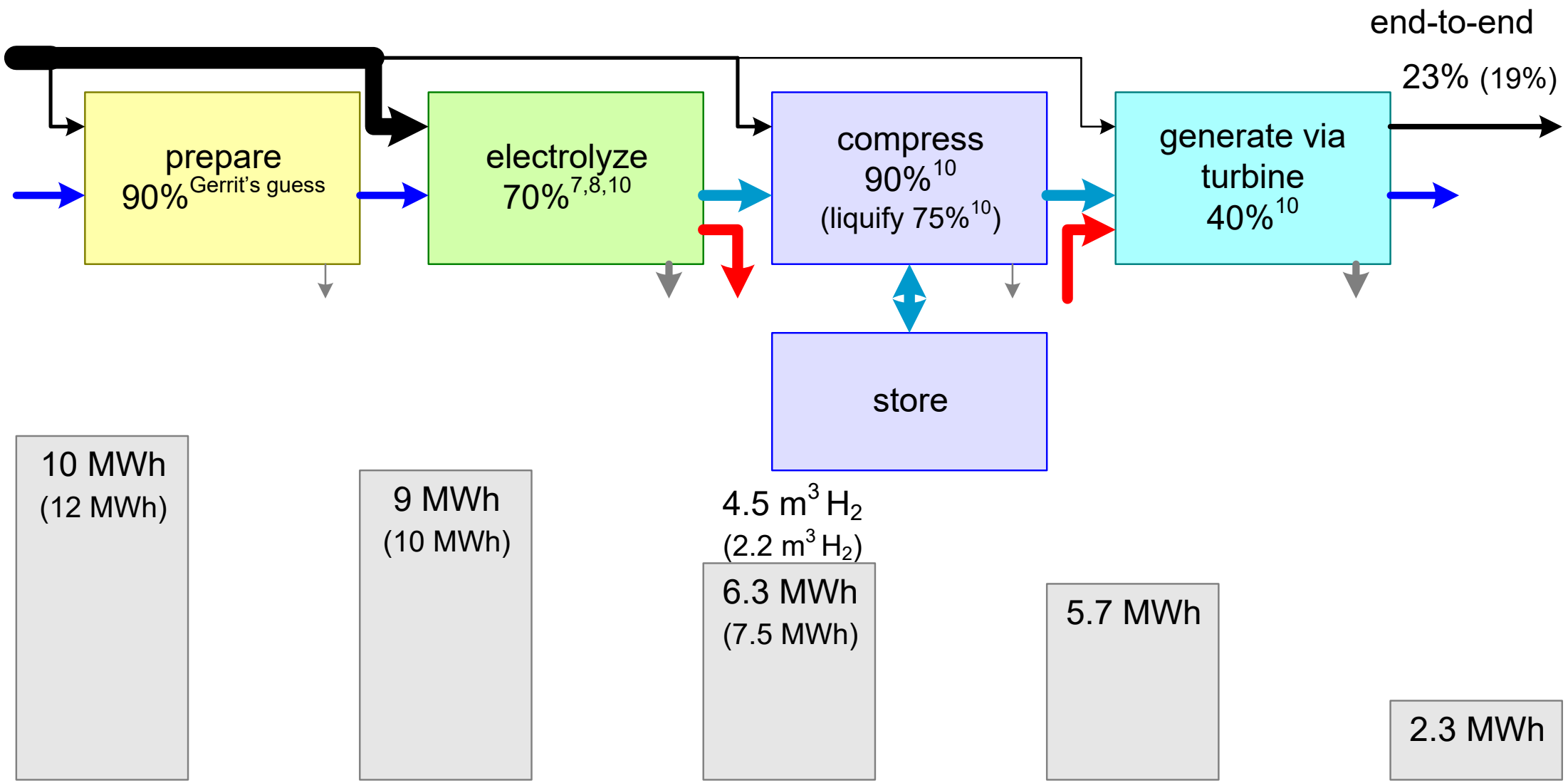


https://en.wikipedia.org/wiki/File:Container_01_KMJ.jpg



Waterstof Techniek

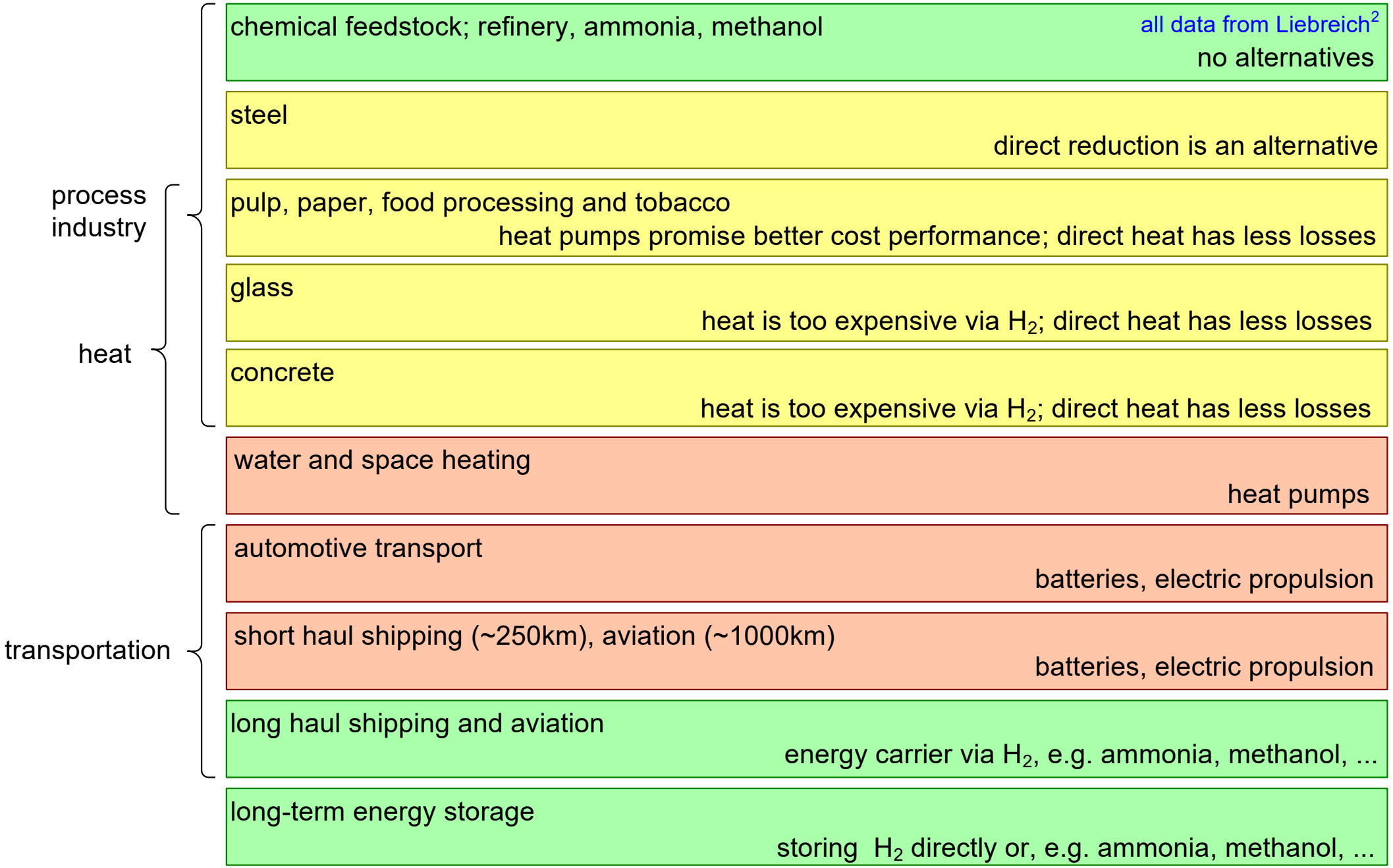
Electriciteit naar electriciteit electrolyse: 23% efficient



Status van de technologie

- De bouwstenen zijn onvolwassen en nog niet op grote schaal beschikbaar
- Electrolyse is duur
  - Daarom wil je dat graag continu of vaak draaien
- Electrolyse productie is niet snel aan en uit te schakelen (het moet eerst warm worden)
  - Daarom wil je graag langdurig draaien
- Continu en langdurig draaien maakt het moeilijk om alleen te draaien bij heel lage of negative stroomprijzen
- Waterstof turbines zijn er nog niet of nauwelijks

Wat kunnen we met
de waterstof technologie
van vandaag en de nabije toekomst?


process industry
heat
transportation
chemical feedstock; refinery, ammonia, methanol
all data from Liebreich[2]
no alternatives
steel
direct reduction is an alternative
pulp, paper, food processing and tobacco
heat pumps promise better cost performance; direct heat has less losses
glass
heat is too expensive via H_2; direct heat has less losses
concrete
heat is too expensive via H_2; direct heat has less losses
water and space heating
heat pumps
automotive transport
batteries, electric propulsion
short haul shipping (~250km), aviation (~1000km)
batteries, electric propulsion
long haul shipping and aviation
energy carrier via H_2, e.g. ammonia, methanol, ...
long-term energy storage
storing H_2 directly or, e.g. ammonia, methanol, ...

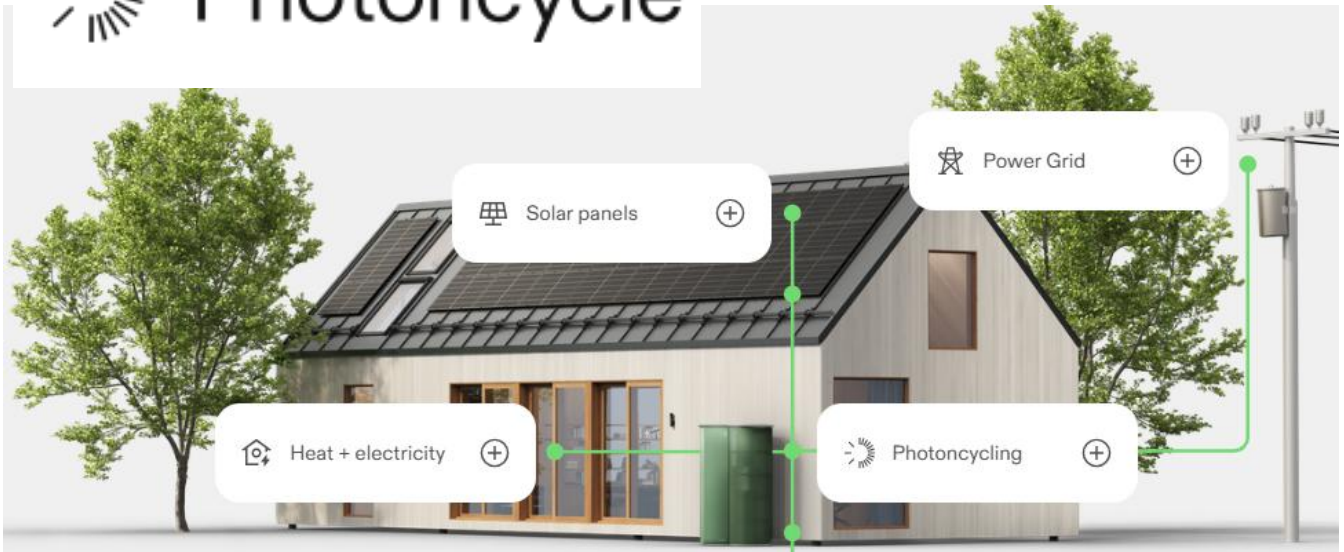
Toekomstige ontwikkelingen

high temperature (750°C) electrolyser, 90%

https://www.solar365.nl/nieuws/bollenbedrijf-zet-overschot-zonnestroom-om-in-waterstof--67A6ACB4.html

https://www.photoncycle.com

Photoncycle



10 MWh
solid-state hydrogen
energy storage

provides hot water,
heat and electricty
subsciption model

HOLTHAUSEN
ENERGY POINTS

Local Hydrogen production using
low cost electricity

https://www.energypoints.nl

https://www.rvo.nl/praktijkverhalen/pionieren-met-betaalbare-waterstofproductie

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https://about.bnef.com/insights/clean-energy/liebreich-separating-hype-from-hydrogen-part-one-the-supply-side/
[2] Liebreich: Separating Hype from Hydrogen – Part Two: The Demand Side, 2020, BloombergNEF,
https://about.bnef.com/insights/clean-energy/liebreich-separating-hype-from-hydrogen-part-two-the-demand-side/
[3] Wikipedia Energy Density https://en.wikipedia.org/wiki/Energy_density
[4] Energy Education, energy density https://www.energyeducation.ca/encyclopedia/Energy_density
[5] Wikipedia Waterstofopslag https://nl.wikipedia.org/wiki/Waterstofopslag
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http://www.iea.org/textbase/nppdf/free/2005/hydrogen2005.pdf
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https://iea.blob.core.windows.net/assets/89c1e382-dc59-46ca-aa47-9f7d41531ab5/GlobalHydrogenReview2024.pdf
[8] Advancements in electrolyser stack performance: A comprehensive review of Latest technologies and efficiency strategies https://www.sciencedirect.com/science/article/pii/S0360319925016635
[9] Fuel Cell Efficiency 2014
https://www.sciencedirect.com/topics/engineering/fuel-cell-efficiency **AI summary?** https://parkingday.org/how-efficient-are-hydrogen-fuel-cells/ confirms 70% for alkaline fuel cells
[10] Power-to-Hydrogen-to-Power: Technology, Efficiency, and Applications, 2025
https://www.oxfordenergy.org/wpcms/wp-content/uploads/2025/07/ET48-Power-to-Hydrogen-to-Power.pdf
[11] From Optimistic Models To Empty Pipelines: The Intellectual History Of Germany's
[12] Steam reforming https://en.wikipedia.org/wiki/Steam_reforming
[13] Electrolysis of water https://en.wikipedia.org/wiki/Electrolysis_of_water
[14] Hydrogen Backbone https://cleantechnica.com/2026/01/24/from-optimistic-models-to-empty-pipelines-the-intellectual-history-of-germanys-hydrogen-backbone/
[15] 400km Hydrogen Pipeline With No Users Will Raise Germany's Electricity Prices
https://cleantechnica.com/2026/01/11/400km-hydrogen-pipeline-with-no-users-will-raise-germanys-electricity-prices/
[16] Wienert, P., Stöver, P., Wiener, P., Schreiber, T., Jensen, B., Hydrogen— study Opportunities, potentials & challenges in the global energy system. Umlaut energy GmbH in cooperation with KONGSTEIN GmbH, July 2021
[17] De vervuiler verzaakt. Door deze vier fabrieken raken de klimaatdoelen uit zicht
https://decorrespondent.nl/16033/de-vervuiler-verzaakt-door-deze-vier-fabrieken-raken-de-klimaatdoelen-uit-zicht/11aafe8a-69c6-0c7d-1cc7-0e13f8c1594b