SARDIGNA CHIRCAS
SARDEGNA RICERCHE

PIATTAFORMA
ENERGIE
RINNOVABILI

"L'ACQUA PER LA PRODUZIONE DI IDROGENO VERDE: OPPORTUNITÀ O LIMITE?"

14 luglio 2023

"L' impronta idrica della produzione di idrogeno elettrolitico su larga scala"

Natalia Pierozzi, RINA

UNIONE EUROPEA
Fondo europeo di sviluppo regionale
REPUBBLICA ITALIANA
REGIONE AUTÒNOMA DE SARDIGNA
REGIONE AUTONOMA DELLA SARDEGNA
POR FESR
SARDEGNA 2014-2020

RINA

5.300
colleagues

200
offices

70
countries

Our People

More than **90 nationalities**

70%+
educated to degree level

43
average age

Who we are

Marine

Rules, technologies and innovative services to manage transport and pleasure vessels

Certification

Solutions to support products, people and processes on their way to excellence

Real Estate & Infrastructures

The path to the next generation of infrastructure and buildings by ensuring their safety and efficiency

Energy & Mobility

Energy solutions from O&G to renewables, taking care of sustainability and environmental impacts

Industry

Materials, Industry 4.0, innovation & research, Space & Defence, Cyber Security

Energy transition & Decarbonization

Our Decarbonization key factors

R&D and Technology Scouting

Various projects on H_2 and CO_2
Best Innovation Award by FCH JU

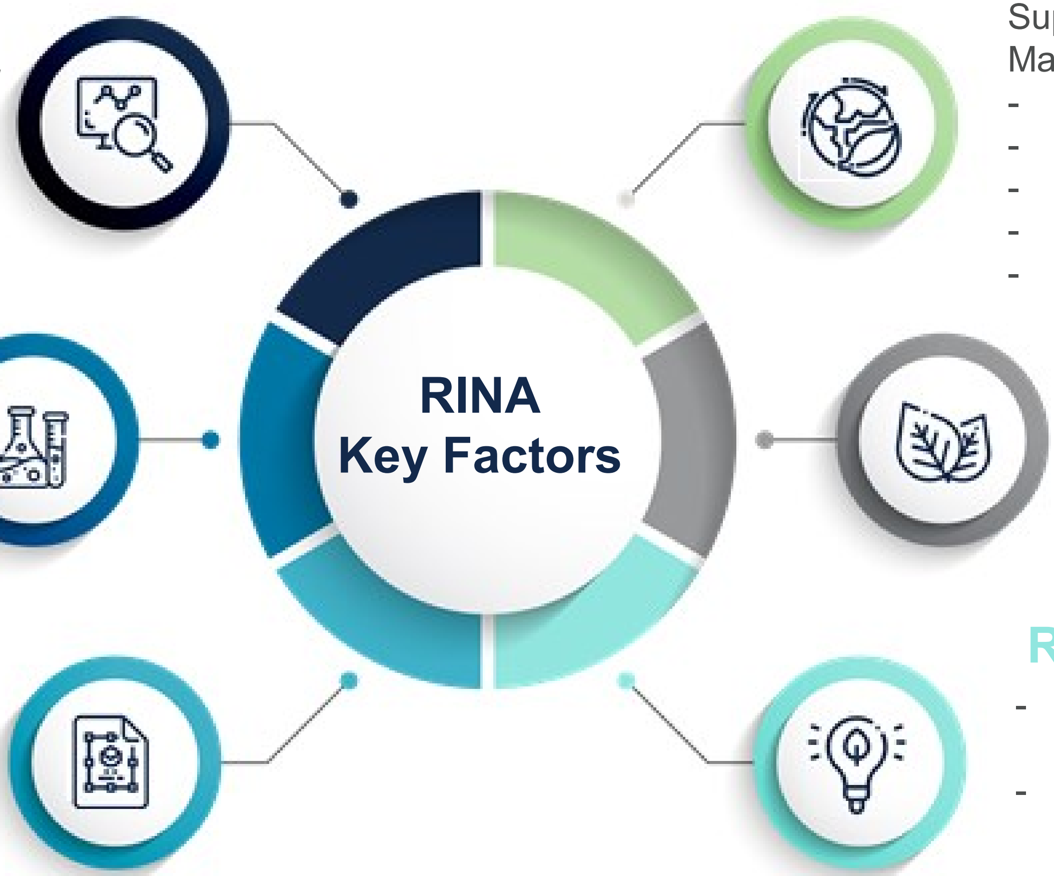
Certification Market Leader With Own Laboratories & Facilities

- ΔH Laboratory
- Combustion Laboratory
- Full Scale Testing capabilities for H_2 and CO_2

On & Off-shore Assets

Implement a technology transfer aimed at overcome the Hydrogen and CCUS challenges:

- HSE
- Project Management Consulting
- Asset Integrity
- Repurposing assessment for transport and storage



Multisector Green Economy

Supporting the supply chain in different Markets:

- Maritime
- Hard to Abate
- Renewables
- Industry
- Banks & Insurers
- Rail & Road Transport
- Multi-utilities
- IFIs
- Infrastructure

Global footprint

Global presence mainly linked to Marine & Energy sectors
70+ Countries

Renewables

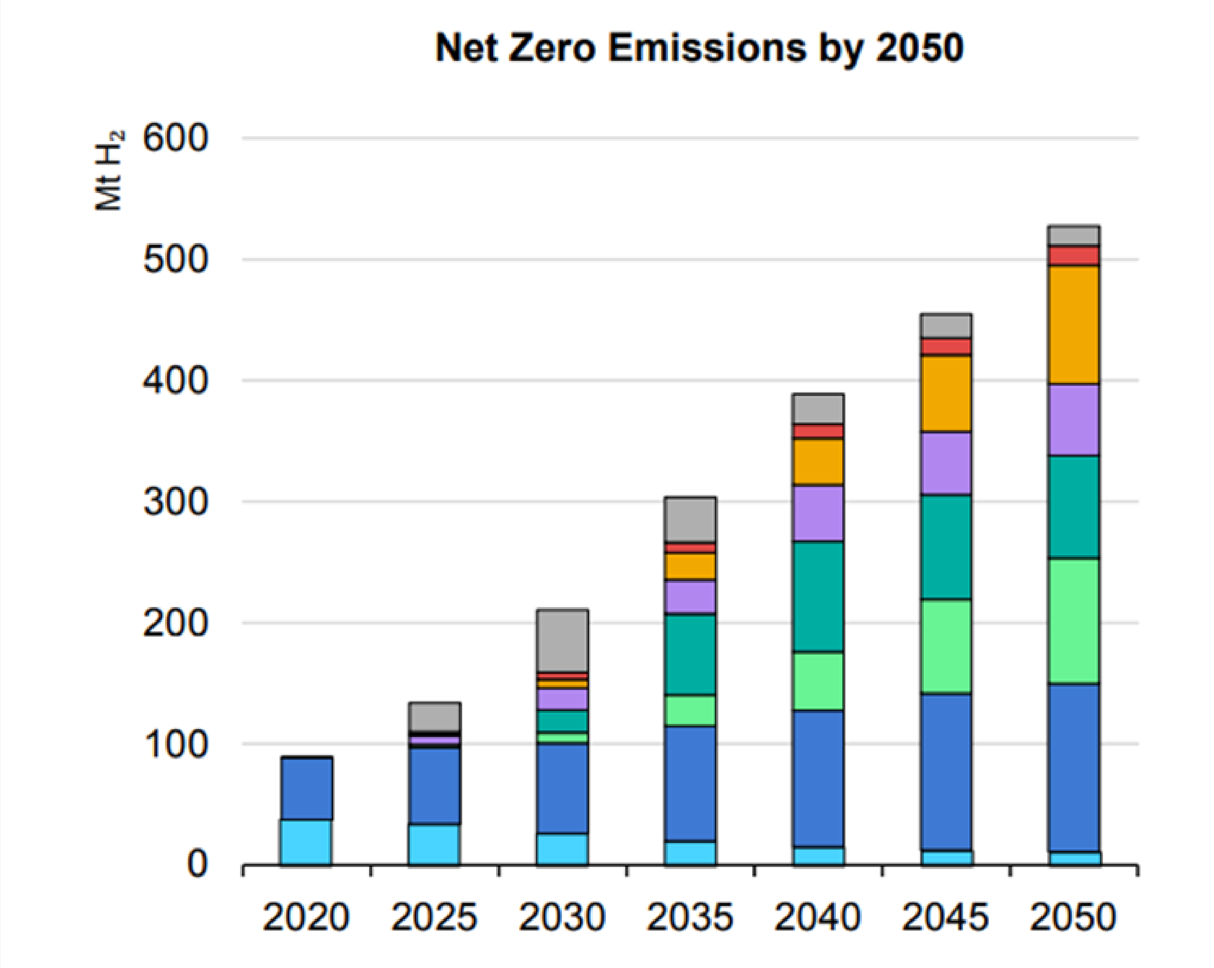
- 20+ Environmental, permitting and biodiversity studies
- 1,350 MW Grid connection support for offshore wind energy in Europe and Asia
- Electrical design for a 476 MW offshore wind farm
- Solar & Smart Grid advisory
- Power to X

Hydrogen overview and outlook
Demand on a global scale

Source: Global Hydrogen Review - 2021 IEA

Global Hydrogen Demand according to IEA's Net Zero Emission Scenario

2030: 200 Milion tons (2X 2020)
2040: 400 Milion tons (2X 2030)
2050: 520 Milion tons (1,3X 2040)



Hydrogen overview and outlook
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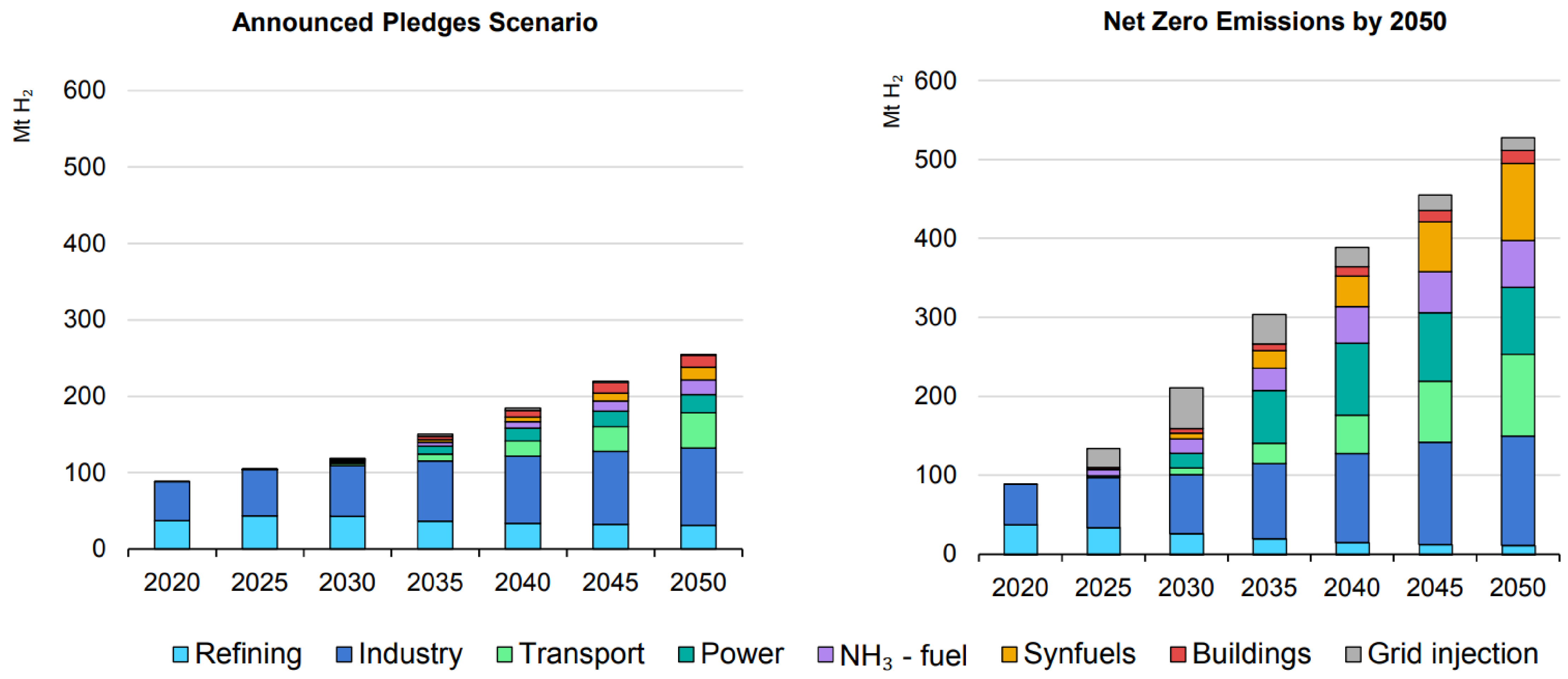
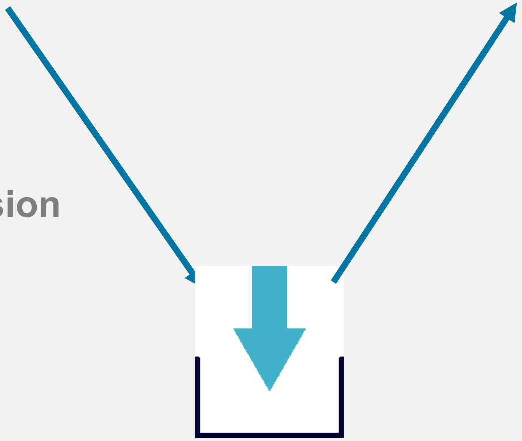


Why hydrogen?

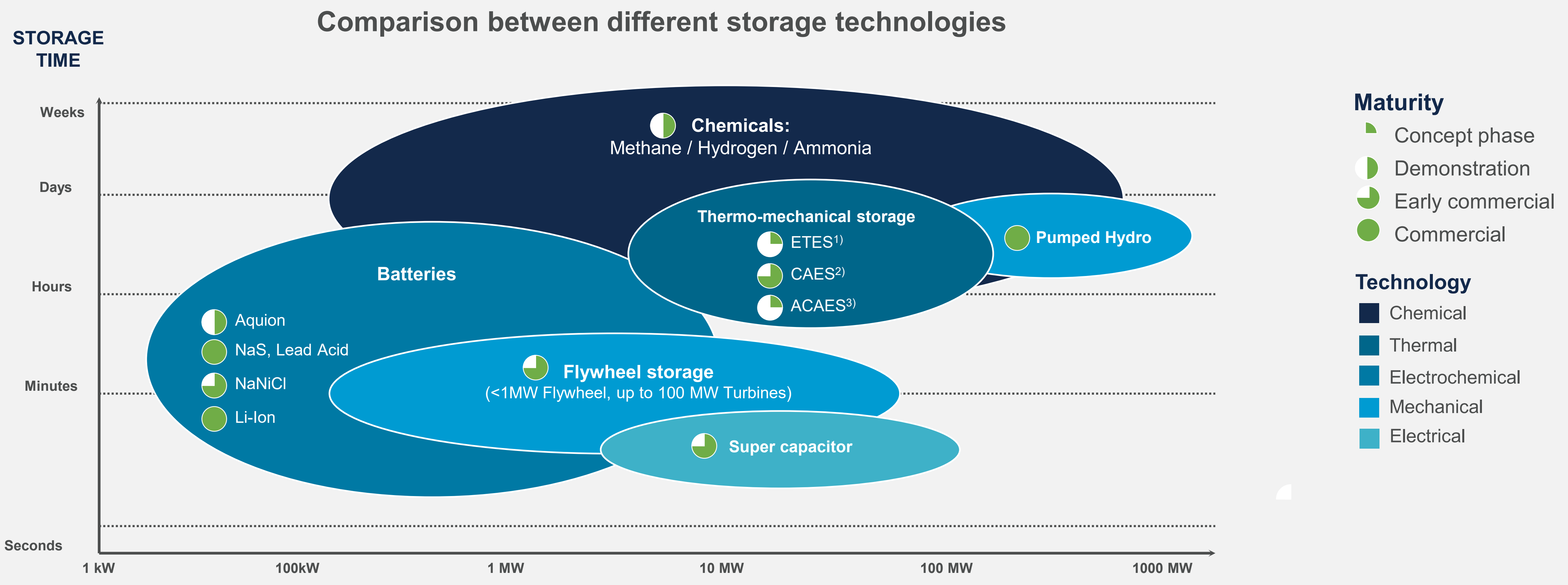
Decarbonizing the energy value chain



*An **energy vector** allows to transfer, in **space** and **time**, a quantity of energy* ”

- Fossil fuels
- Electricity
- Hydrogen
- Biol & Syn Fuels

Energy storage
Comparing different technologies and means



[1] Electro-Thermal Energy Storage [2] Compressed Air Energy Storage [3] Adiabatic Compressed Air Energy Storage

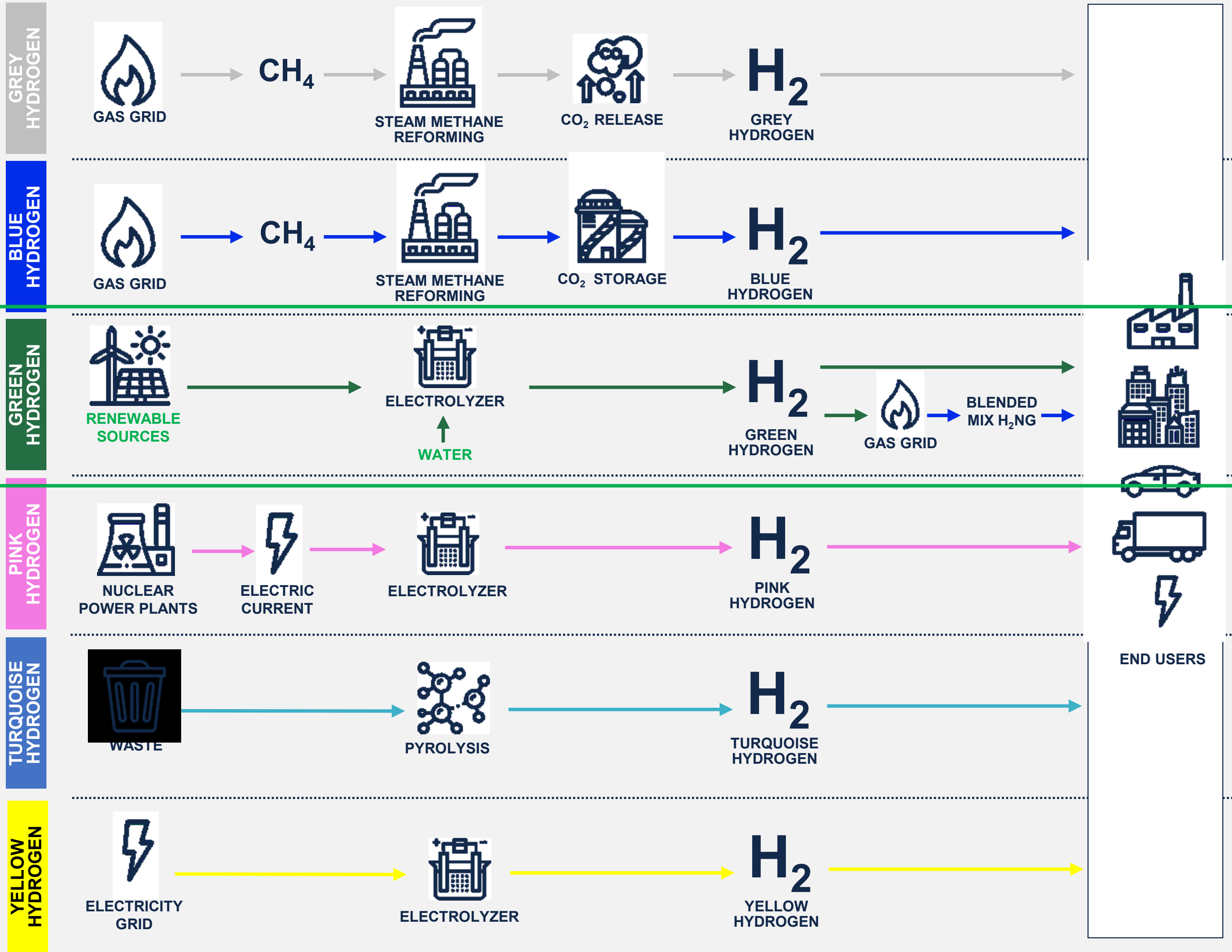
Source: U.S. Department of Energy Fuel Cell Technologies Office

Shades of Hydrogen

How to produce

Inspired by Global Energy Infrastructure (GEI) 2021
DIRECT: emissions for H2 production process
INDIRECT: emissions by feedstock and energy supply chains

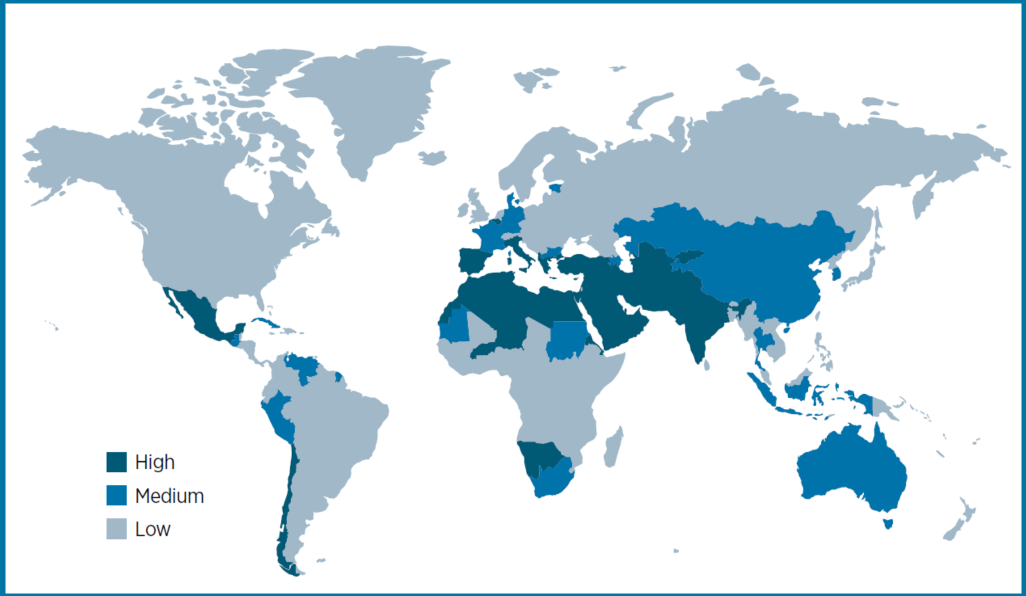
Hydrogen Council (2021) and Energy Transition Commission (2021)



Grey hydrogen	9,5 – 15 Kg CO_2/Kg H_2 DIRECT: 9 – 11 INDIRECT: 0,5 – 4	2020: 0,7 - 2,1 USD/kg 2030: 0,8 – 2,1 USD/kg
Blue hydrogen	1 – 11 kg CO_2/Kg H_2 DIRECT: 0,5 - 4 INDIRECT: 0,5 - 7	2020: 1,6 – 2,6 USD/kg 2030: 1 – 2,1USD/kg
Green hydrogen	> 0 kg CO_2/Kg H_2 DIRECT: 0 INDIRECT: >0	2020: 3,2 – 5,3 USD/kg 2030: 1,8 – 2,7 USD/kg
Pink hydrogen	> 0 kg CO_2/Kg H_2 DIRECT: 0 INDIRECT: >0	NA
Turquoise hydrogen	NA	NA
Yellow hydrogen	< 1 – 30 kg CO_2/Kg H_2 DIRECT: 0 INDIRECT: <1 – 30 depending on the grid mix	NA

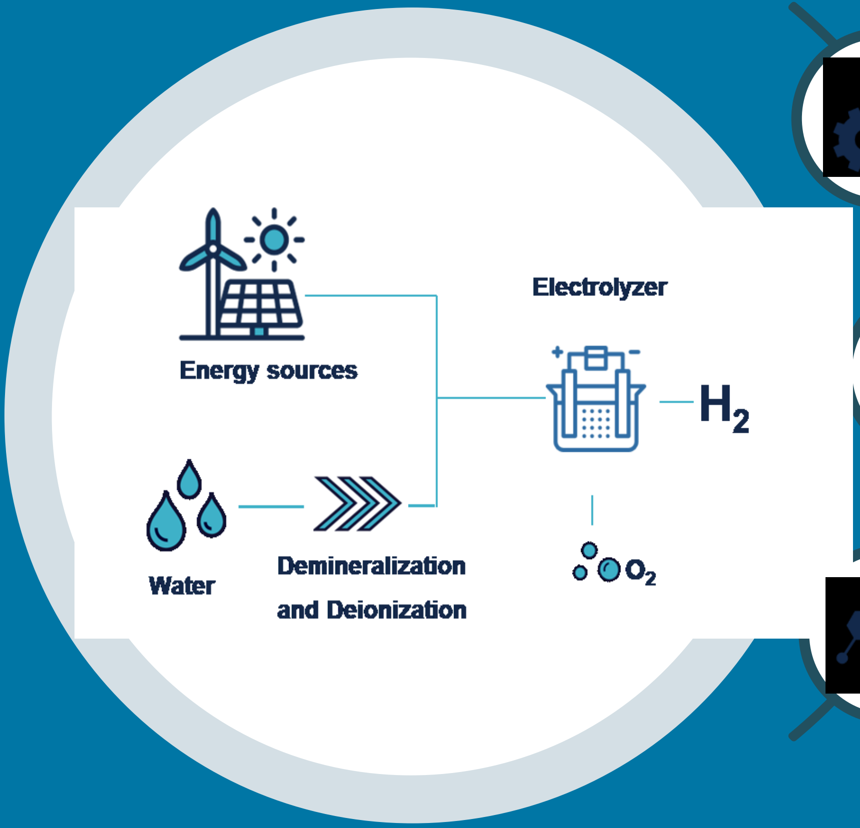
Water sustainability of green hydrogen production

DEMAND:
Water use across the whole green hydrogen production life cycle



OFFER:
Water scarcity in the region of plant installation

Water use of green hydrogen production over the life cycle

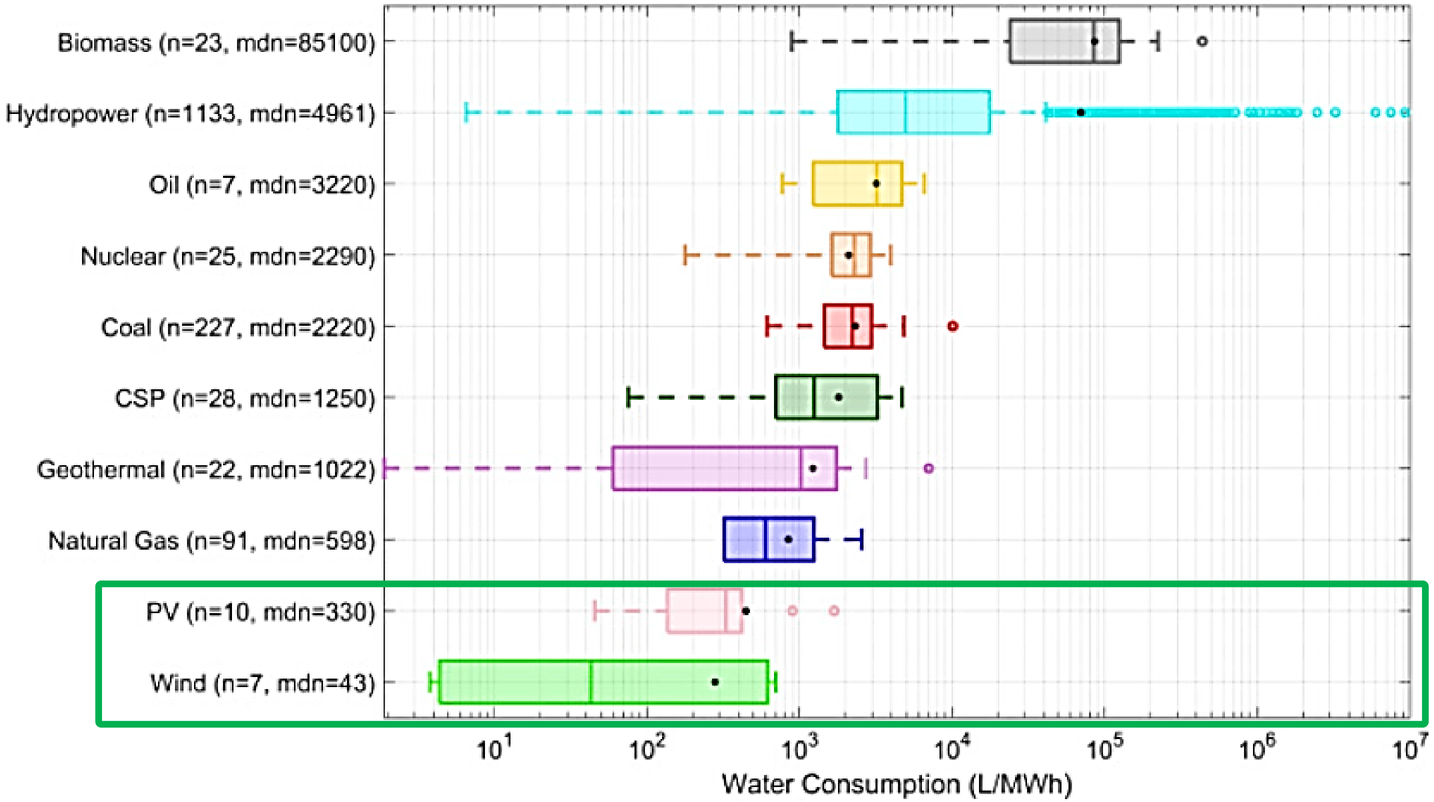


PLANT INFRASTRUCTURE:
manufacturing of the components

ENERGY SOURCE:
Electricity production needs water

ELECTROLYZER OPERATION:
Water for splitting and cooling

Water use of the energy source



Green hydrogen is generated by renewable electricity

Source: Yi Jin at al. Water use of electricity technologies: A global meta-analysis. 2019

Renewable electricity production requires water.

Photovoltaics and wind power consume relatively little water, when compared to biomass, hydropower or fossil fuels:

- 43 l/MWh for wind (median value) - water needed for manufacturing the materials of the plant
- 330 l/MWh for PV (median value) - water needed for mirrors washing and manufacturing the materials of the plant

Water use for water splitting

$$2\,H_2O \rightarrow 2H_2 + O_2$$

Water for 1 kg of hydrogen – stechiometric value	**9 l/kg** of hydrogen
De-ionized water for 1 kg of hydrogen	**10 - 11 l/kg** of hydrogen
Tap water for 1 kg of hydrogen	**20 - 25 l/kg** of hydrogen
water purity required	99.8% to 99.9998%

Electrolyzers need high quality water which requires treatment.
A low quality water can lead to faster degradation and shorter lifetime.

Water use based on different electricity sources

ELECTRICITY SOURCE

WIND

- Wind water consumption = 43 l/MWh = **2,4 kg H20/kgH2**

PV

- PV water consumption = 330 l/MWh = **18,2 kg H20/kgH2**

Natural Gas

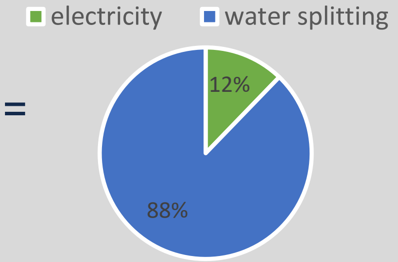
- NG water consumption = 598 l/MWh = **32,9 kg H20/kgH2**

WATER SPLITTING

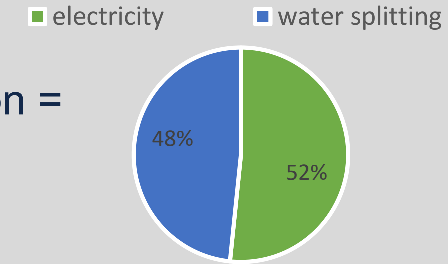
- Electrolyzer efficiency = 55 KWh/Kg H2
- Water for electrolysis = **17 kg H20/kgH2**

ELECTRICITY + WATER SPLITTING

- Total water consumption = **19,4 kg H20/kgH2**



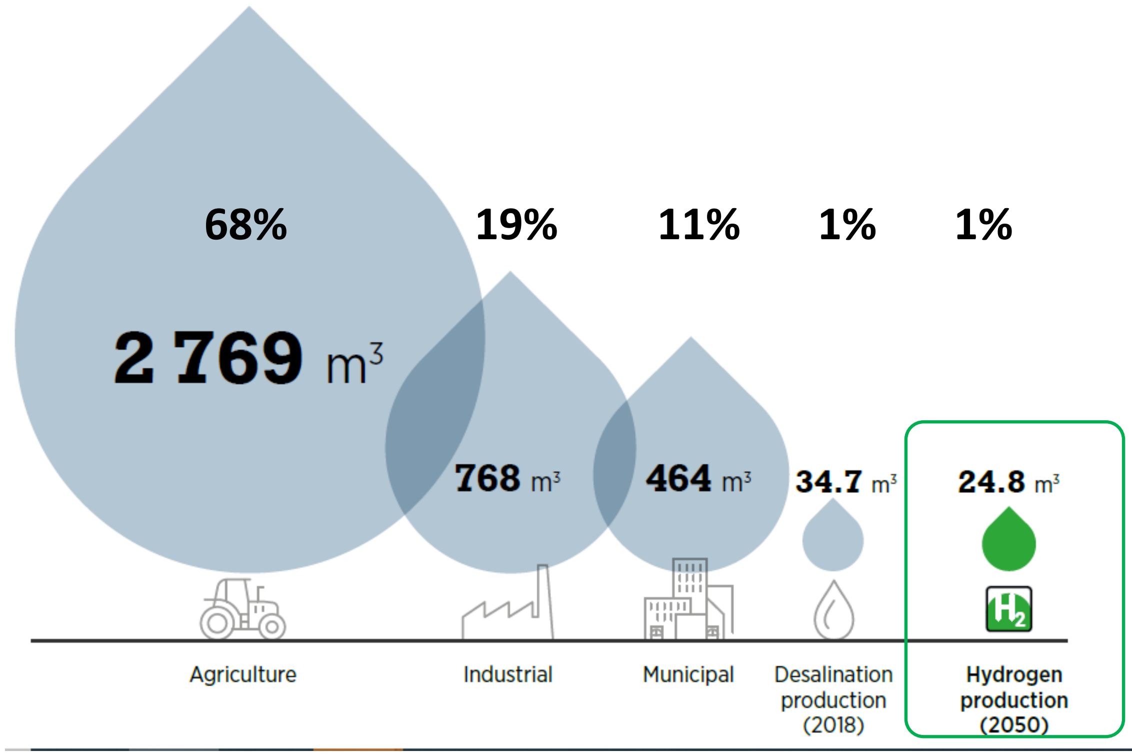
- Total water consumption = **35,2 kg H20/kgH2**



How much water is needed to produce the expected amount of H2?

IRENA World Energy Transitions Outlook 2021:
In the 1.5°C Scenario, by 2050, there will be a demand for **409 million tonnes** of green hydrogen. They will require around **7 – 9 billion cubic meters (m3) of water** a year – less than 0.25% of current freshwater consumption.
Only water for electrolytic splitting is considered

Water consumption of hydrogen in 2050 compared with selected sectors today (billion cubic meters)



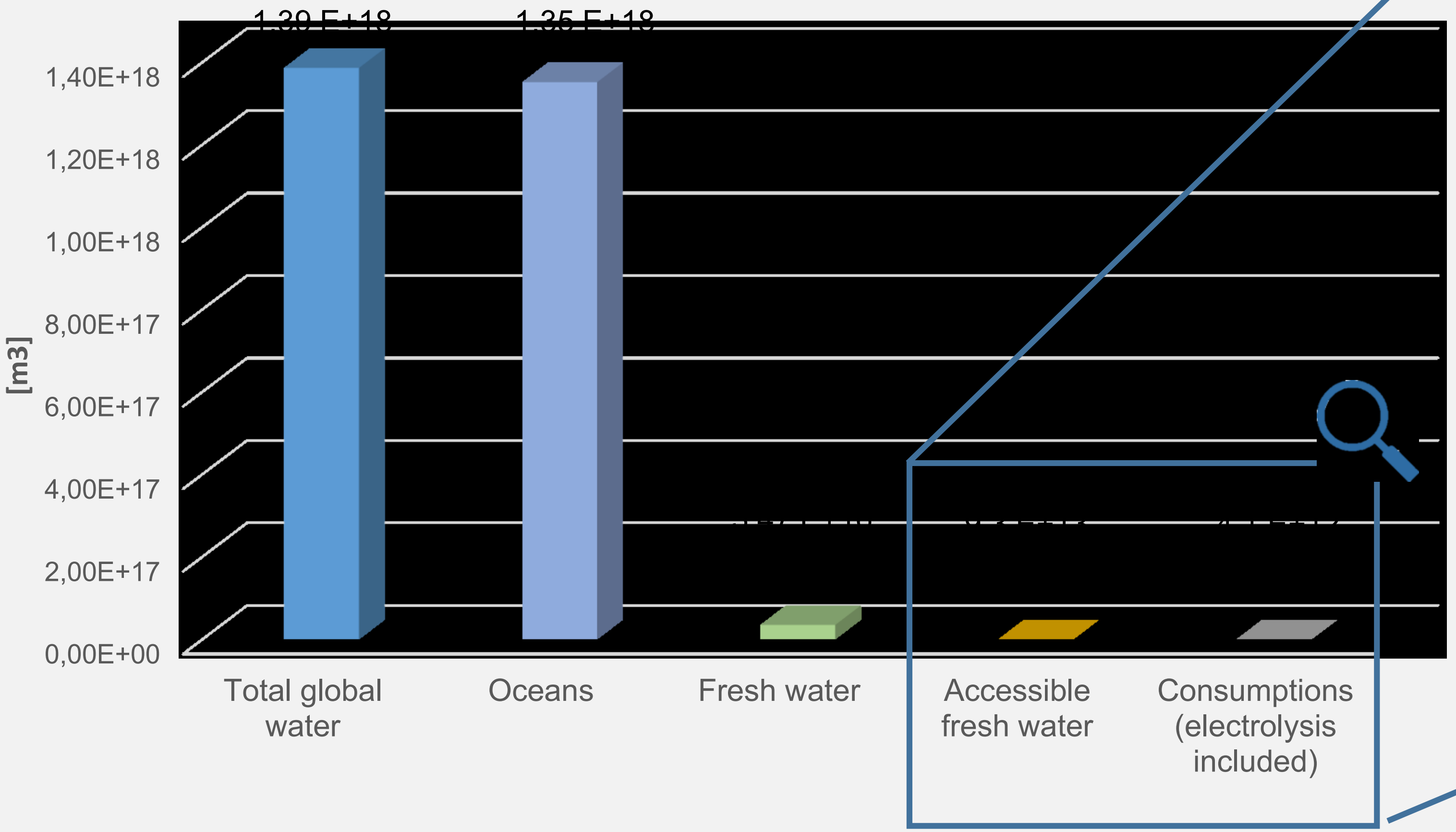
Overestimated Assumption: all hydrogen in 2050 is green

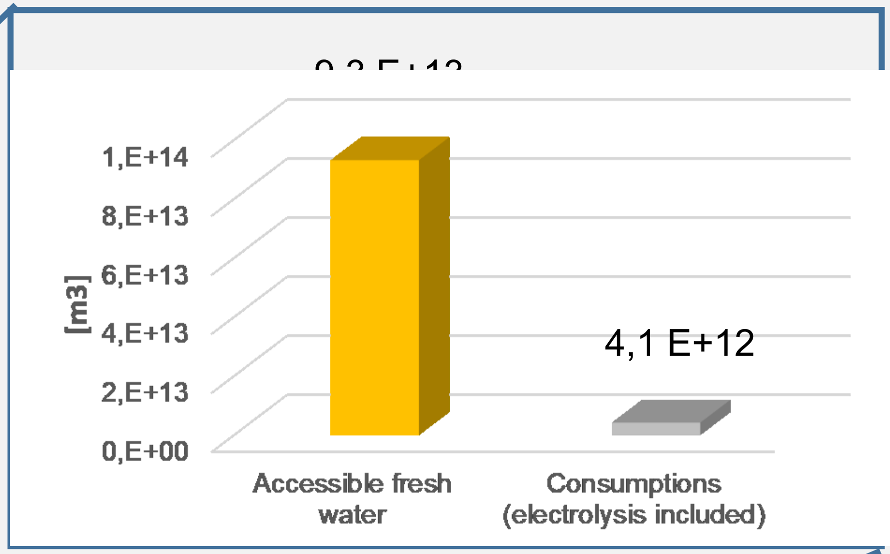
Source: IRENA 2022 Geopolitics of the Energy Transformation The Hydrogen Factor

Do we have enough water to satisfy the expected amount of H2?

The volume of all the water on earth is 1.386 billion km3 = 1.386 *10^18 m3 (vs 7-9*10^9 for electrolysis @2050

- 96,5% oceans
- 2,5% fresh water



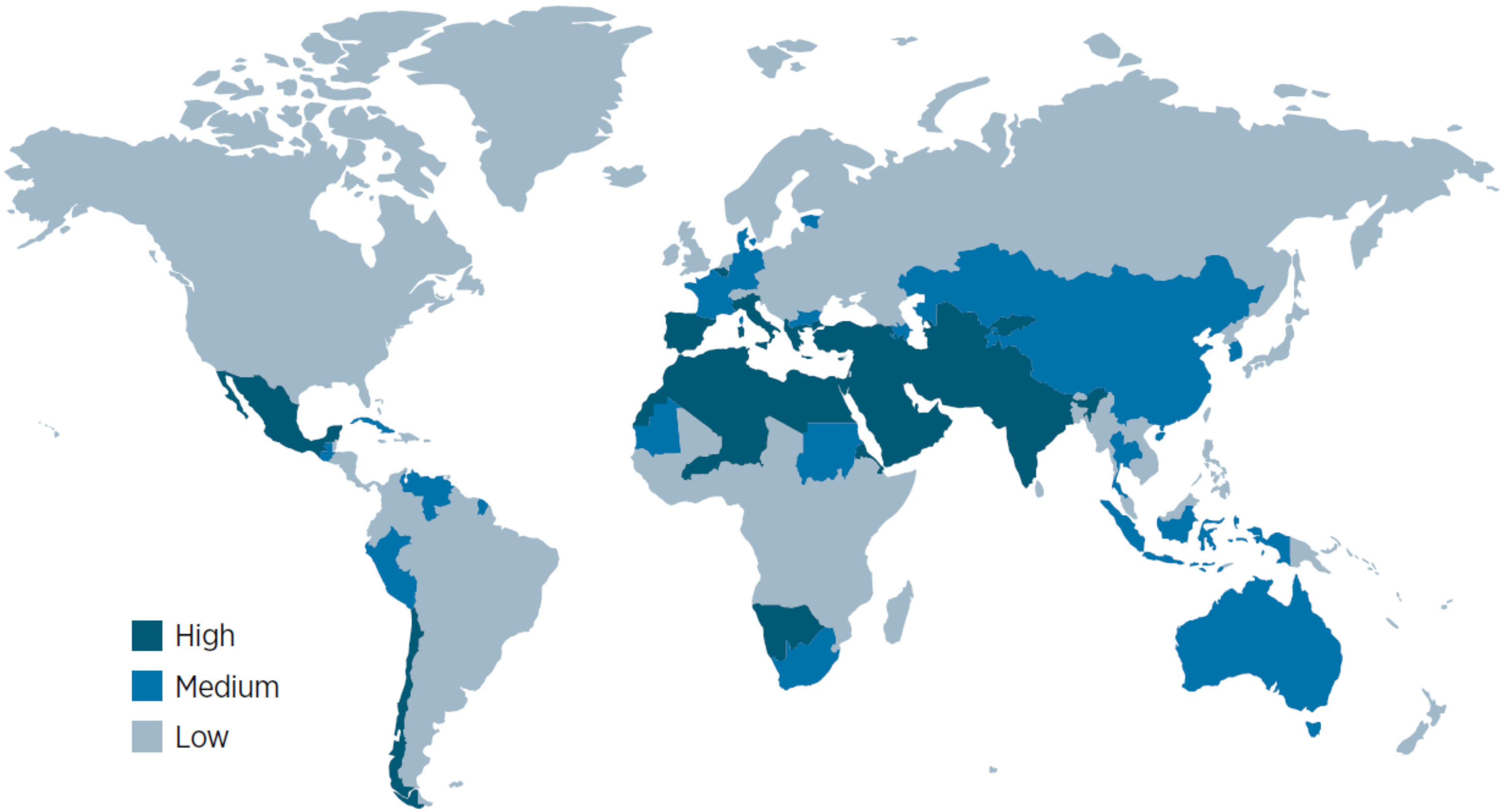


There is no water shortage globally.
What about locally?

Potential hydrogen projects map

Hydrogen production costs from hybrid solar PV and wind systems for a minimum load of 40%, 2030. *IEA Global Hydrogen review 2022*

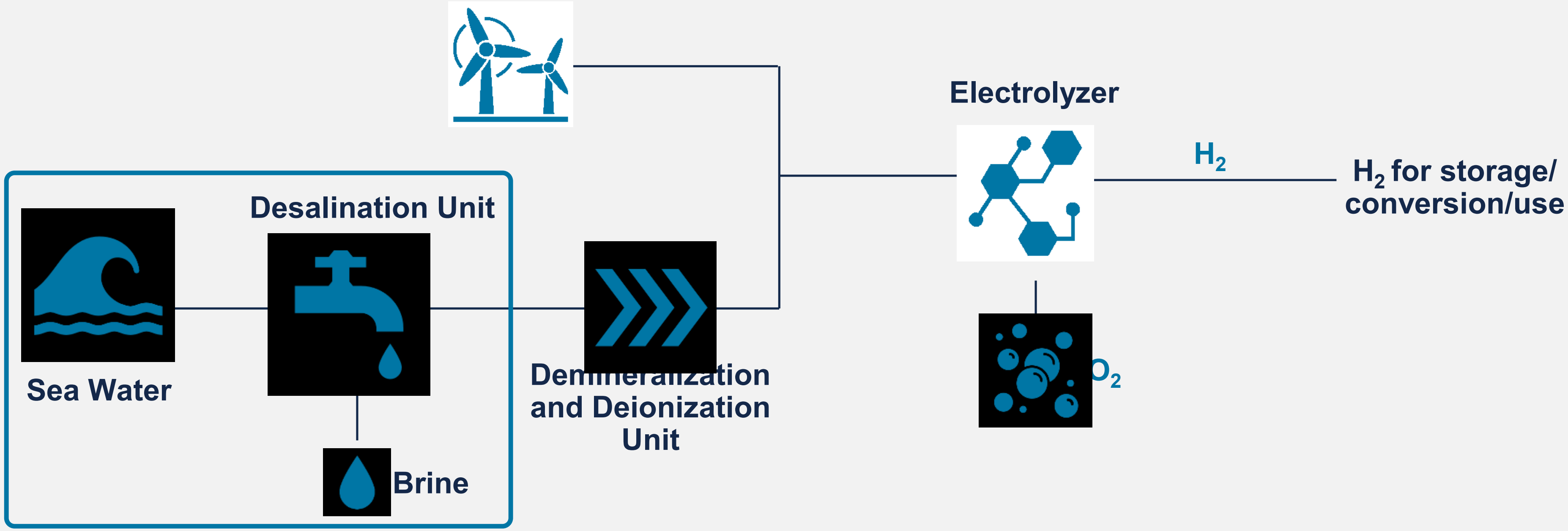
Heat map of water stress level



Source: IRENA 2022.Geopolitics of the Energy TransformationBased on Rystad Energy RenewableCube (2021)

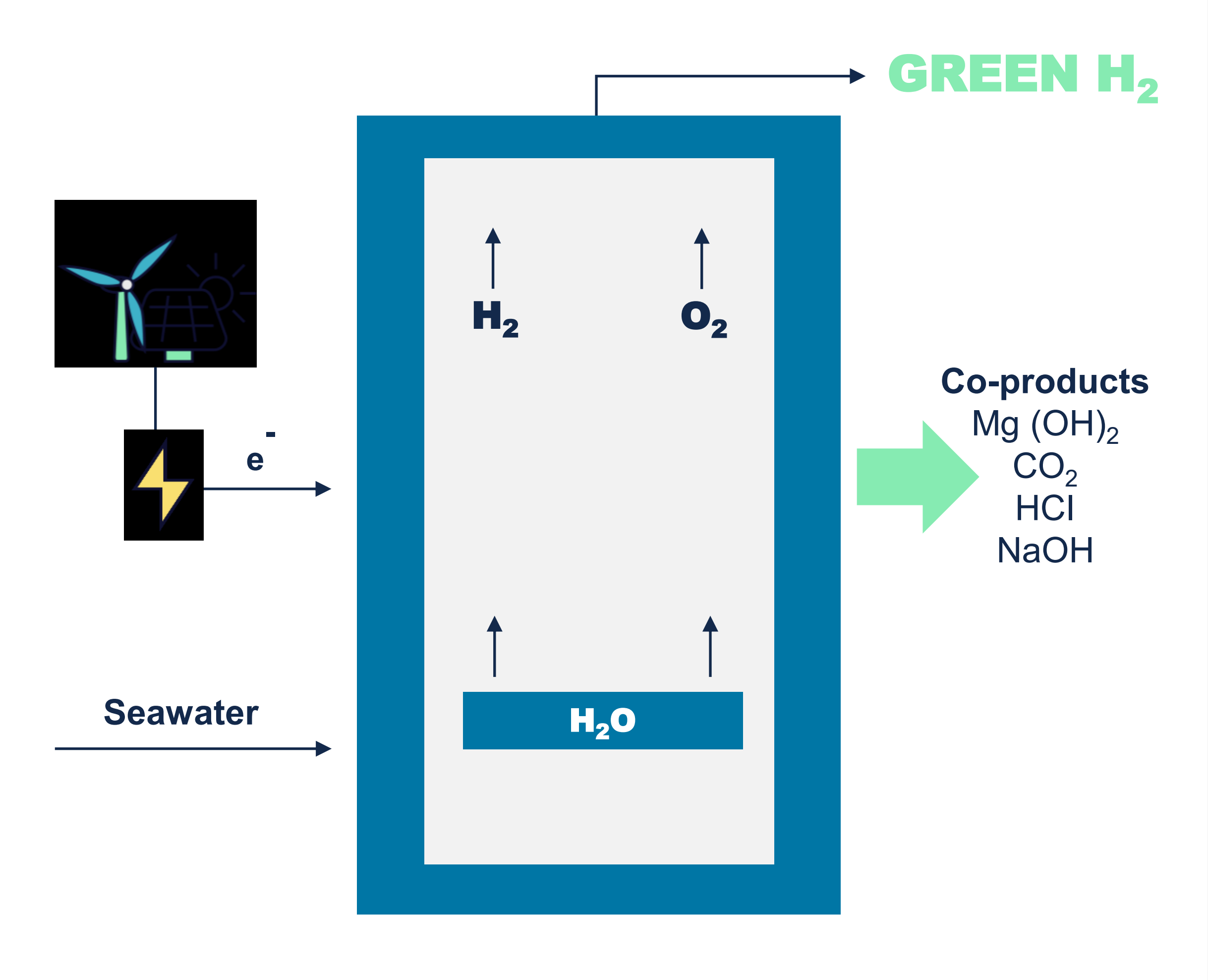
Renewable-rich regions are water-stressed regions.
More than 70% of the hydrogen electrolyzer projects will be located in areas such as Australia, Chile, Oman, Saudi Arabia, etc. In these regions the use of desalination plants would help to limit the depletion of fresh water resources.

Water desalination



- Desalination is a mature technology. The leading desalination technology today is reverse osmosis (RO)
- Current state-of-the-art RO plants can achieve recoveries of up to 50%.
- Desalination plants produce brine enriched with salt and chemicals. Salinity is double compared with the initial one of sea water. Ecological effects could arise from its return to the sea. It can often not be discharged to the environment and requires connection to a waste treatment facility or onsite.
- Desalination for green hydrogen adds 1–2% to energy consumption and the cost of production (IRENA 2022). These figures could become more relevant due to expected electrolyzers cost reduction and efficiency improvement..

Electrolysis of seawater



Main Info about the Technology

- Desalination not required for saltwater sources
- Co-products add value
- Different concepts and architectures:
  - Membraneless electrolyzers
  - Re-designed stacks
- TRL: 2 - 4

Conclusions

- Different pathways towards a low-emissions future have different implications for water use. Green hydrogen production has lower water requirements than some CO2 low emissions technologies like biofuels, carbon capture or nuclear.
- Water footprint is a very **location-specific** parameter that depends on the local water availability, consumption, degradation, and pollution. However, it **is not** foreseen that water consumption will be a **major barrier for scaling up electrolytic hydrogen.**
- The production of electrolytic hydrogen in **renewable-rich but water-stressed regions** requires careful assessment. In these regions the use of **desalination plants** would help to limit the depletion of freshwater resources. **Green hydrogen projects and water management** must be planned together from the **very early stages** of the design.
- The production of hydrogen can represent an opportunity to **improve water security**, indirectly fulfilling some local needs in terms of desalinated water generation and oxygen production. Green hydrogen can spur the desalination industry, resulting in a massive scale-up of desalination capacity and **increasing the supply of freshwater** for other purposes beyond electrolysis.

Thank you!

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