

# Green hydrogen: why and how?

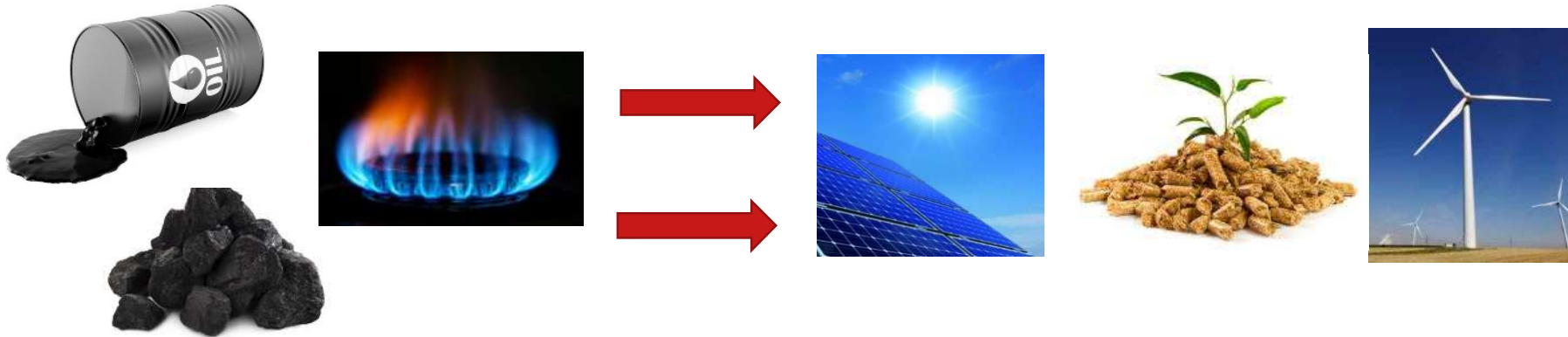
**Thijs de Groot**

Eindhoven Institute of Renewable Energy Storage, Department of Chemical Engineering and Chemistry



Climate change is happening now....

# ... so we need to switch our energy sources



A side discussion of limited relevance:

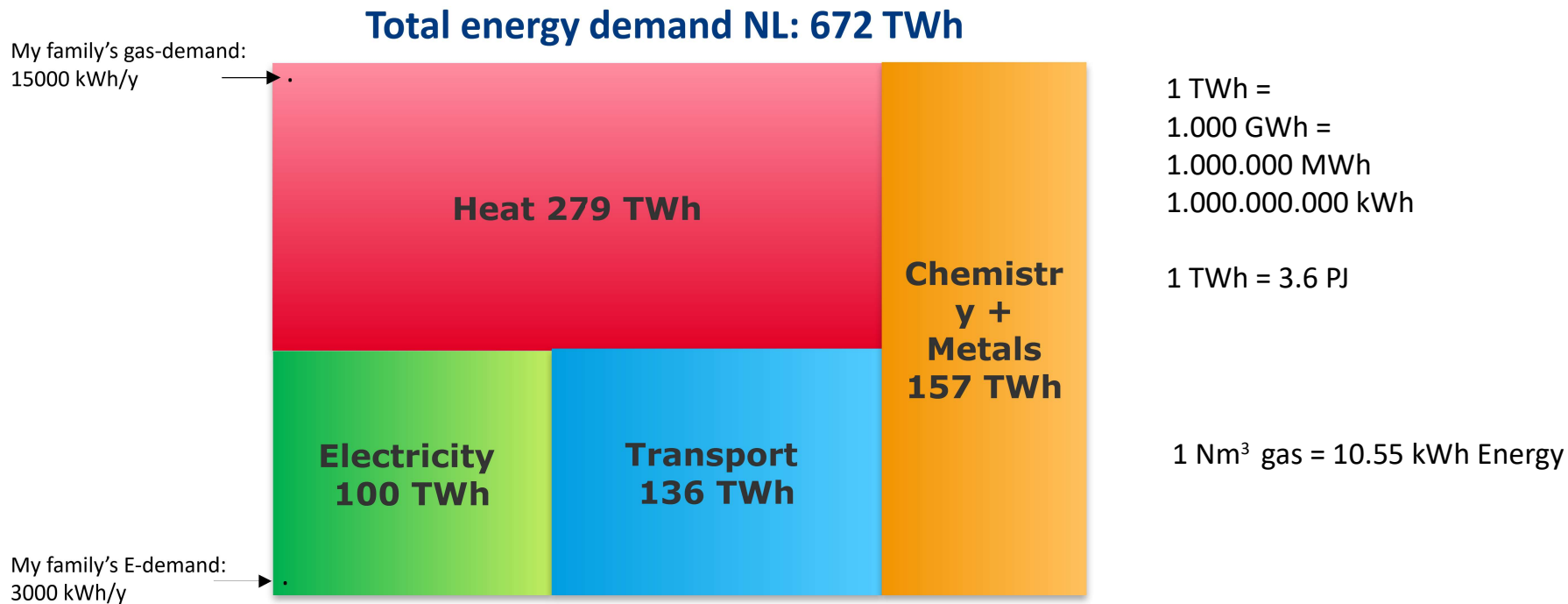


# With electricity we are heading the right direction

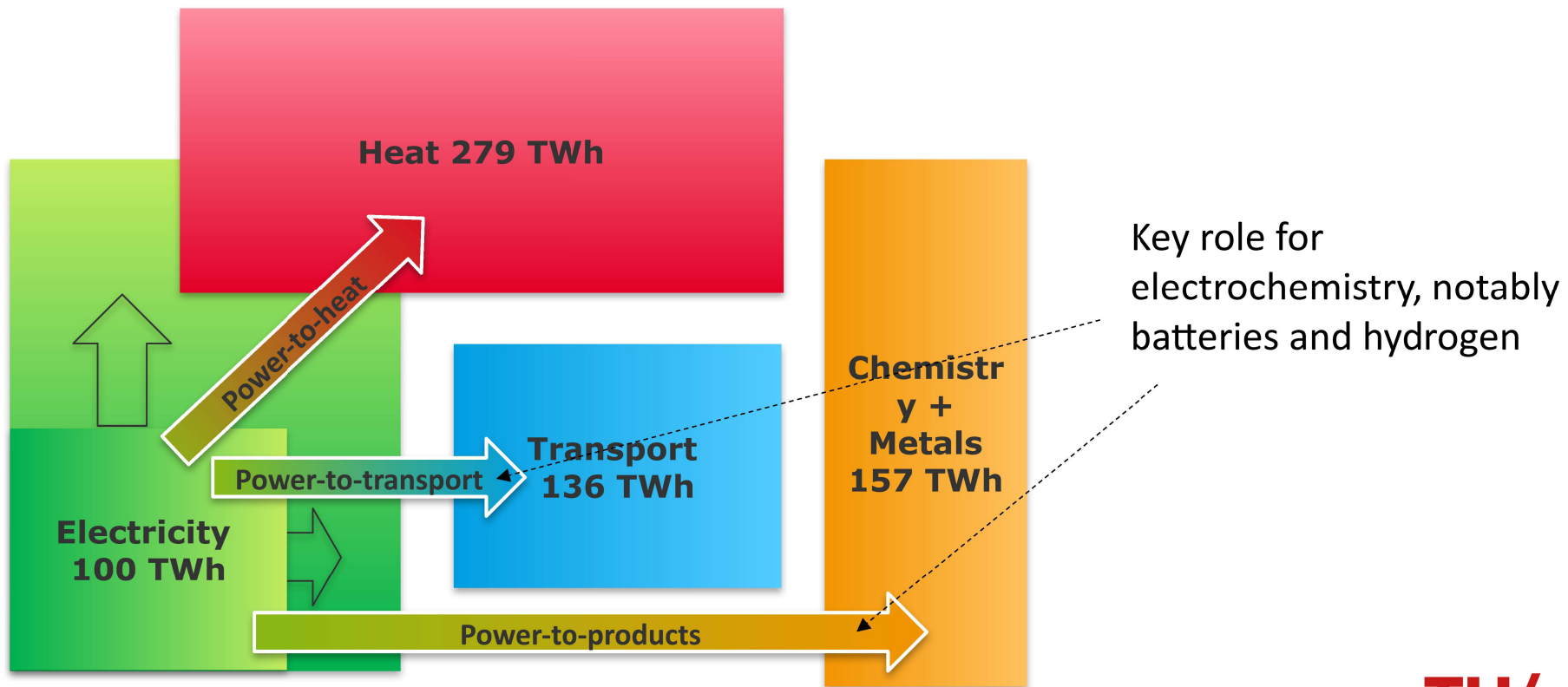




# But there is more energy demand than just electricity



# What we need to do:



# Sometimes it is “easy” to switch to electricity



Internal combustion engine vehicle



Battery electric vehicle



Central heating



Heat pump

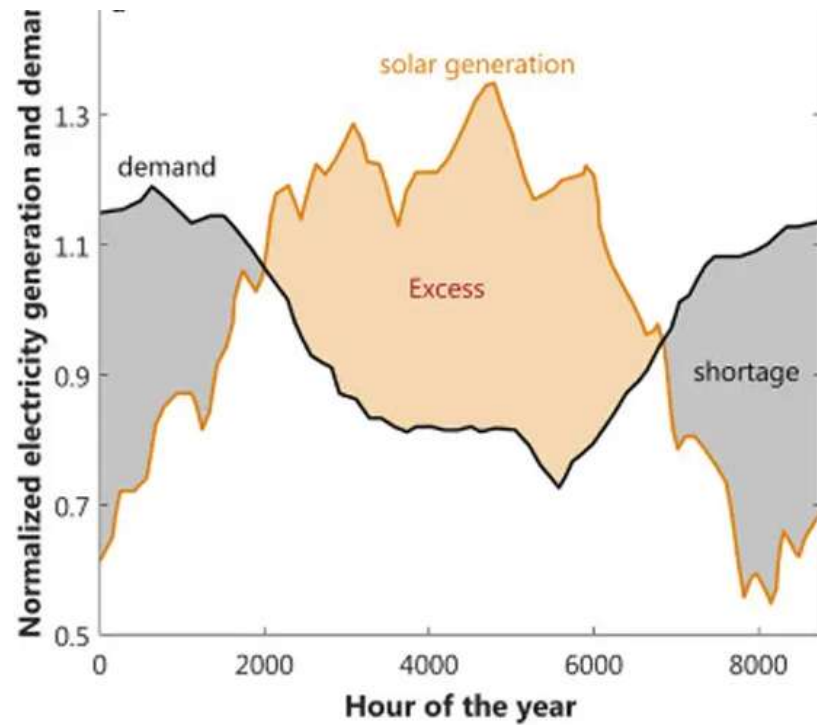
Also more efficient!

# But there are more difficult energy areas



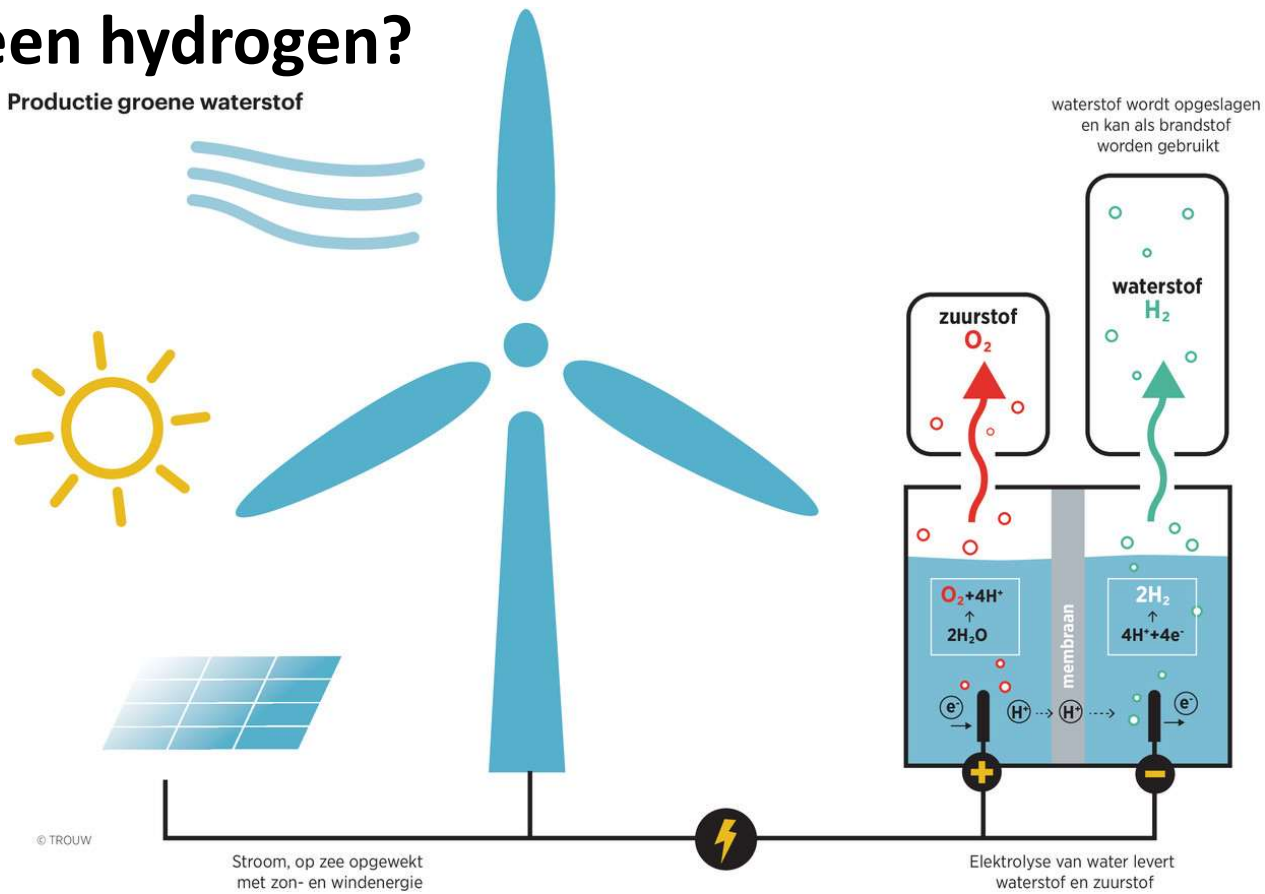


## And there is the challenge of seasonal storage



# What is green hydrogen?

Productie groene waterstof



# Water electrolysis is a dutch invention

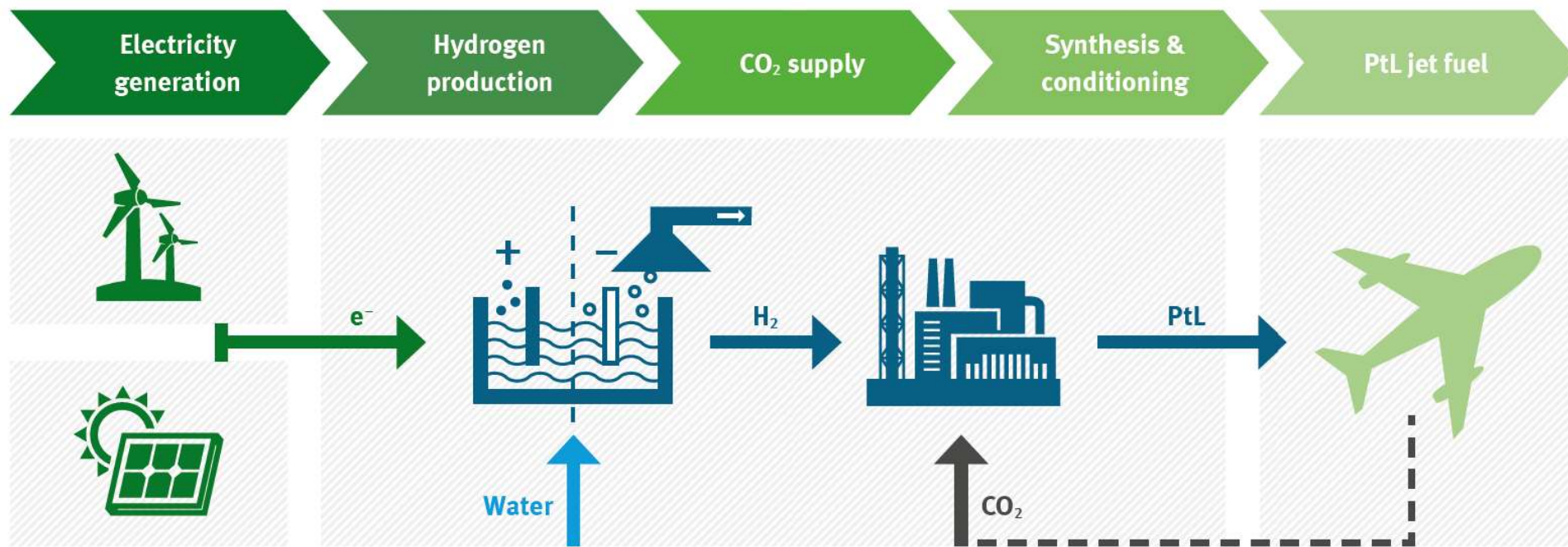


**Adriaan Paets van Troostwijk**  
(4 maart 1752 – 3 april 1837)



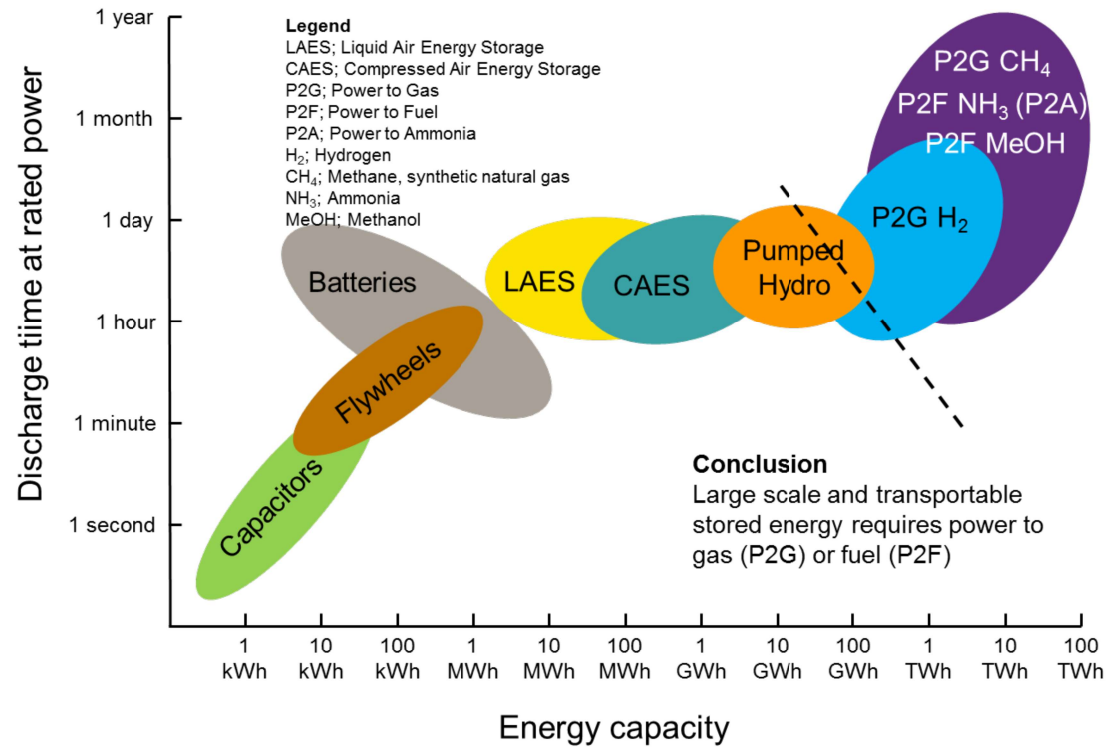
He only has a Wikipedia page in English.....

# For the difficult applications green hydrogen can help





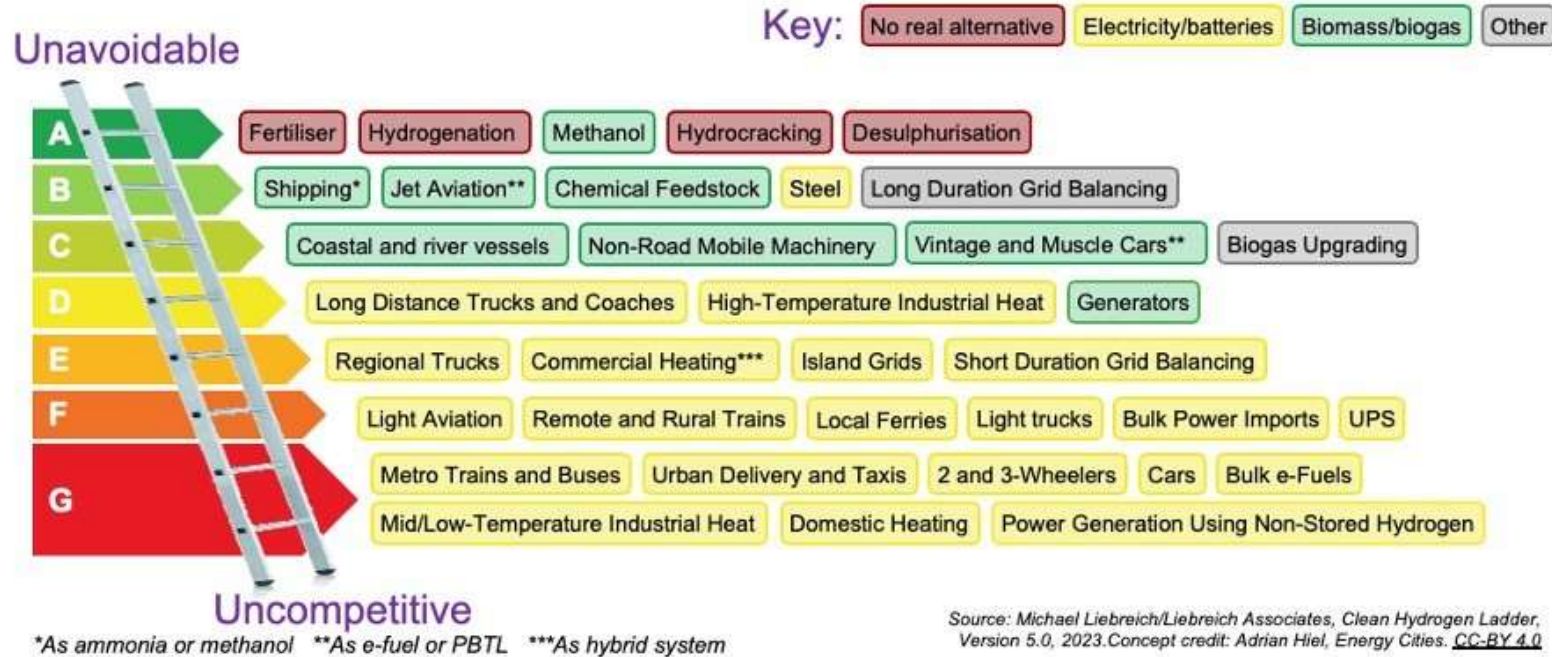
# And hydrogen can help for long term storage



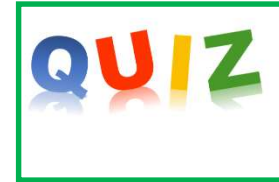
# But is not the solution for everything!

Liebreich  
Associates

## Hydrogen Ladder 5.0



# How much water electrolyzer capacity is expected to be needed in the world in 2050?



- a) ~5 GW
- b) ~50 GW
- c) ~500 GW
- d) ~5000 GW

|  |         |
|--|---------|
| Worldwide electricity production capacity: | 9000 GW |
| Dutch electricity production capacity:     | 47 GW   |
| Dutch average electricity use:             | ~15 GW  |

# How much water electrolyzer capacity is expected to be needed in the world in 2050?

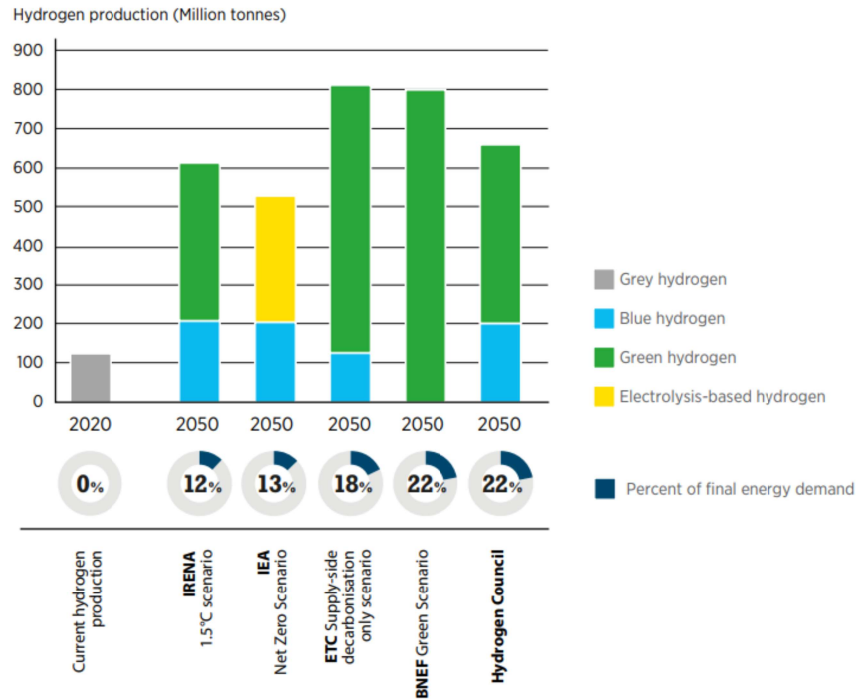


- a) ~5 GW
- b) ~50 GW
- c) ~500 GW
- d) ~5000 GW



# Green hydrogen: how much do we need?

Figure 1.1 Estimates for global hydrogen demand in 2050



~500,000,000 ton H<sub>2</sub> in 2050

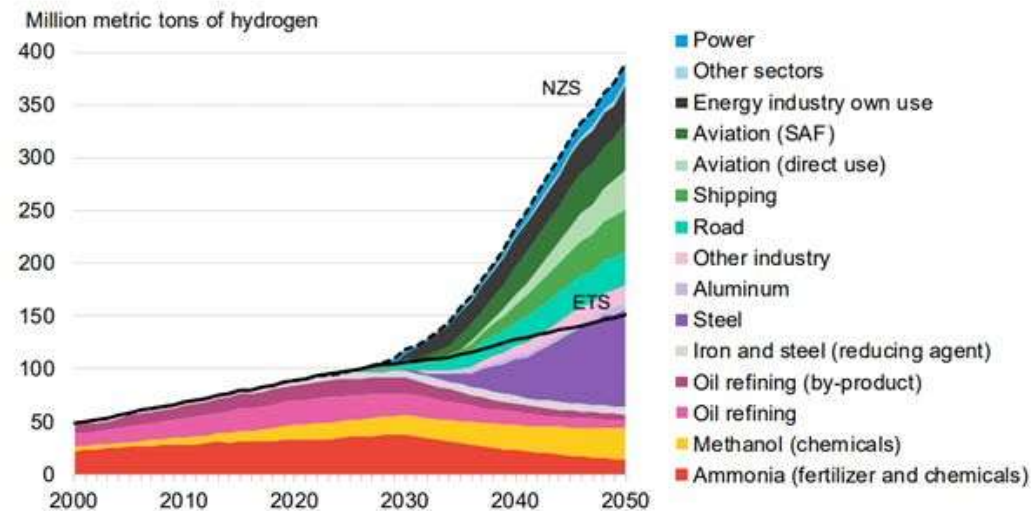


~55 MWh/ton  
4000h per year (typical for  
wind or solar)

6,000,000 MW eletrolysis

# Expected hydrogen demand (controversial)

Figure 15: Global hydrogen demand by sector and application, Net Zero Scenario



Source: BloombergNEF. Note: 'Energy industry own use' includes energy consumed to produce final energy carriers from primary energy carriers and energy industry's own use. SAF is sustainable aviation fuel. NZS is Net Zero Scenario; ETS is Economic Transition Scenario. Assumes gravimetric energy density of 140 megajoule per kilogram for hydrogen.

# What is the largest electrochemical process in the world in terms of power consumption today?

- a) Water electrolysis
- b) Chlor-alkali electrolysis
- c) Aluminum electrolysis
- d) Iron electrolysis



# What is the largest electrochemical process in the world in terms of power consumption today?

- a) Water electrolysis (nr. ?, ~2 GW)
- b) Chlor-alkali electrolysis (nr. 2, ~25 GW)
- c) Aluminum electrolysis (nr. 1, ~100 GW)
- d) Iron electrolysis (absent)

