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FML

Power to iron for safe and cheap long duration hydrogen storage

Samuel Heiniger
Functional Materials Laboratory
ETH Zürich

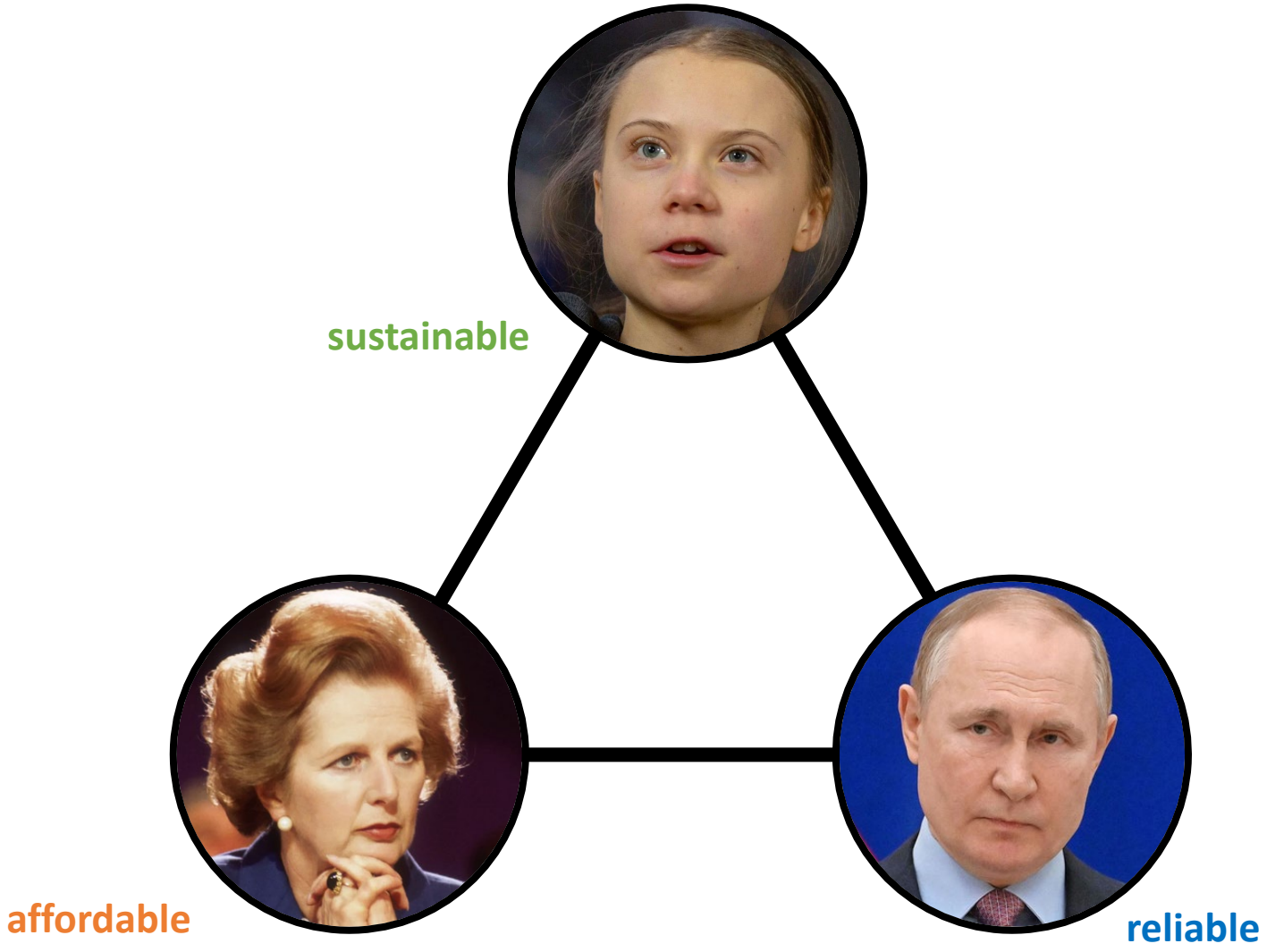
Energy Trilemma

However energy supply must not only be

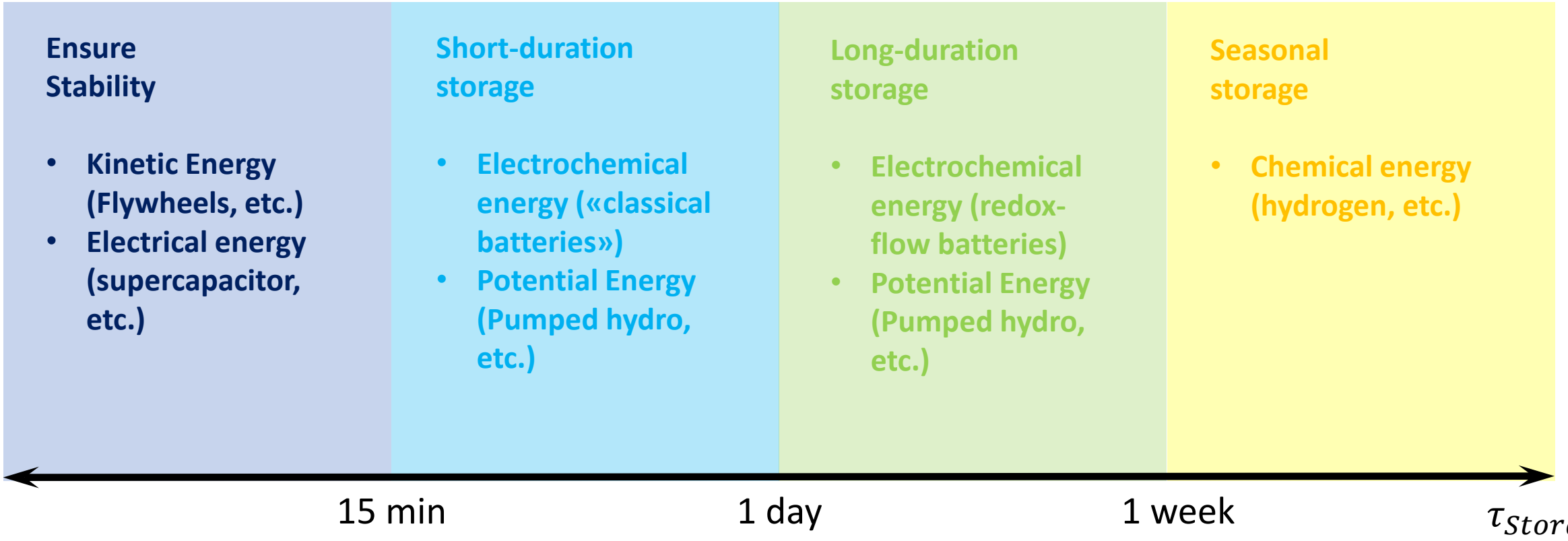
- **environmentally sustainable**

but also

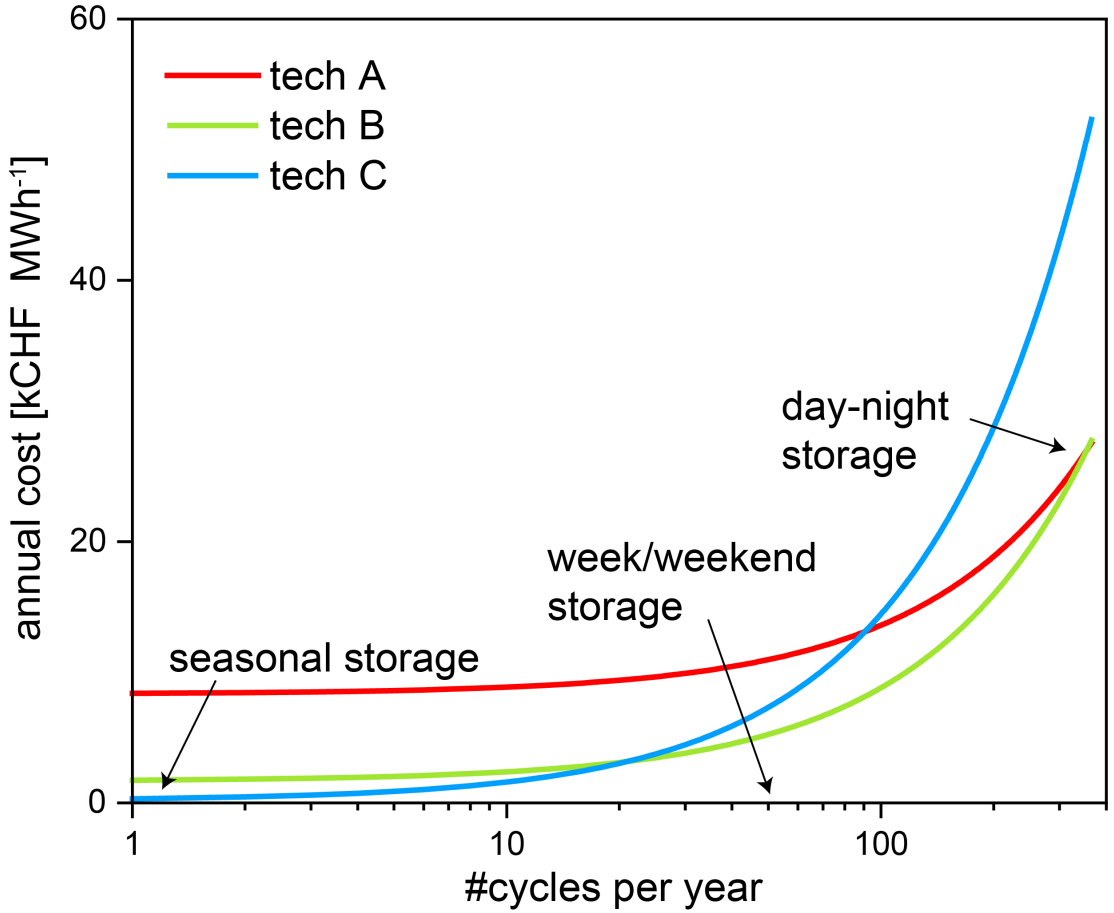
- **affordable**
- **reliable**
- (and socially/politically acceptable)



Characteristic time of storage



Energy storage economics



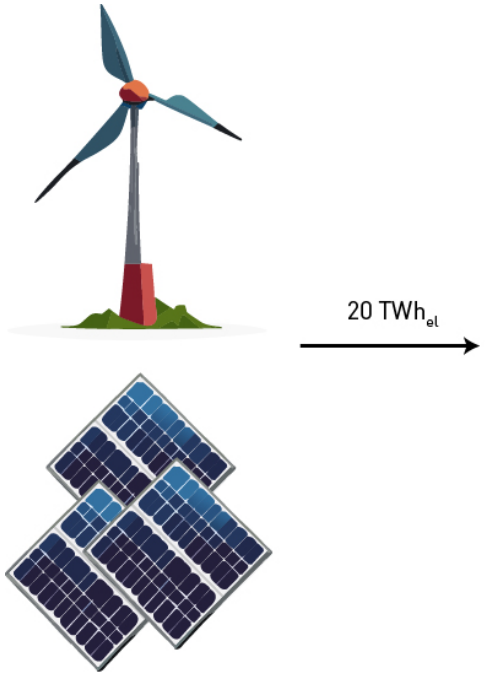
Technology A:
- **High efficiency (95%)**
- **High cost (250 USD kWh^{-1})**

Technology B:
- **Mid efficiency (70%)**
- **Mid cost (50 USD kWh^{-1})**

Technology C:
- **Low efficiency (35%)**
- **Low cost (5 USD kWh^{-1})**

Other Assumptions:
- electricity price 50 CHF MWh^{-1}
- no self-discharge
- interest free money
- 30 years lifetime

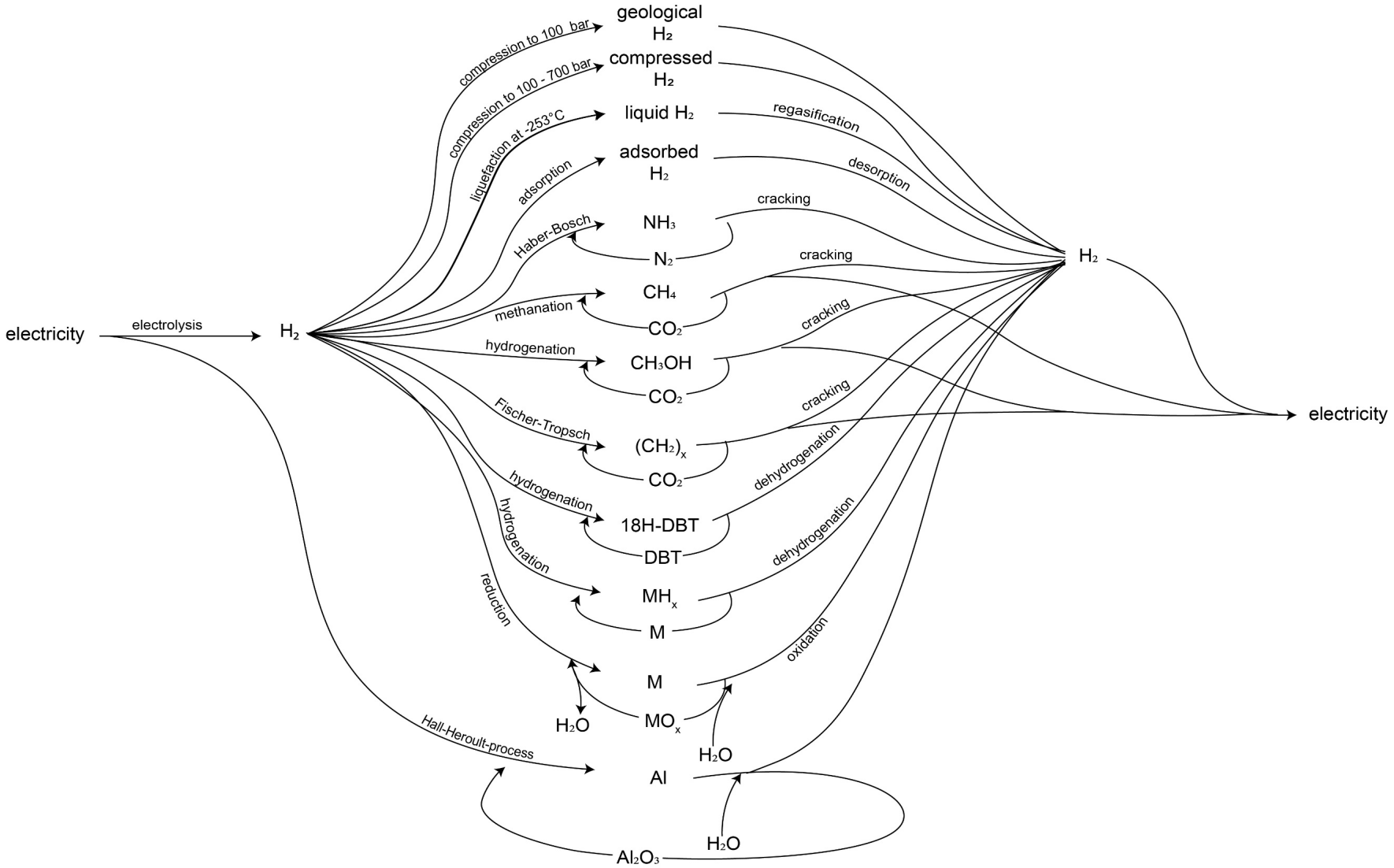
Let’s just do hydrogen storage?



State of the art hydrogen storage is too expensive!
-> We need Power-to-X!

Calculations based on assumptions used in C. Eisenring, S. Stocker, das Schweizer Sommerstrom-Problem, AvenirSuisse, **2024**, https://www.avenir-suisse.ch/das-schweizer-sommerstrom-problem/

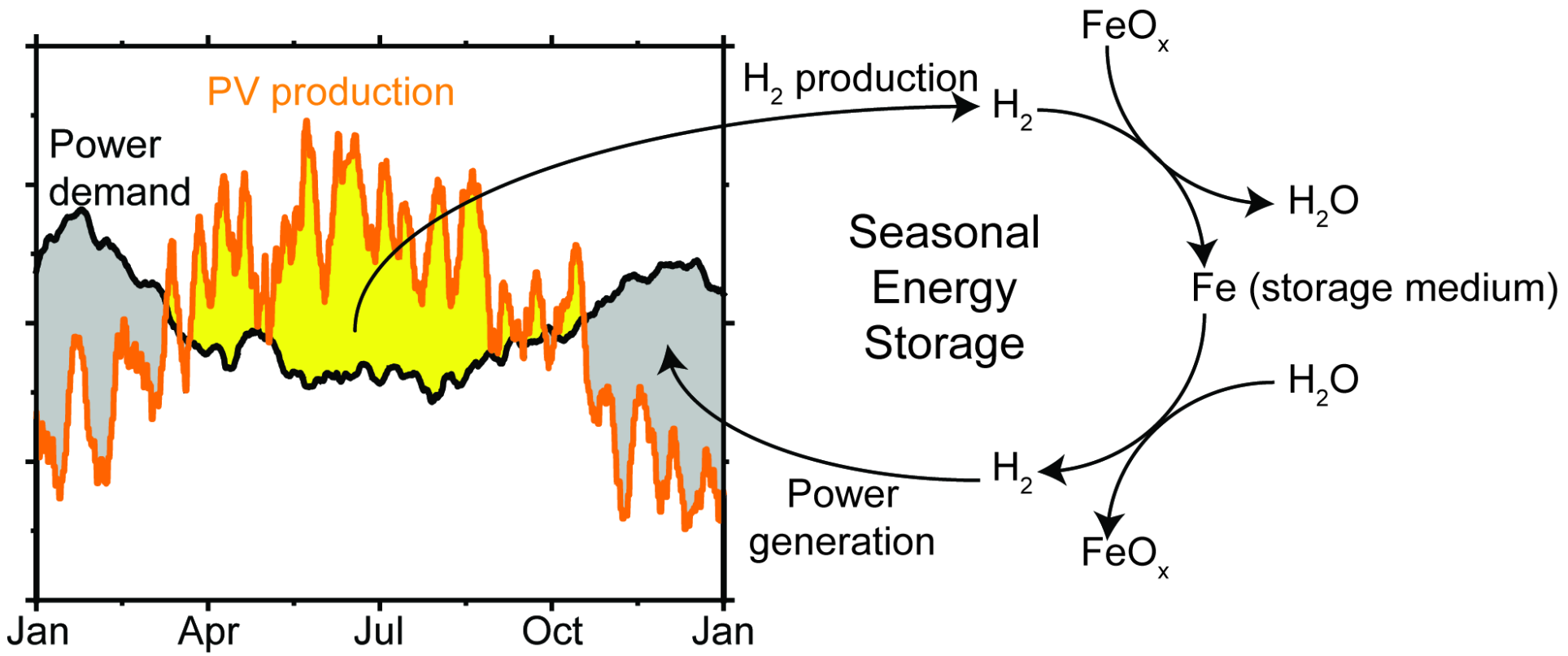
Power2X technologies



Which X is desirable?

- **Cheap** → Economical feasibility
- **Abundant** → ~~Ecol~~ogical feasibility
- **Safe** → Not explosive, no pressure and non toxic
- **Simple** → Cheap and reliable
- **Dense** → Limits space use

how does Power to Iron work?

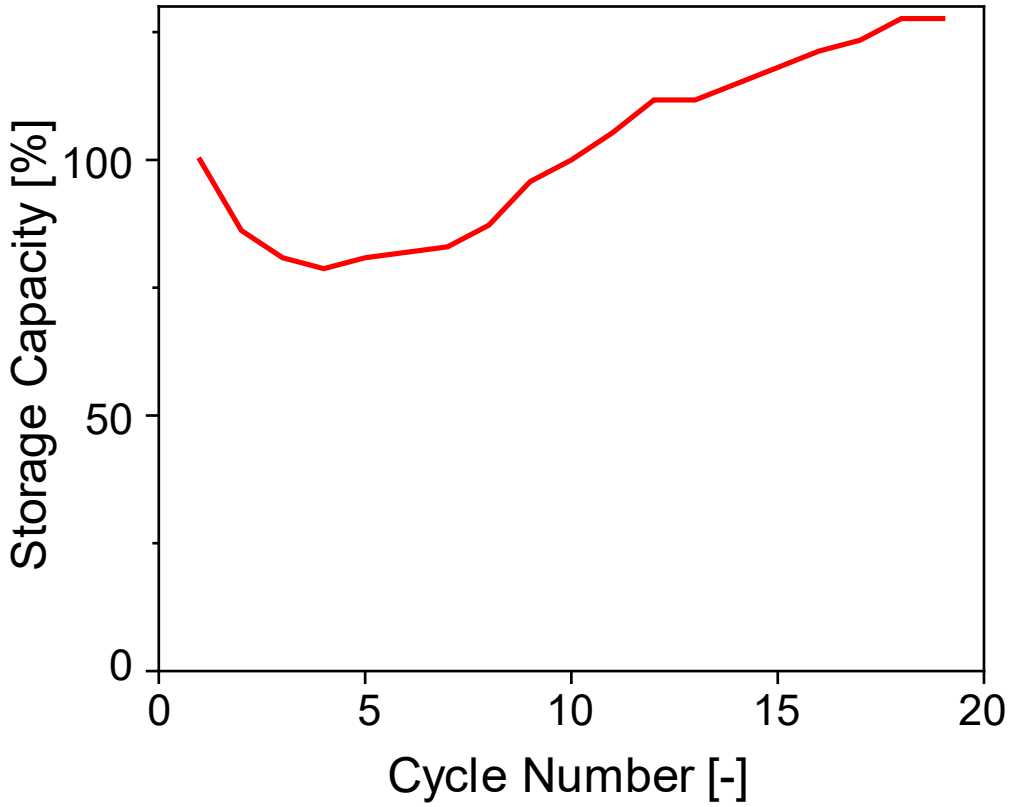


S.P. Heiniger, Z. Fan, W.J. Stark, *Safe seasonal energy and hydrogen storage in a 1: 10 single-household-sized pilot reactor based on the steam-iron process*, **2024**, Sust. Ener. Fuel

Is iron stable enough?

- Synthetic and natural iron ore stable over 20 cycles
- Natural ore increases reactivity over time

→ **Reliable storage over many seasonal cycles**



Storage capacity of a synthetic and a natural iron ore at 500°C in 4 h cycles

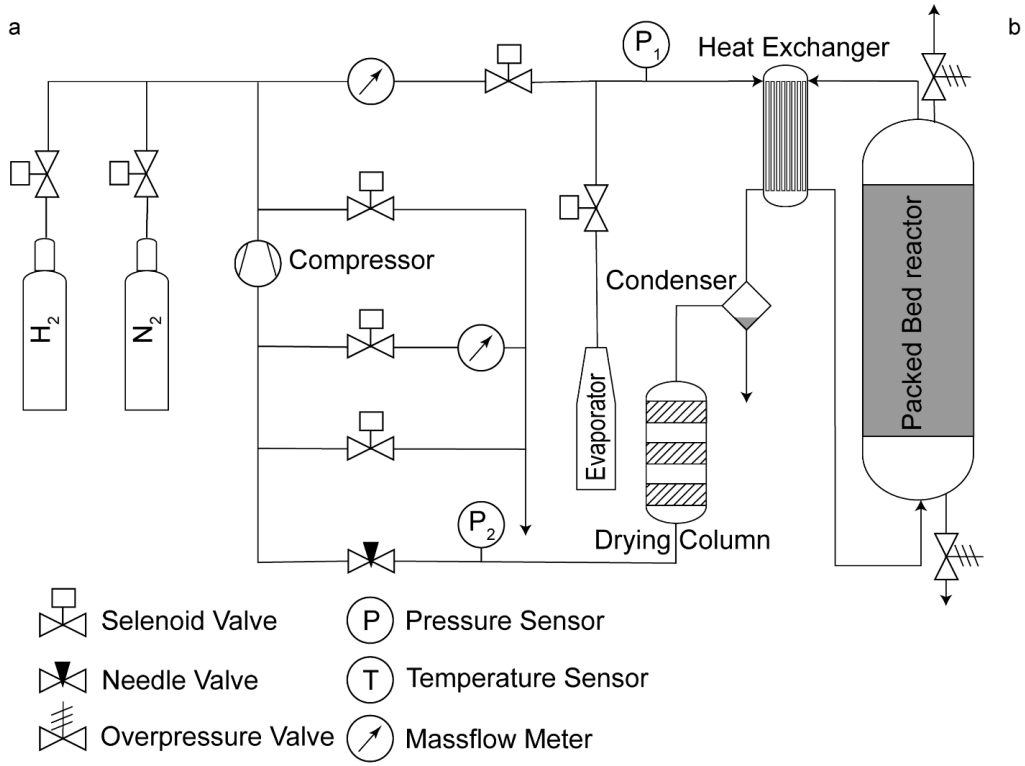
Pilot 1: 250 kWh size

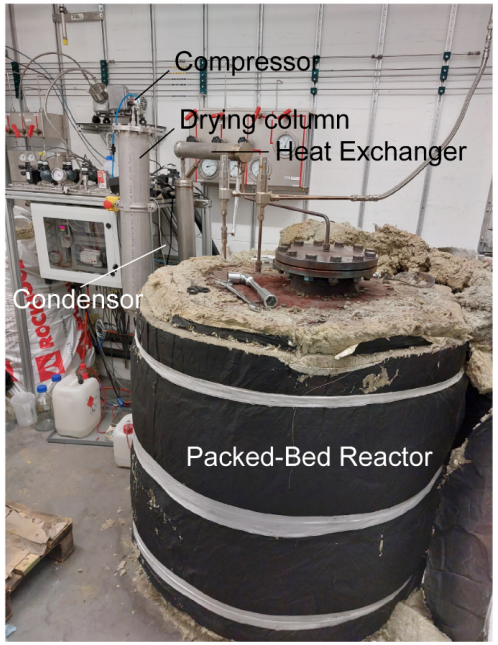
Reactor of 210 L size [1-3]

2 successful cycles shown

7.1 kg H_2 stored

(10% of seasonal storage needs of a family)





a) Schematic representation of the lab scale pilot b) picture of the reactor after the 2nd charging after cool-down and removal of the insulation on top of it

1. S.P. Heiniger, Z. Fan, W.J. Stark, *Safe seasonal energy and hydrogen storage in a 1: 10 single-household-sized pilot reactor based on the steam-iron process*, **2024**, Sust. Ener. Fuel
2. W. J. Stark and U. B. Lustenberger, EP3699991B1, 2020.
3. W. J. Stark and U. B. Lustenberger, EP3902040B1, 2021.

Pilot 2: ≈10 MWh size

3x 1.4 m^3 storage tanks

natural iron ore

Each can cover 150% of winter energy needs of a household

second cycle ongoing

10 MWh seasonal energy storage pilot plant at ETH Hönggerberg campus

Reliable supply is possible

Samuel Heiniger
samuel.heiniger@chem.ethz.ch

ETH Zürich
Functional Materials Laboratory
Vladimir-Prelog-Weg 1/HCI E112
8093 Zürich