

Utilizing large-scale hydrogen storages for Nordic industry

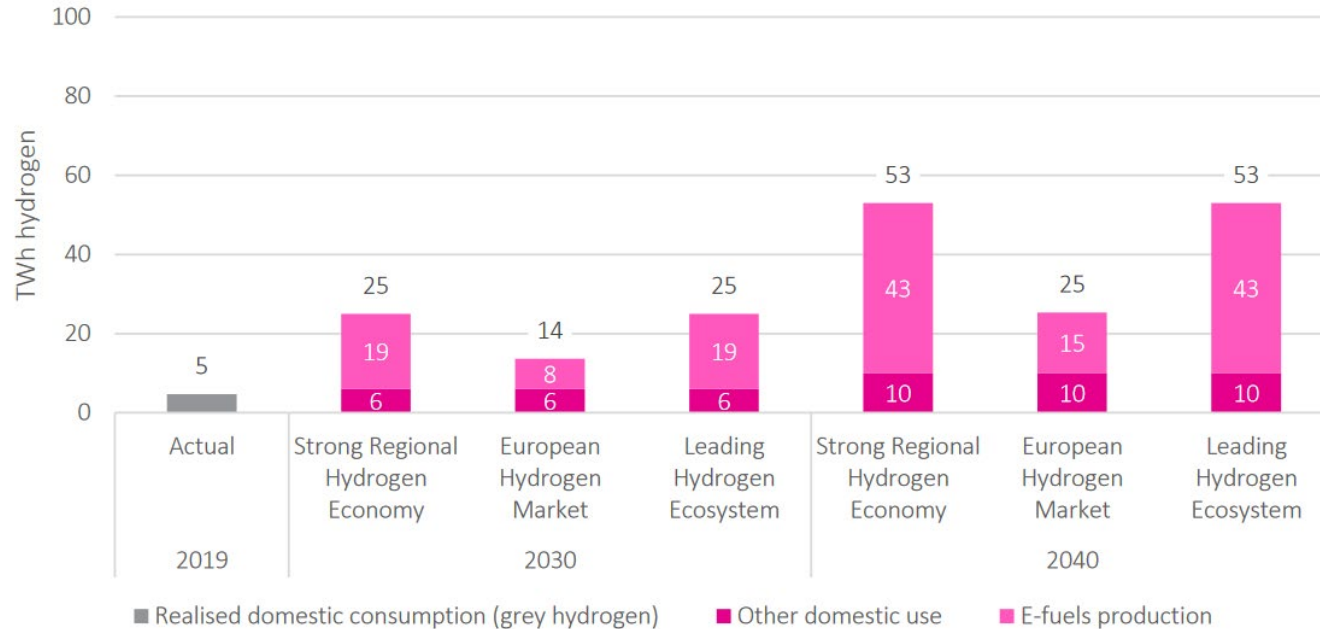


Aalto University
School of Engineering

Simo Pekkinen

3.10.2024

Why hydrogen storages?

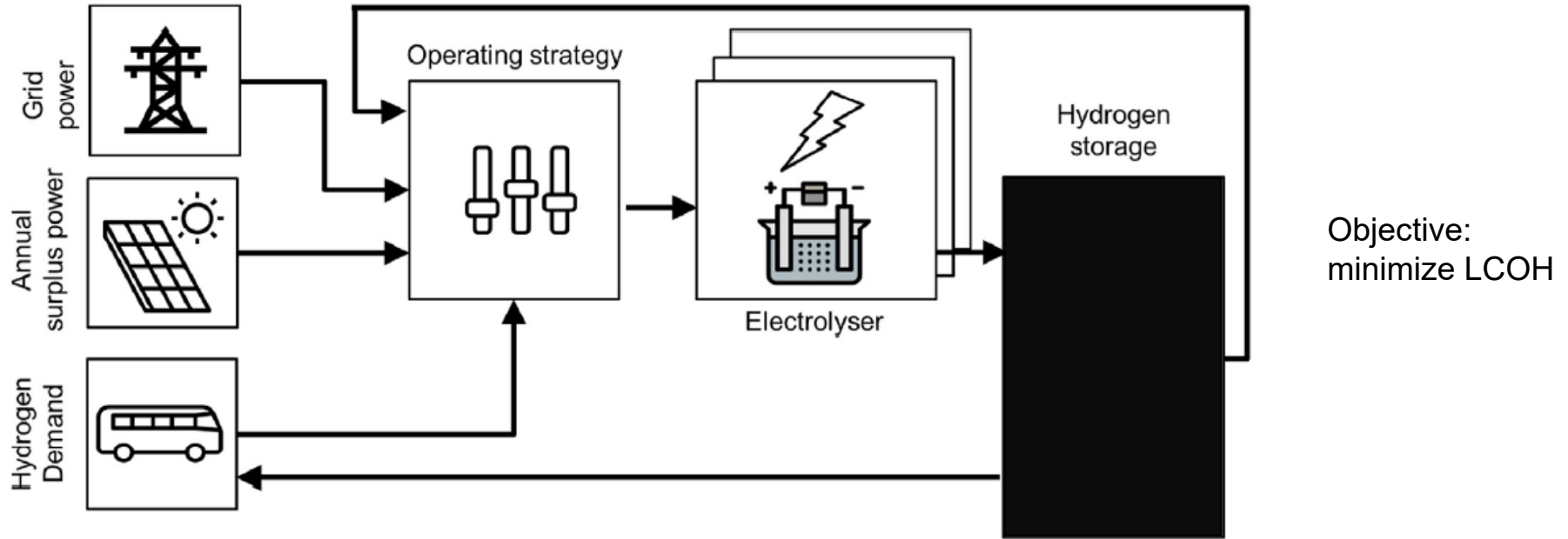


Source: Fingrid & Gasgrid, 2023



Hydrogen storages are needed to balance renewable energy and industrial processes

What is missing?

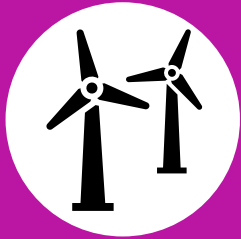


Source: Maurer et al., 2022



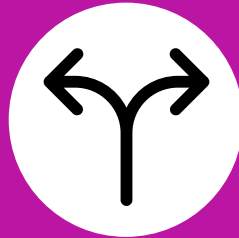
A different approach is needed to analyze the operation of the storage

Modelling process



Renewable energy into hydrogen

- Hourly production profile



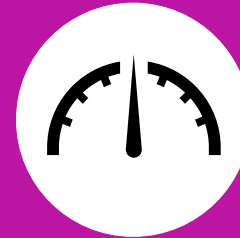
Hydrogen mass balance

- Between production and demand



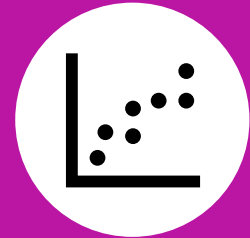
Storage level change

- Mass-based and percentage of full



Hydrogen gas state variables

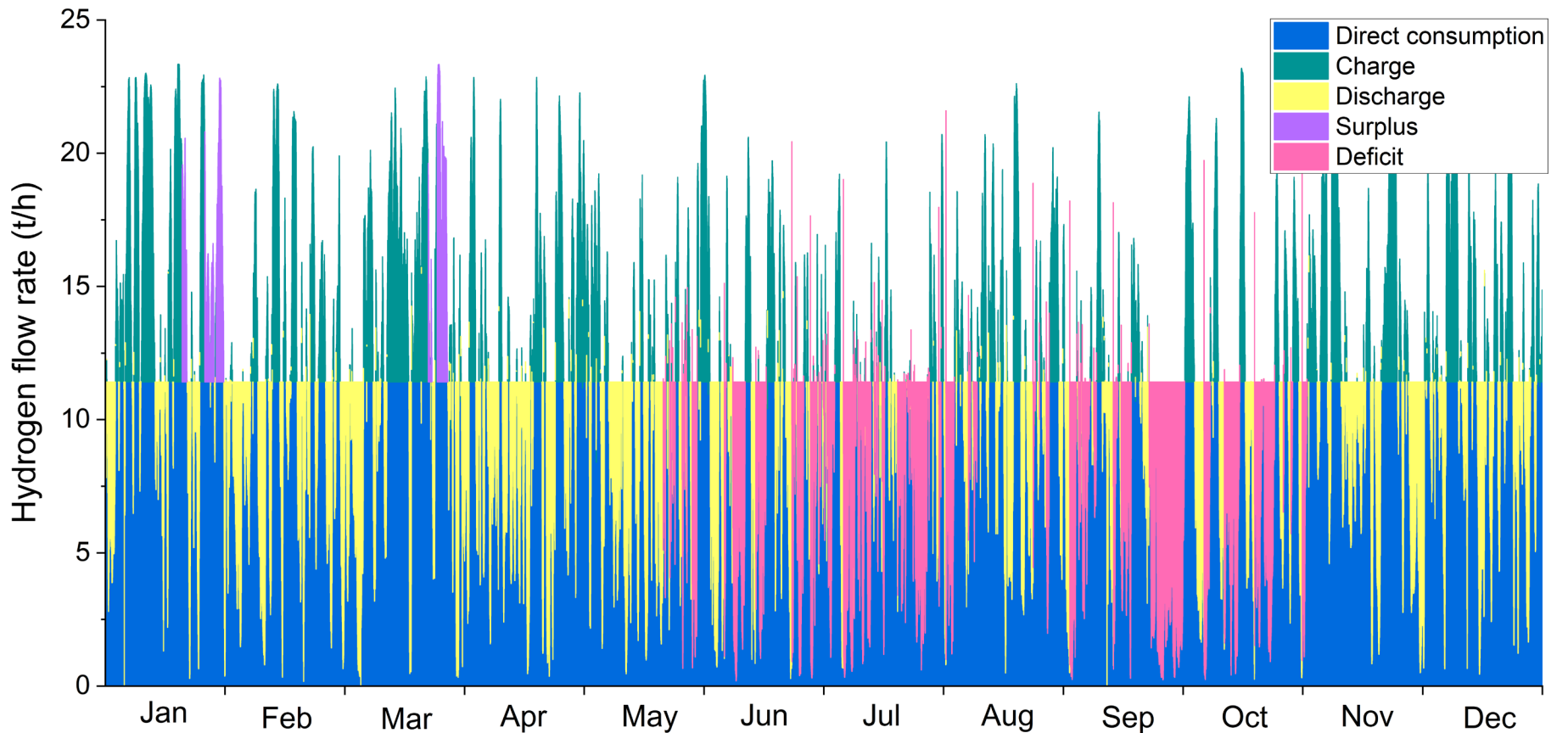
- Pressure
- Compressibility factor



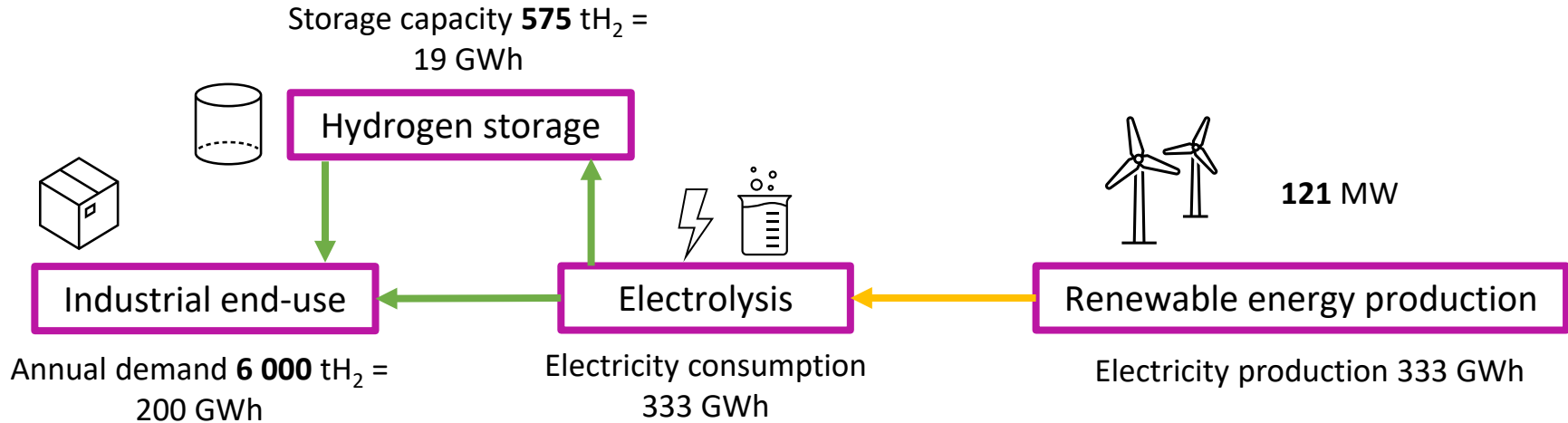
Visualization of hydrogen streams

- Charge and discharge
- Deficits and surpluses

Hourly hydrogen streams

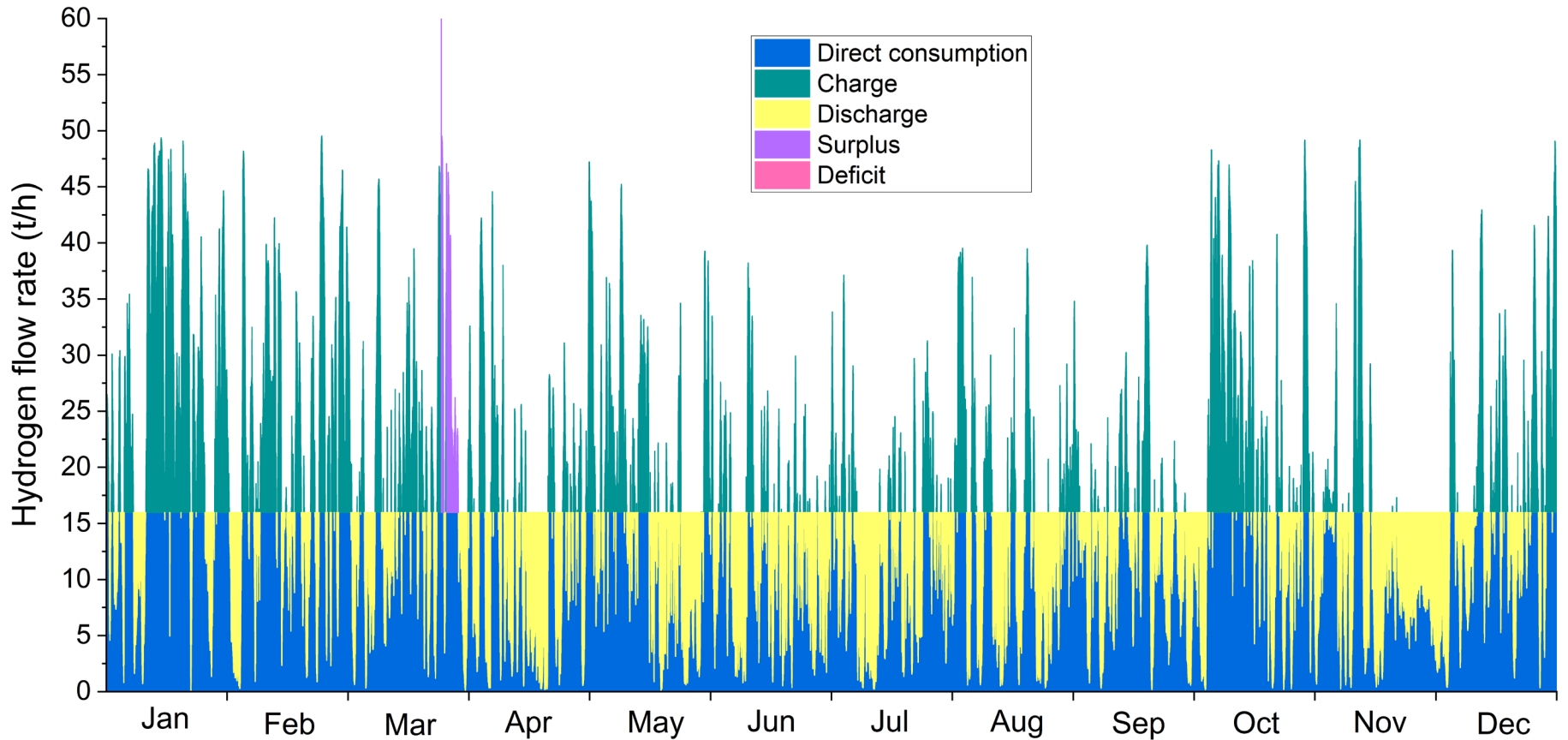


Break-even case study



- Location: Western Finland
- Year: 2022
- Wind power capacity factor: 31.5%
- Electrolyzer capacity equal to wind power

Break-even case study



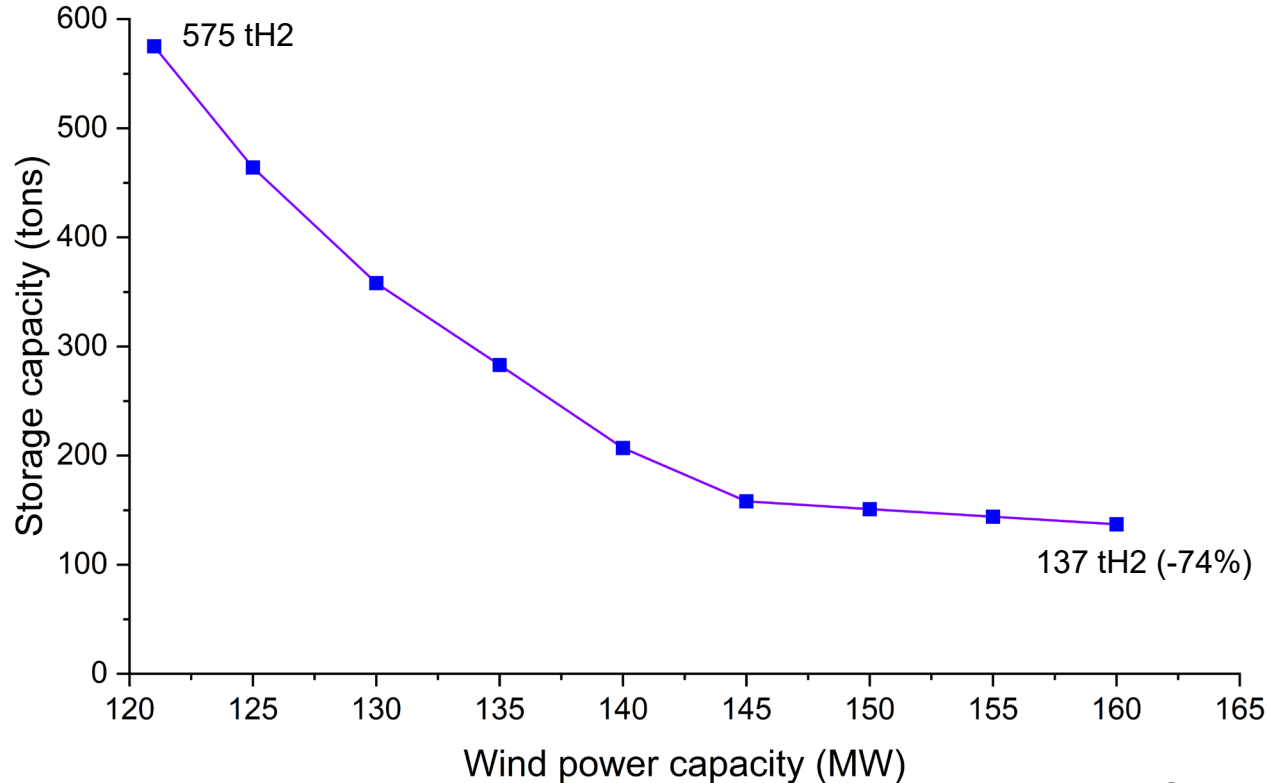
Break-even case study



Sensitivity analysis

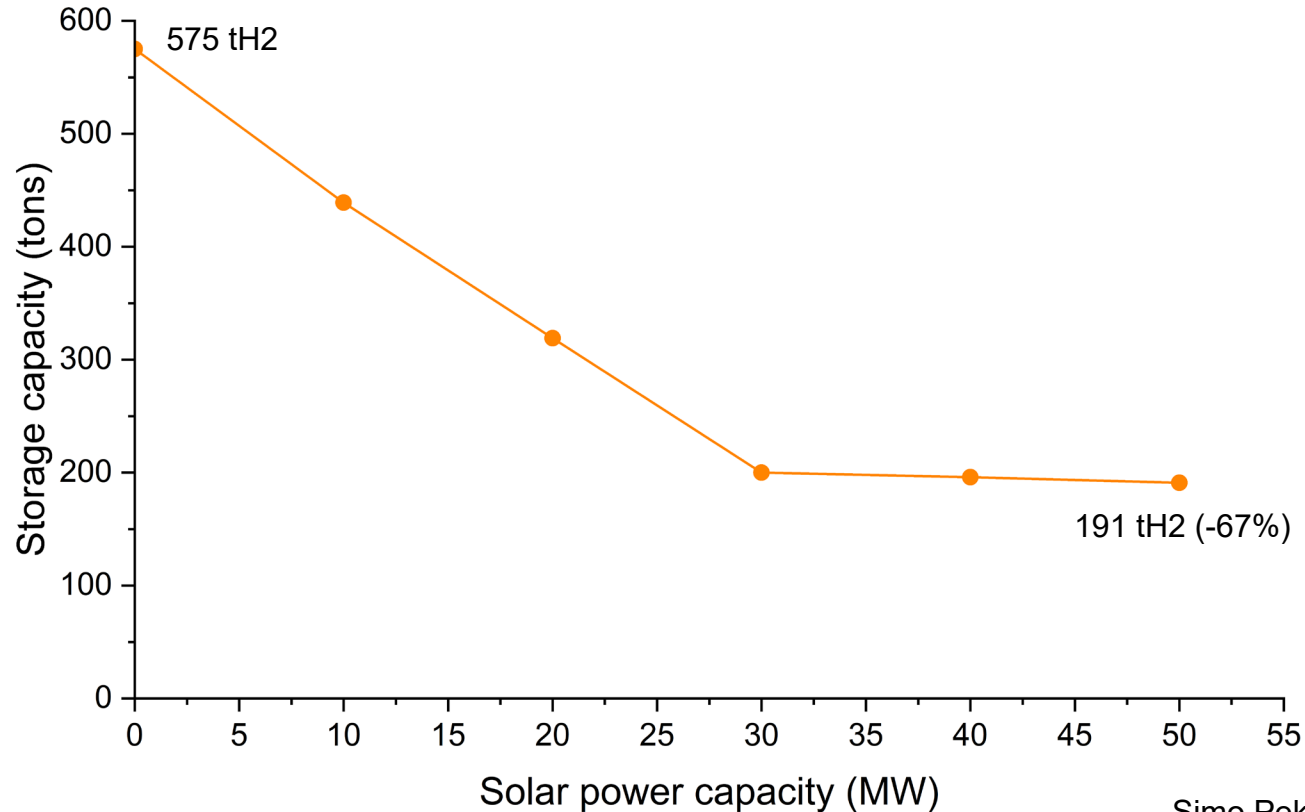
- **Hydrogen storage capacity analyzed based on system parameters**
- **Four parameters considered:**
 - Additional wind capacity
 - Solar power
 - Cushion gas amount
 - Electrolyzer capacity
- **Break-even system as a starting point**

Sensitivity analysis: wind power



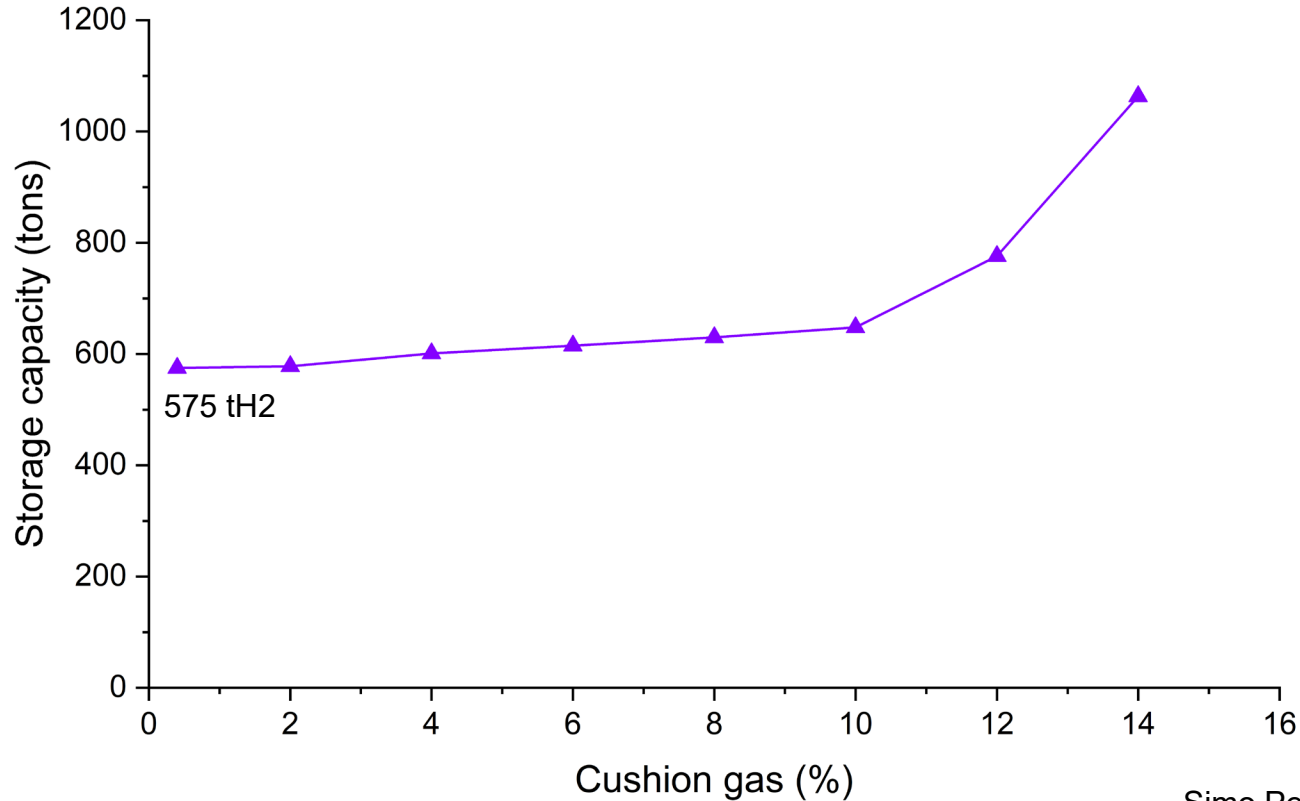
A?

Sensitivity analysis: solar power



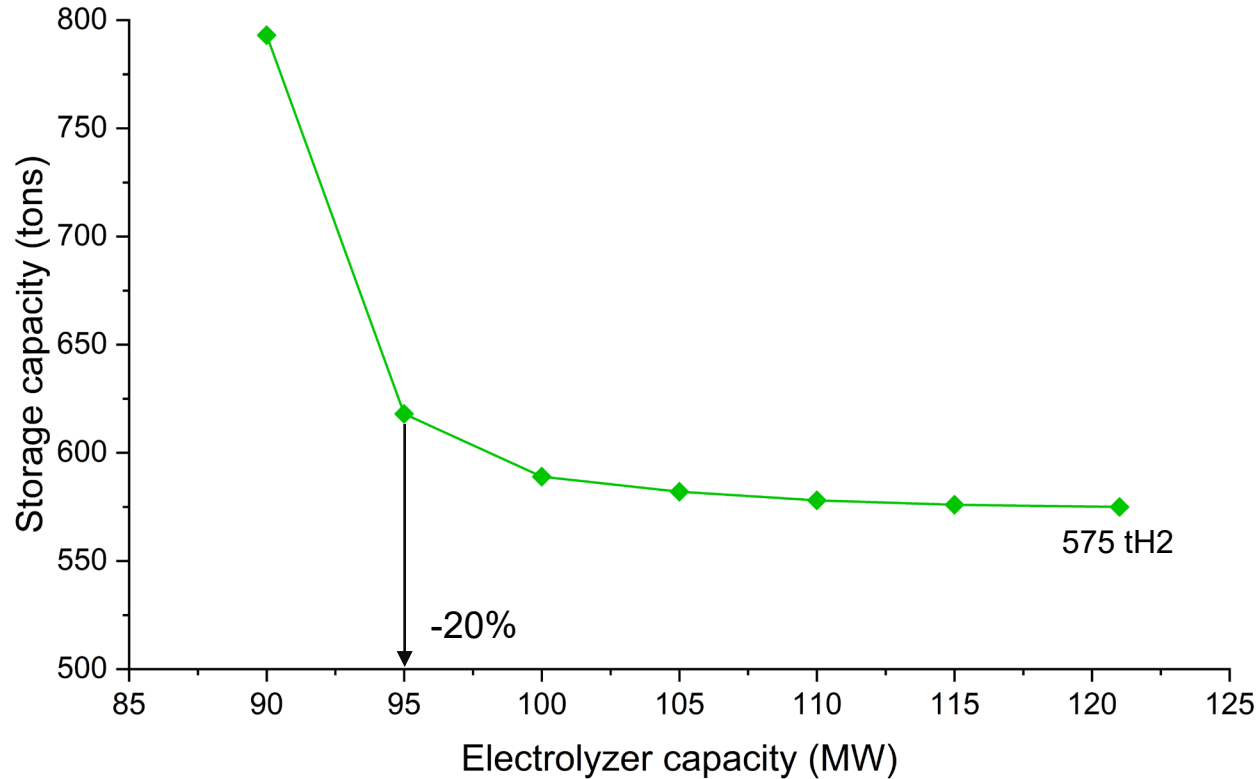
A?

Sensitivity analysis: cushion gas



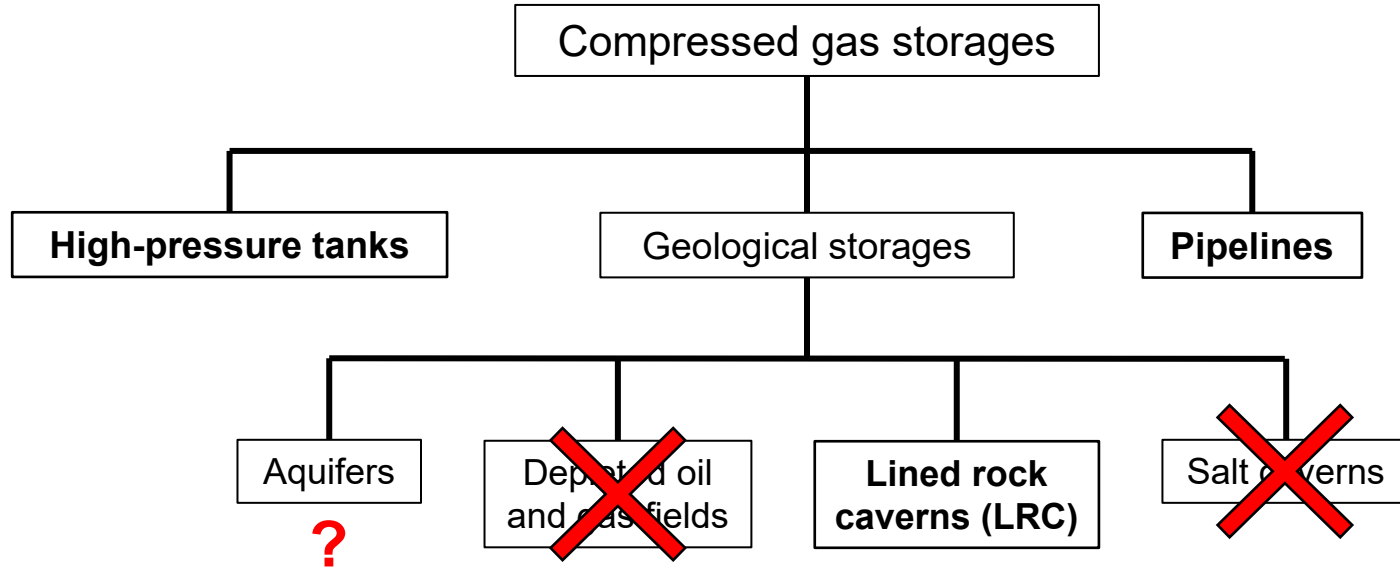
A?

Sensitivity analysis: electrolyzer capacity



A?

Technology comparison



Technology comparison

Technology	High-pressure tanks	Lined rock cavern (LRC)	Pipeline
Pressure (bar)	500	250	100
Storage volume	++	+	-
Investment cost	-	++	--
Compression work	--	+	++

Data from article titled “Hydrogen storages – The missing link for decarbonization of industrial processes”, under review in Journal of Energy Storage

Conclusions



Industrial use cases of green hydrogen require large-scale hydrogen storages



Combination of different RE sources reduces storage needs significantly



Lined rock cavern storages economically favorable, pipelines mainly for transportation

Thank you!

simo.pekkinen@aalto.fi

Linkedin:



Research funding



MAJ AND TOR
NESSLING FOUNDATION



Aalto University
School of Engineering