Prospective life cycle assessment of hydrogen produced through solid oxide electrolysis

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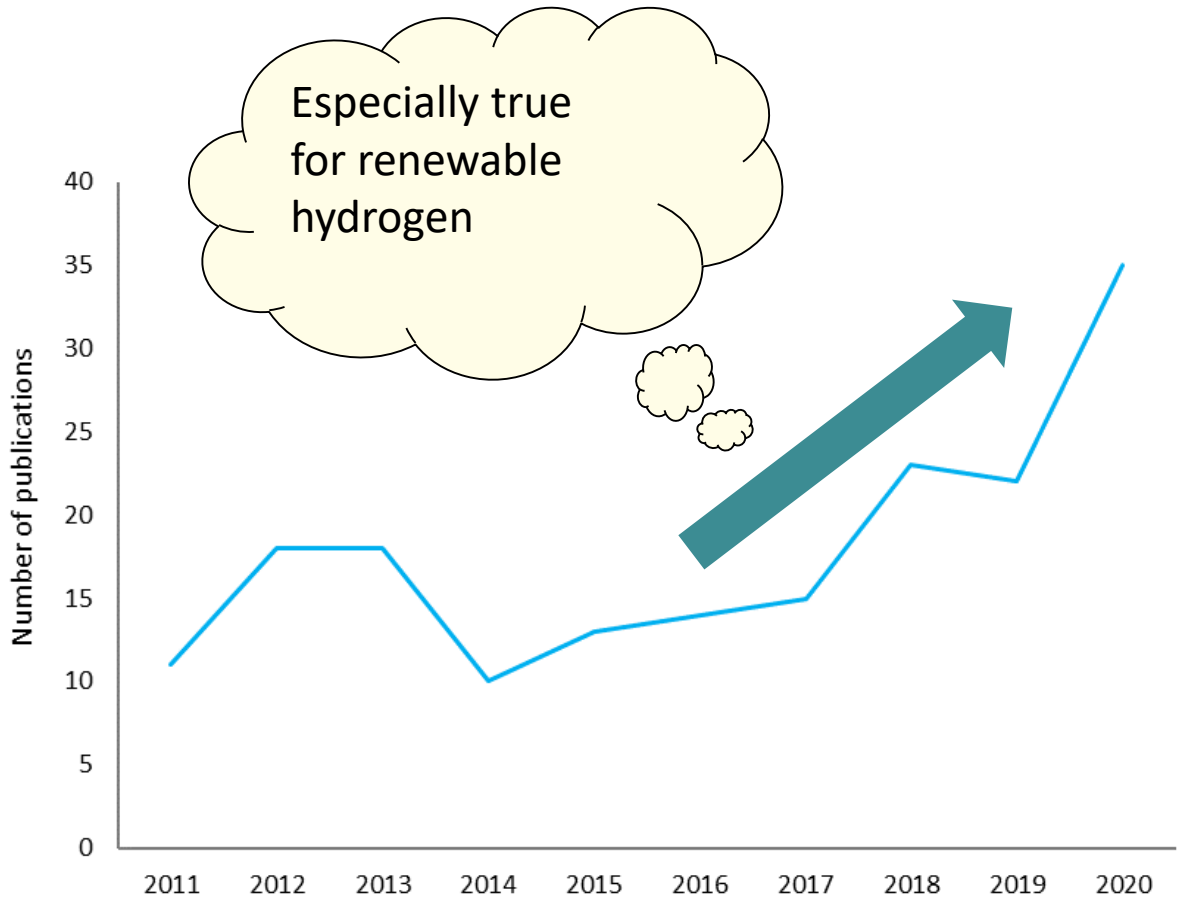
Background

Interest in hydrogen has boomed in 2020, also among LCA practitioners.



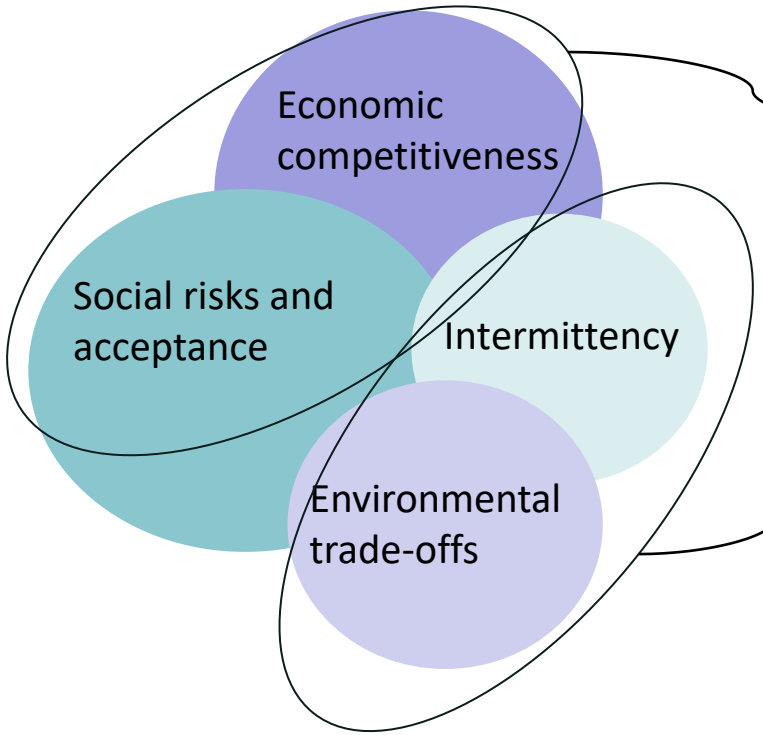
Need to evaluate hydrogen sustainability:

- ✓ EU taxonomy
- ✓ RED II
- ✓ Scientific developments

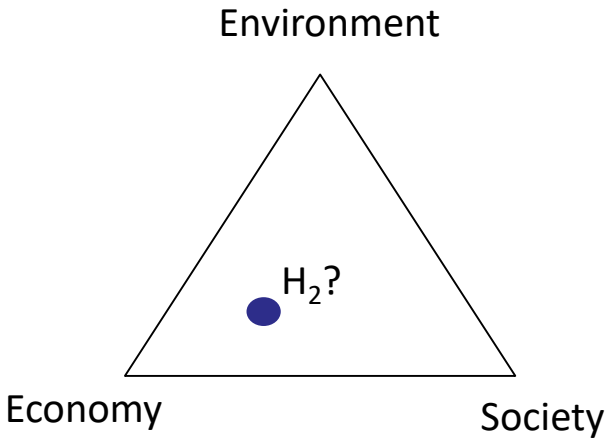
CO_2

Background

Electrolysis coupled with renewable energies is usually seen as one of the best solutions from a carbon footprint perspective…



LCSA needed



LCA approach required

Impacts of the sizing and back-up fossil fuels?

Impacts of future systems?

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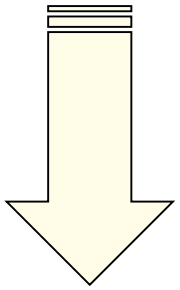
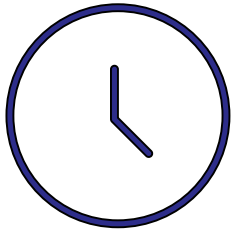
Background

Within this context, the project **SH2E** aims to set guidelines and tools for LCSA of fuel cells and hydrogen systems



Future systems sustainability



Prospective LCA – Case study of H_2 from SOE

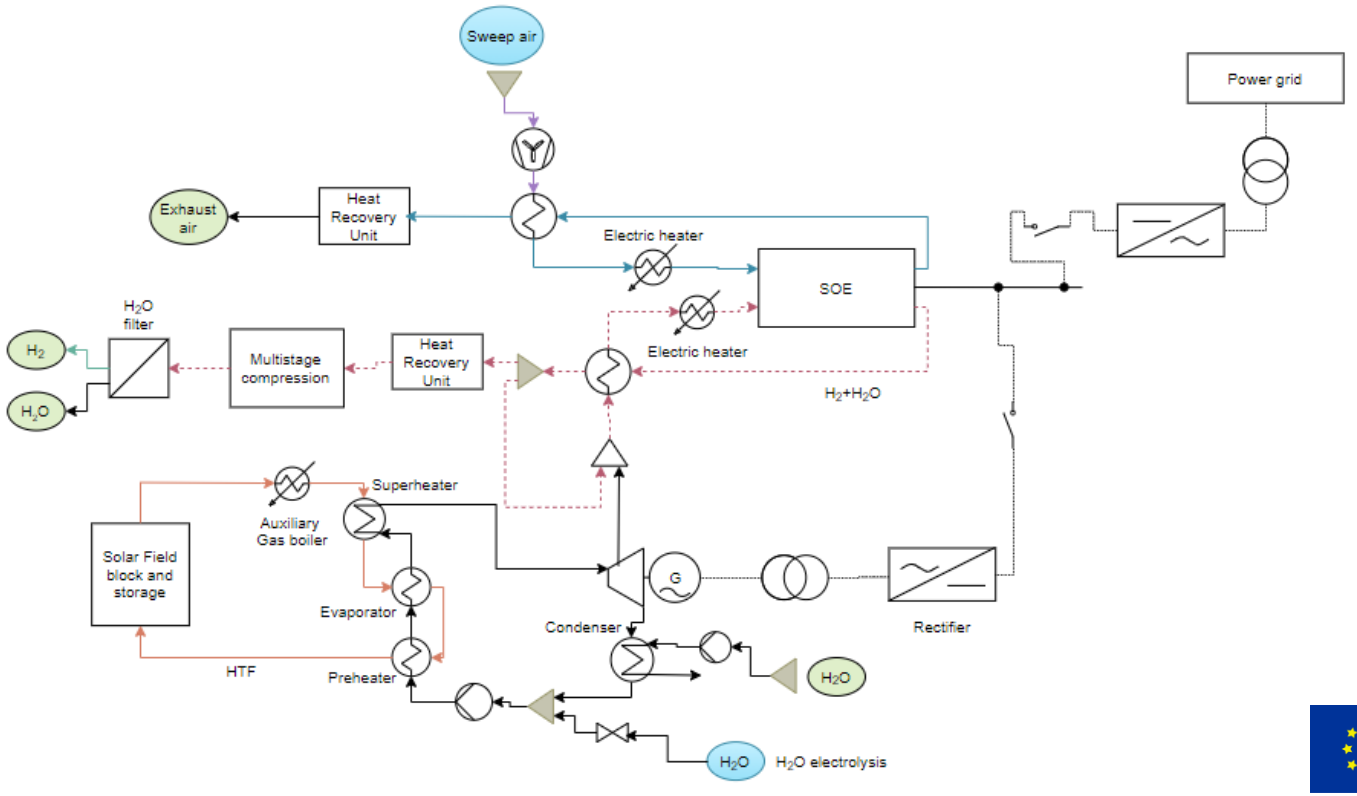
- ✓ TRL 5-6
- ✓ Expected to be commercially available in 2030
- ✓ Higher electrolysis efficiency
- ✓ Good coupling with low-carbon technologies (nuclear and CSP)

Methods

Parabolic trough CSP + SOE

CSP P_N = 12.41 MW → Thermal storage = 11.80 h, Capacity factor = 58.4%

SOE P_N = 3.52 MW → Initial hydrogen production of 98.8 kg/h



Manufacturing
- SOE
- CSP with storage
- BoP

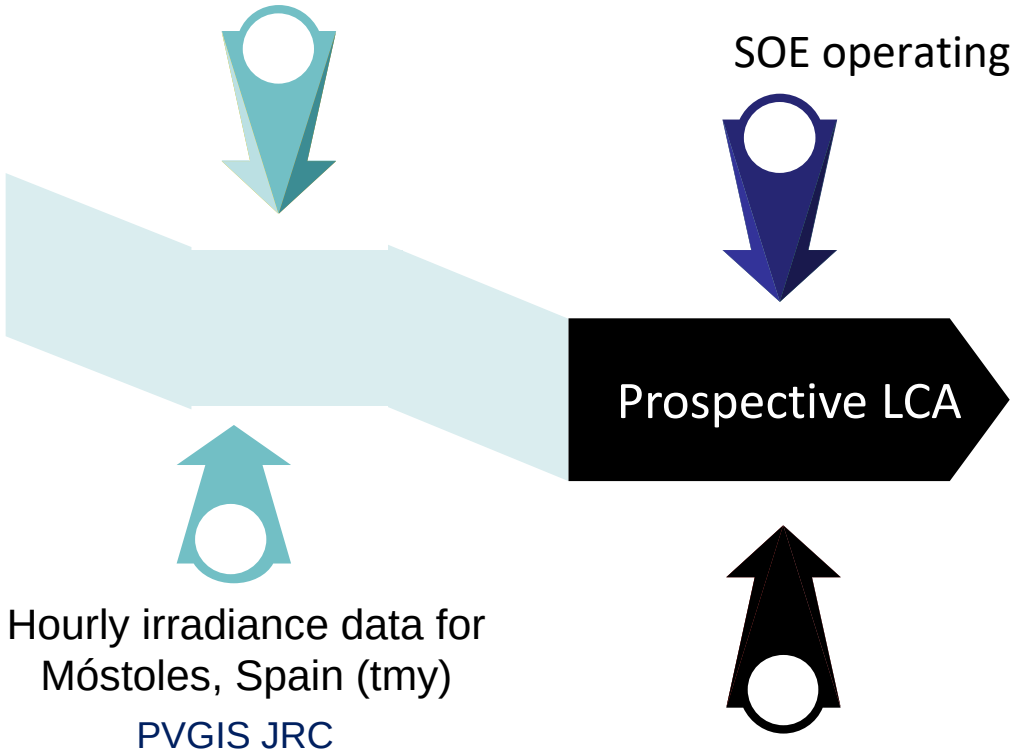
Operation
- Auxiliary NG
- Grid electricity

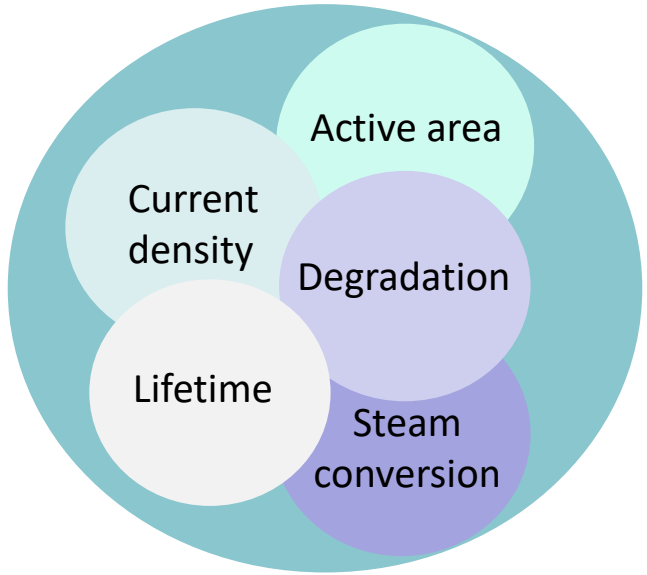
3 SOE needed to maintain operation over the CSP lifetime

Methods

Parabolic trough CSP coupling with SOE

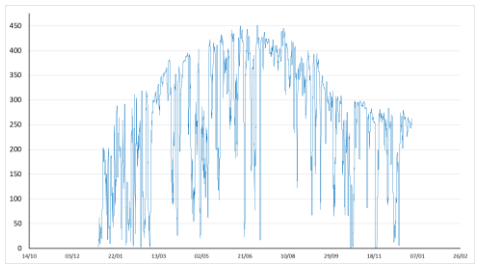
SOE operating conditions





Hourly irradiance data for Móstoles, Spain (tmy)

PVGIS JRC



Inventory for the Spanish 2030 electricity mix

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Modelling results

KPI results for the electrolyser are in line with Hydrogen Europe targets for 2030

Specific heat demand could be further reduced by heat recovery optimisation

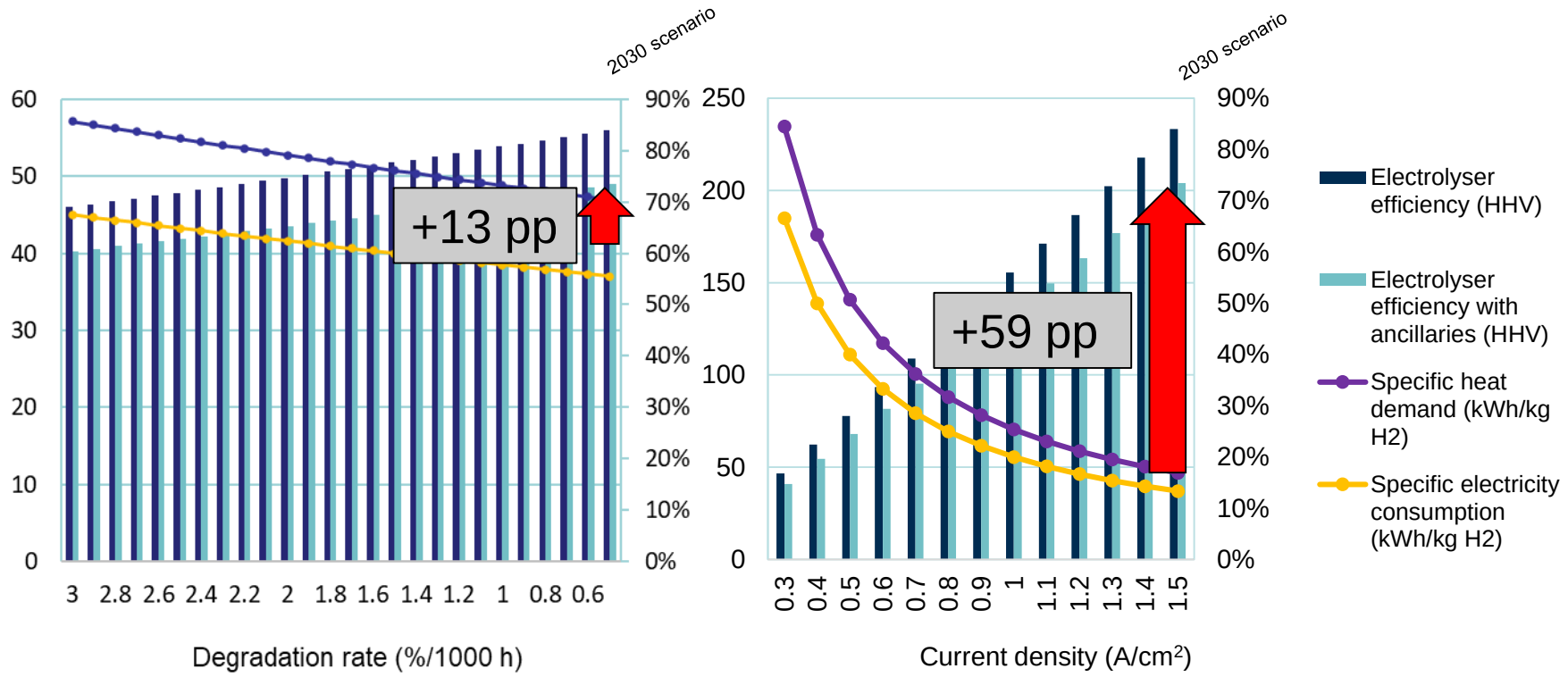
- ✓ SOE specific electricity consumption: 37 kWh/kg H_2
- ✓ SOE specific heat demand: 9.9 kWh/kg H_2
- ✓ SOE efficiency (HHV): 84 %
- ✓ SOE efficiency with ancillaries (HHV): 73%

Global system efficiency (annual basis)

$$Efficiency_{system} = \frac{Production_{H_2} \cdot HHV_{H_2}}{Heat\ demand + Total\ electricity\ demand}$$

Modelling results

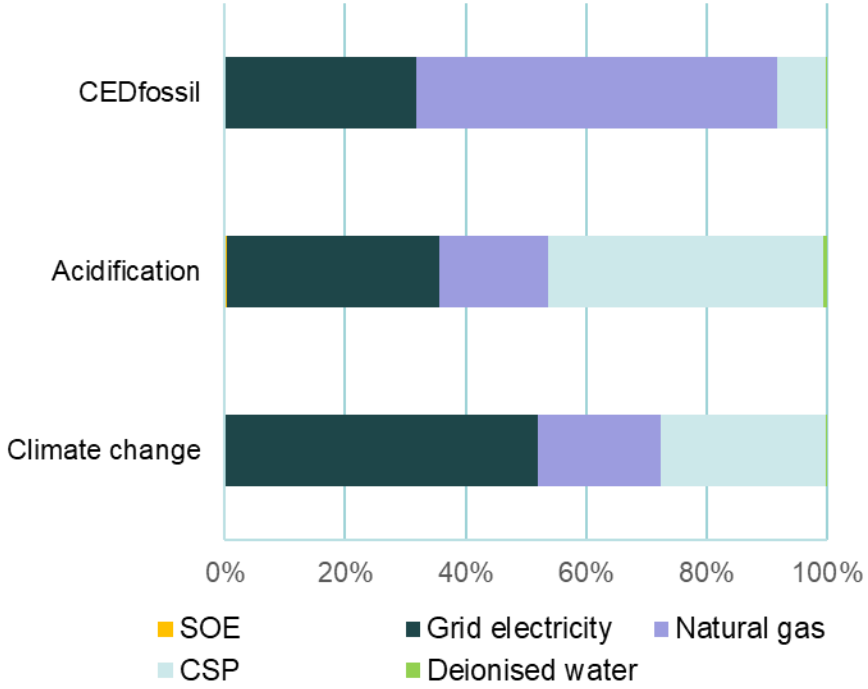
Impacts of the prospective parameters considered for the electrolyser on the KPI results



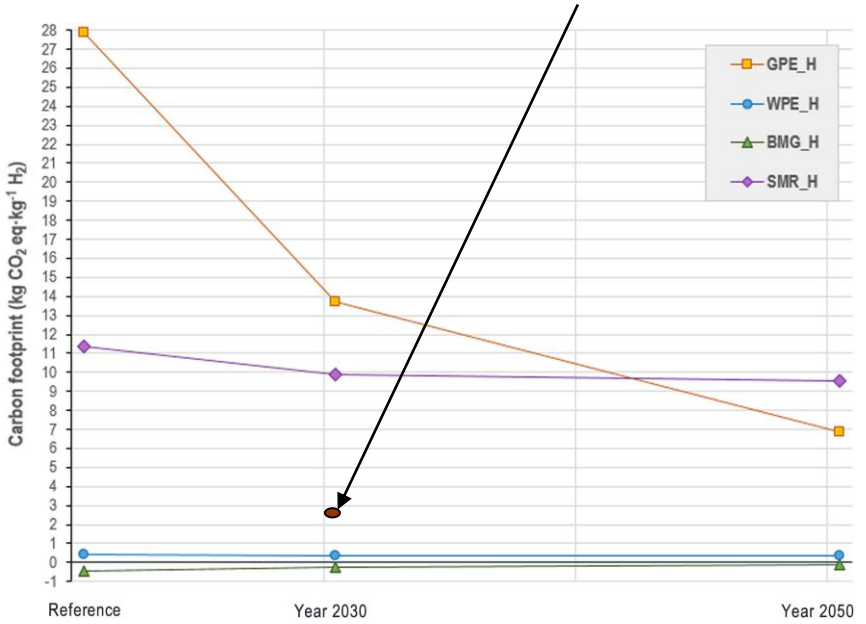
LCA Results

Annual mean carbon footprint of 2.73 kg CO_2 eq/kg H_2

Promising result if correctly located and sized



2030 contextualisation

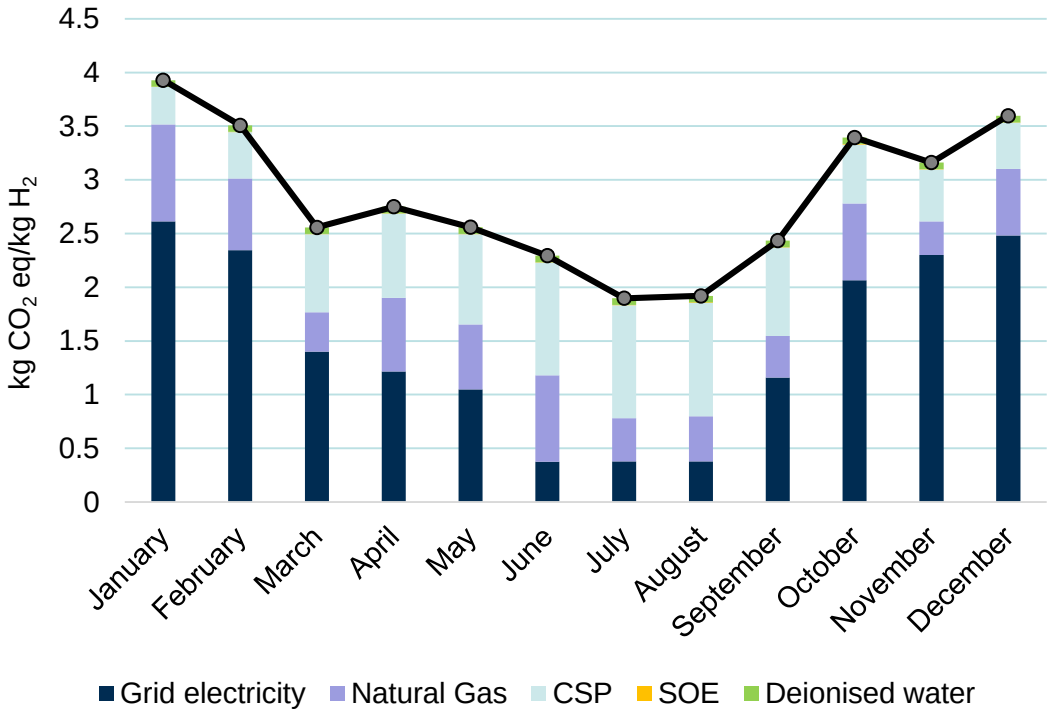


Based on Valente et al. (2020)

LCA Results

LCA results strongly depend on the time of the year in which the “photo” is taken

The case of GWP

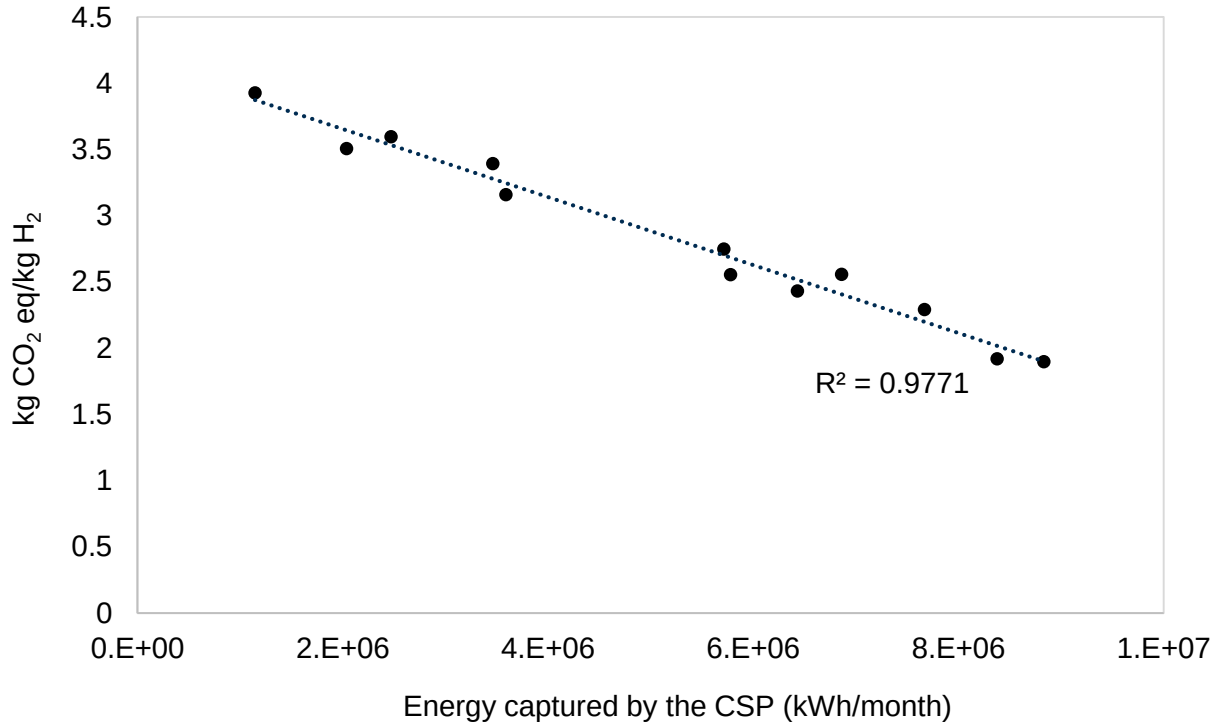


Higher degree of detail thanks to process modelling

LCA Results

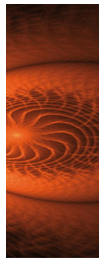
CSP location is a key factor not only from an economic perspective but also for carbon footprint

The case of GWP



Conclusions

- ✓ Prospective LCA is required to appropriately support decision-making in this case study
- ✓ Hydrogen production from SOE is a promising option from a carbon footprint perspective
- ✓ Renewable energies intermittency plays a major role
  - ✓ LCA results might vary a lot for SOE plants because of their low flexibility regarding operation mode
  - ✓ SOE itself has a very low contribution to the selected indicators



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Thank you for your attention!

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