Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

Aachen Hydrogen Colloquium 2023

Solar Heat Supported High Temperature Cell Electrolysis

Timo Roeder [1,2] | Kai Risthaus [1] | Nathalie Monnerie [1] | Prof. Christian Sattler [1,2]

Background and Motivation

- Using green hydrogen is a promising way to avoid greenhouse gas emissions in a future energy system
- Solar energy is an enormous energy source and using a combination of PV and CSP plants including thermal energy storage can provide cost-efficient electricity even during night.
- High temperature electrolysis yields the highest electrical energy efficiency as high temperature heat can substitute a part of the electricity. The heat can be supplied with solar energy at low costs. Thus, OPEX can be reduced while CAPEX increase with such a system compared to other electrolysis systems.
- Therefore, a techno-economic analysis is conducted to identify the potential of concentrated solar heat supported high temperature electrolysis and to identify the main cost drivers.

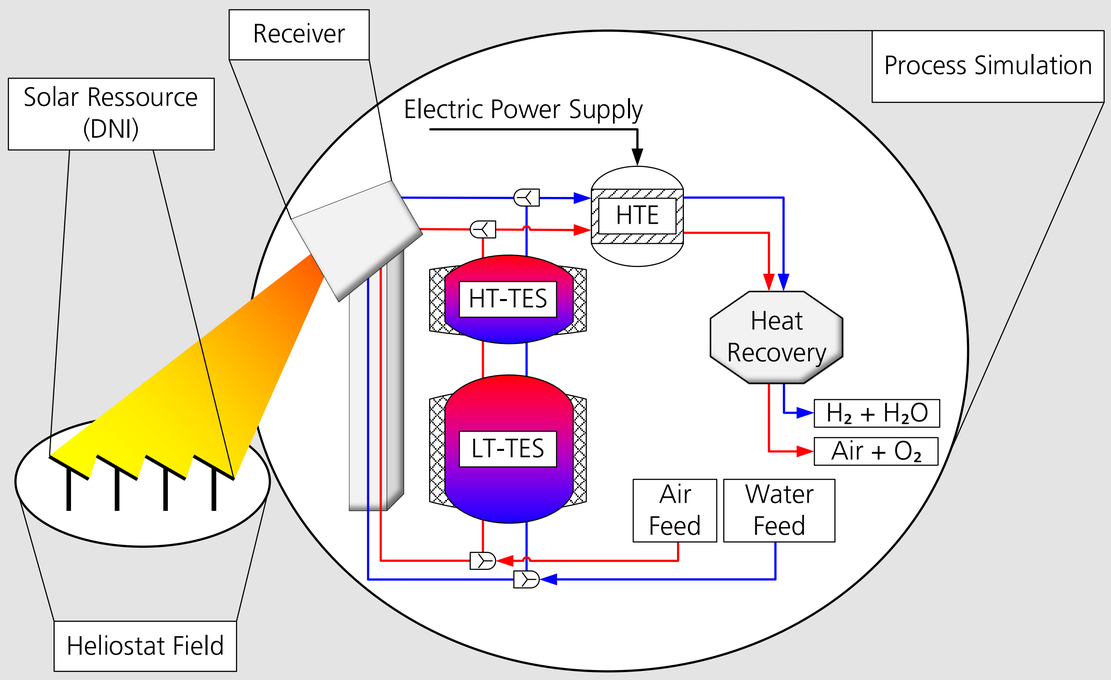
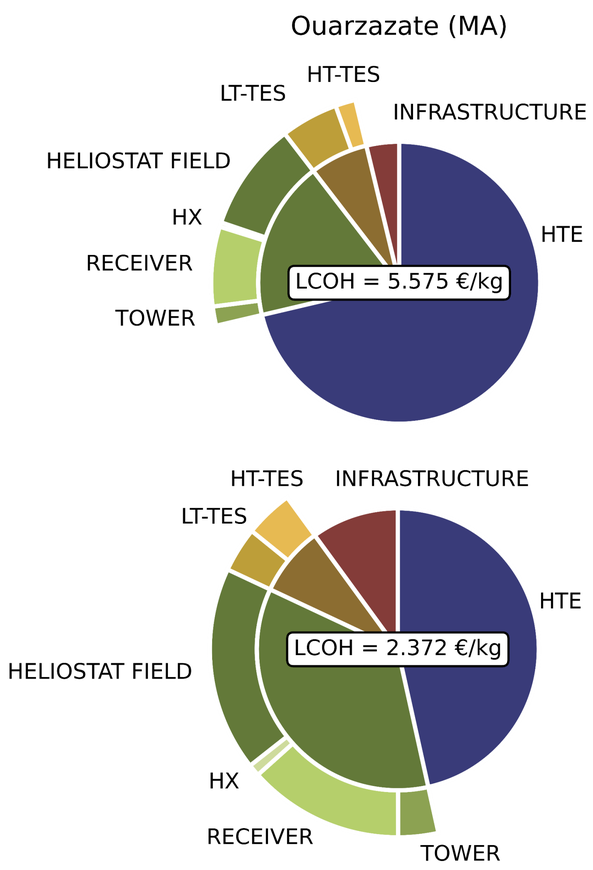


Figure 1: Concentrated Solar Heat Supported High Temperature Electrolysis Process

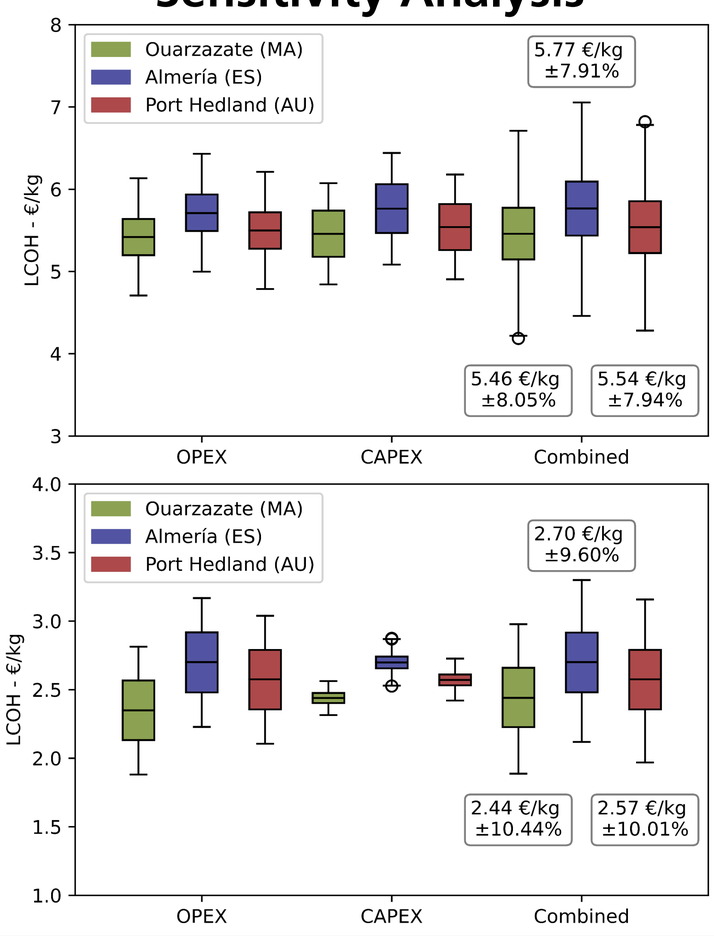
Methods and Assumptions

- Based on a selected location, hourly data of the solar resources are used to optimize the heliostat field and simulate the process including different control strategies.
- Techno-economic optimization of the system to minimize the LCOH by variation of:
  - Electrolyser power
  - Thermal storage capacity
  - Location dependent solar resources
- Sensitivity analysis using Monte Carlo simulation with ±25% cost parameter variation.
- Main assumptions:
  - Fixed average costs for electricity
  - Electrolyser lifetime of 40,000 h and 80,000 h in 2020 and 2035, respectively.
  - Economy of Scale is neglected.

Techno-Economic Assessment



Sensitivity Analysis



Conclusion

- To achieve low LCOH, the specific investment costs must first be reduced. Further, the electricity price has a major influence on the production costs in the 2035 scenario with lower CAPEX. Therefore, operating scenarios with variable electricity price have to be investigated.
- Larger thermal energy storage capacities increase process full load hours and decrease LCOH. This has a smaller impact at sites with high solar irradiance.
- With investigated cost development goals the solar powered high temperature electrolysis process is a potentially cost-effective technology for green hydrogen production. With further studies on the impact of economies of scale, a potential reduction in capital cost could lead to lower LCOH.

References

[1] Dersch, Jürgen und Dieckmann, Simon und Hennecke, Klaus und Pitz-Paal, Robert und Krüger, Dirk Rinus und Taylor, Michael und Ralon, Pablo (2020) LCOE Reduction Potential of Parabolic Trough and Solar Tower Technology in G20 Countries until 2030. In: 2019 International Conference on Concentrating Solar Power and Chemical Energy Systems, SolarPACES 2019, 2303 (120002). AIP Publishing. SolarPACES Conference 2019, 1.-4. Oct. 2019, Deagu, Süd Korea. doi: 10.1063/5.0028883. ISBN 978-073544037-1. ISSN 0094-243X.

[2] Clean Hydrogen Joint-Undertaking (Clean Hydrogen JU), 2022. Strategic Research and Innovation Agenda (SRIA) 2021-2027. Available at: https://www.clean-hydrogen.europa.eu/about-us/key-documents/strategic-research-and-innovation-agenda_en

www.h2-cluster.de

[1] DLR - German Aerospace Center - Institute of Future Fuels
[2] RWTH University Aachen - Chair of Solar Fuel Production (DLR)

M.Sc. Timo Roeder | Research Scientist
Institute of Future Fuels | Solar Chemical Process Development
Telephone +49 2203 601 5205 | Timo.Roeder@dlr.de
www.DLR.de/FF