HyConSys - Hydrogen Control in Solar Thermal Parabolic Trough Heat Transfer Fluid Systems

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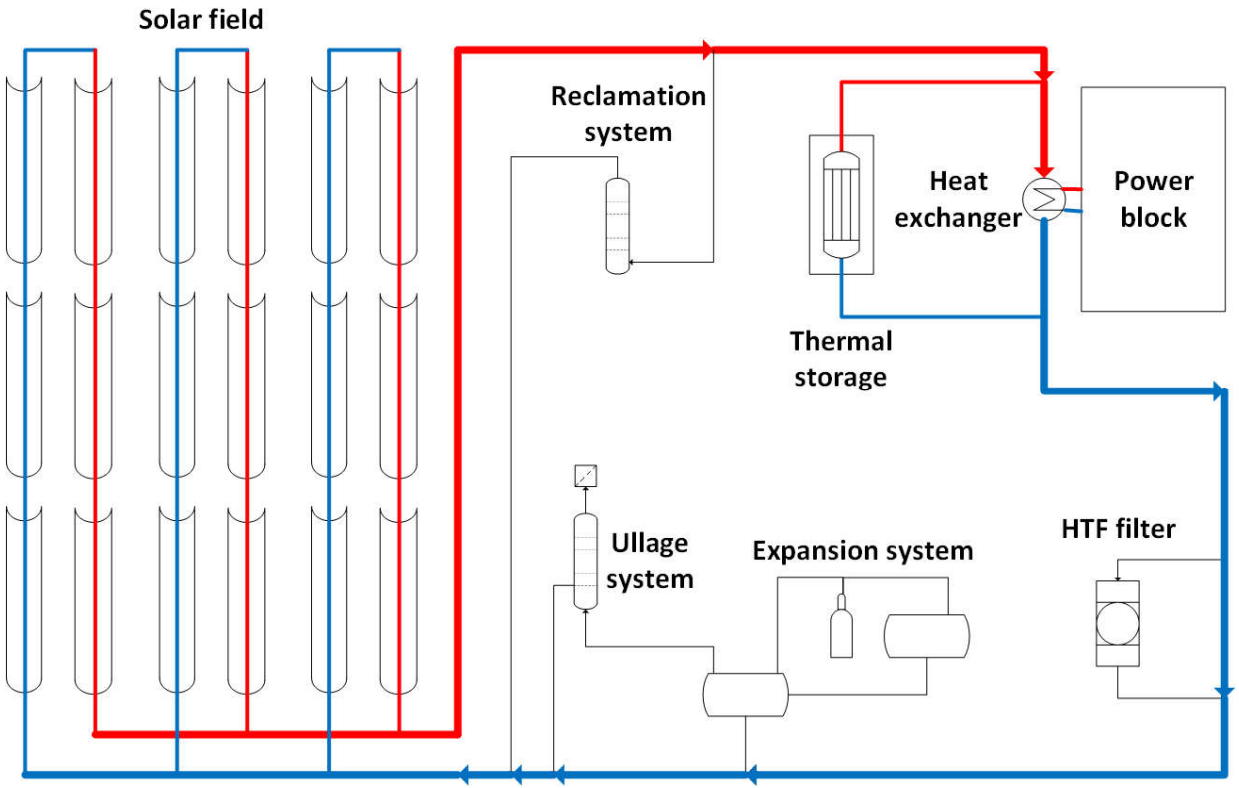
Outline

- Scientific and technical challenges
- Key outcomes, results and benefits
- Dissemination and exploitation
- Experiences gained in transnational set-up
- Critical factors and lessons learned

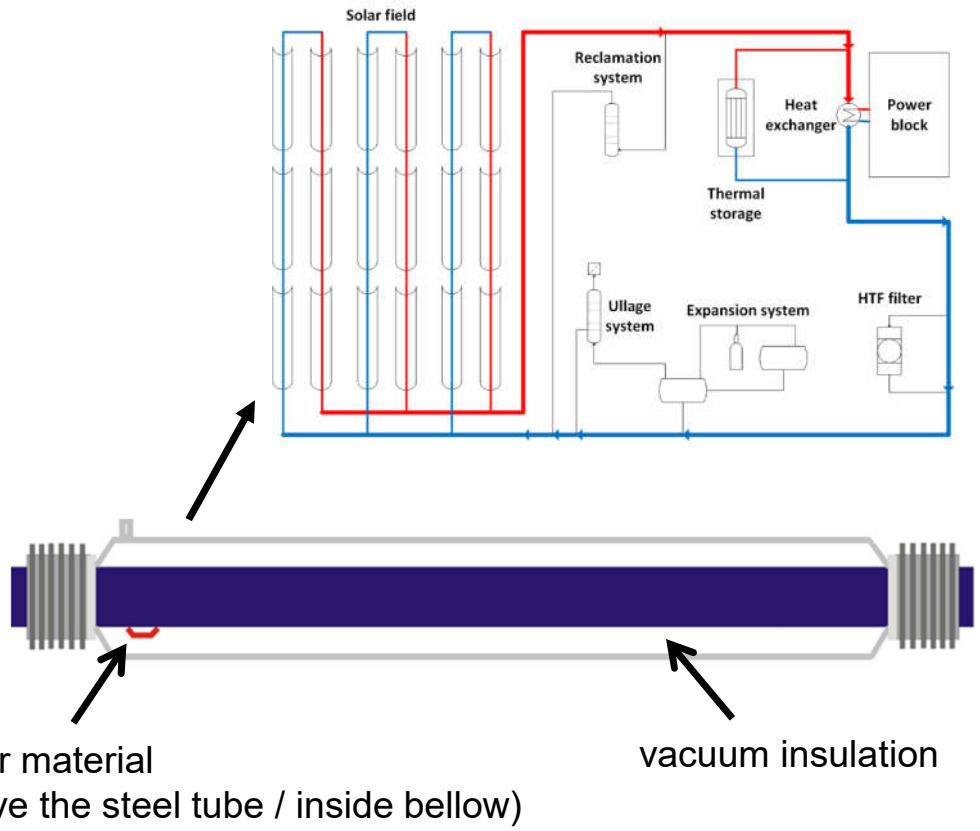
Solar Thermal Parabolic Trough Systems – A Short Overview

- Solar power is collected with mirror & receivers (heat collecting elements, HCEs)
- Heat transfer fluid (HTF) transports heat to the power block or the thermal storage (cold HTF ~ 293 °C, hot HTF ~393 °C)
- HTF is composed of biphenyl (BP) and diphenyl oxide (DPO)
- BP/DPO needs some processing due to slow decomposition at 393 °C
  - Ullage – low boiler removal
  - Reclamation – high boiler removal
  - No specific gas removal



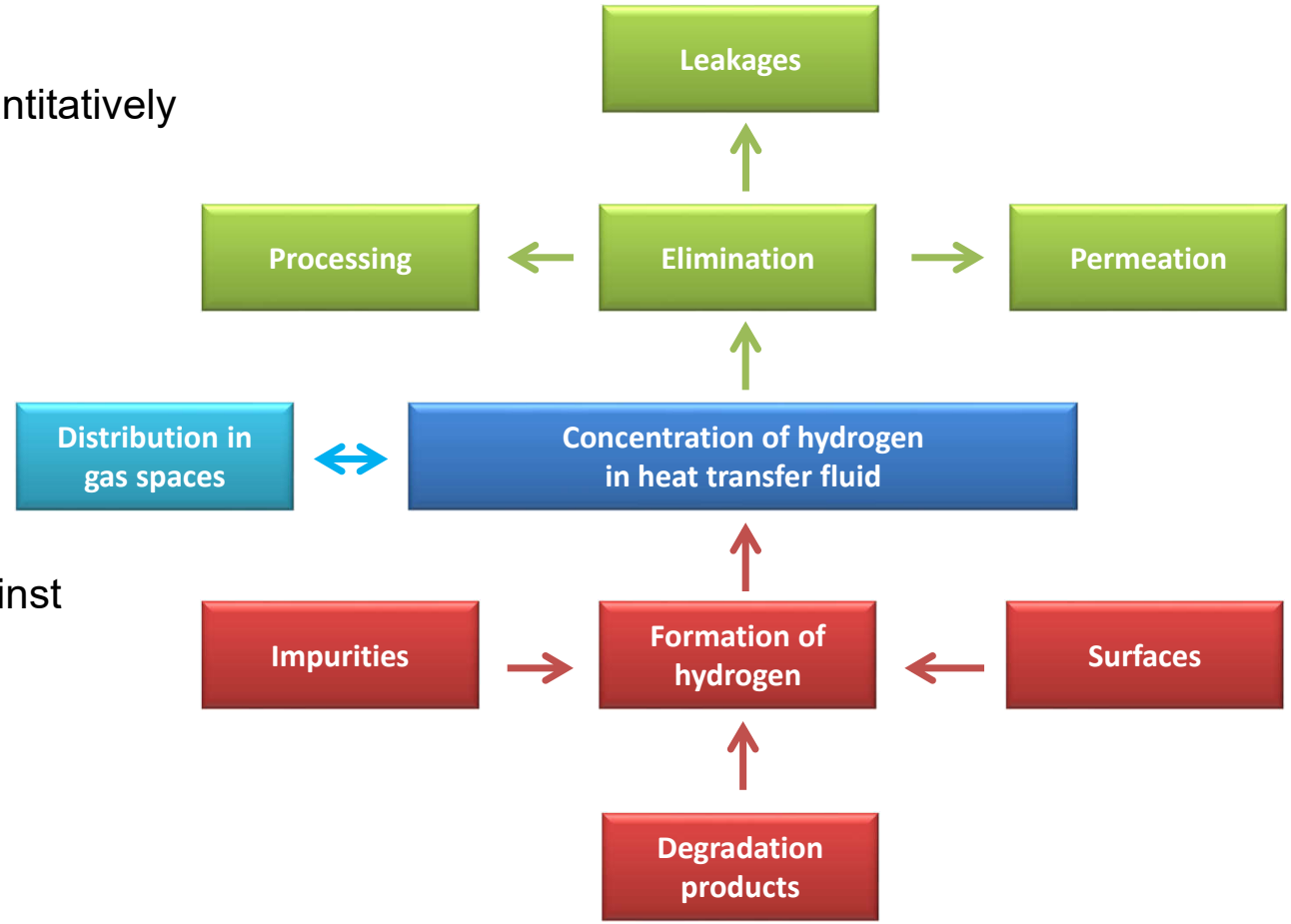
Hydrogen – A Challenge for Vacuum Insulations of Solar Receivers

- Heat collecting elements (HCE) in solar field
  - Intact vacuum insulation at 0,001 mbar
    - 250 W/m heat loss at 400 °C (for PTR-70 receiver)
  - Compromised insulation with 0,3 mbar hydrogen
    - 450 W/m additional heat loss at only 350 °C
- Hydrogen limit <u>in heat transfer fluid</u>
  - 0,3 mbar effective pressure
    - ~0,8 µmol/kg
      - 3 g hydrogen in 2000 t HTF!



Scientific and Technical Challenges in Hyconsys

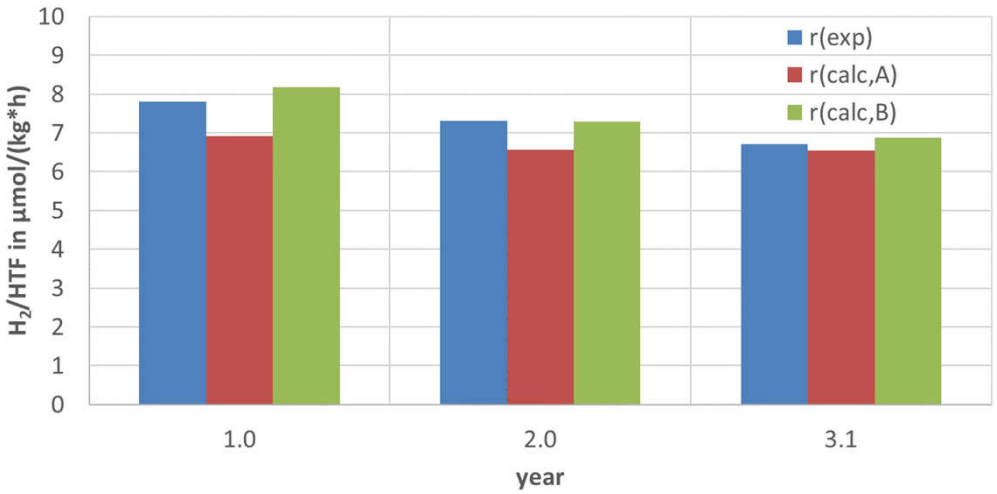
- Understanding hydrogen in the system quantitatively
  - Generation rate
  - Distribution
  - Losses
- Simulation model for hydrogen
- Establishing on-site H_2 monitoring
- Developing effective countermeasures against accumulation of hydrogen



Key outcomes, results and benefits - Hydrogen Formation

- Kinetic data derived from lab studies
  - Enhanced hydrogen formation rate accessible from kinetic model and chemical analysis of HTF

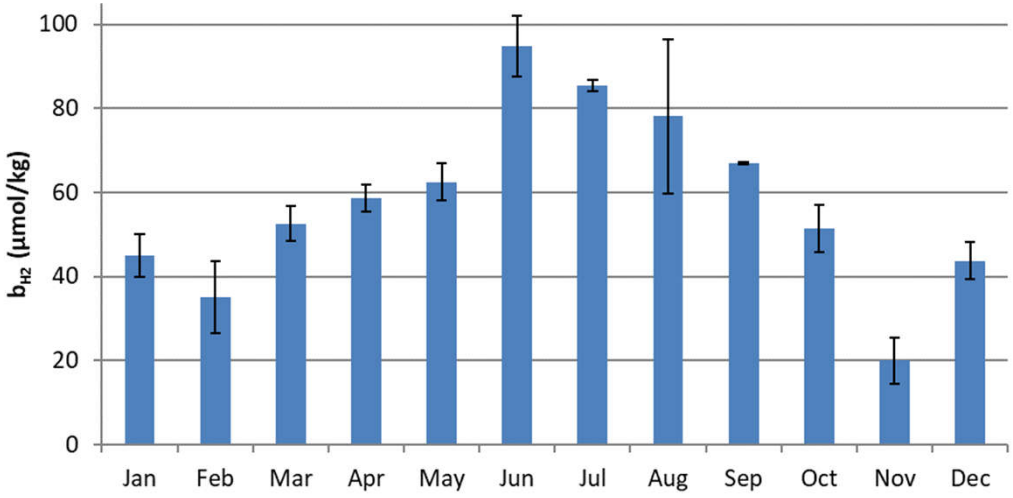
- Hydrogen formation rate validated over three years with data from Spanish CSP plant
  - Less than 5% deviation using specific kinetic parameters
  - Less than 10% deviation using generalized parameters



Specific hydrogen formation at 393 °C of used HTF from a Spanish CSP plant

Key outcomes, results and benefits - Hydrogen Monitoring and Modelling

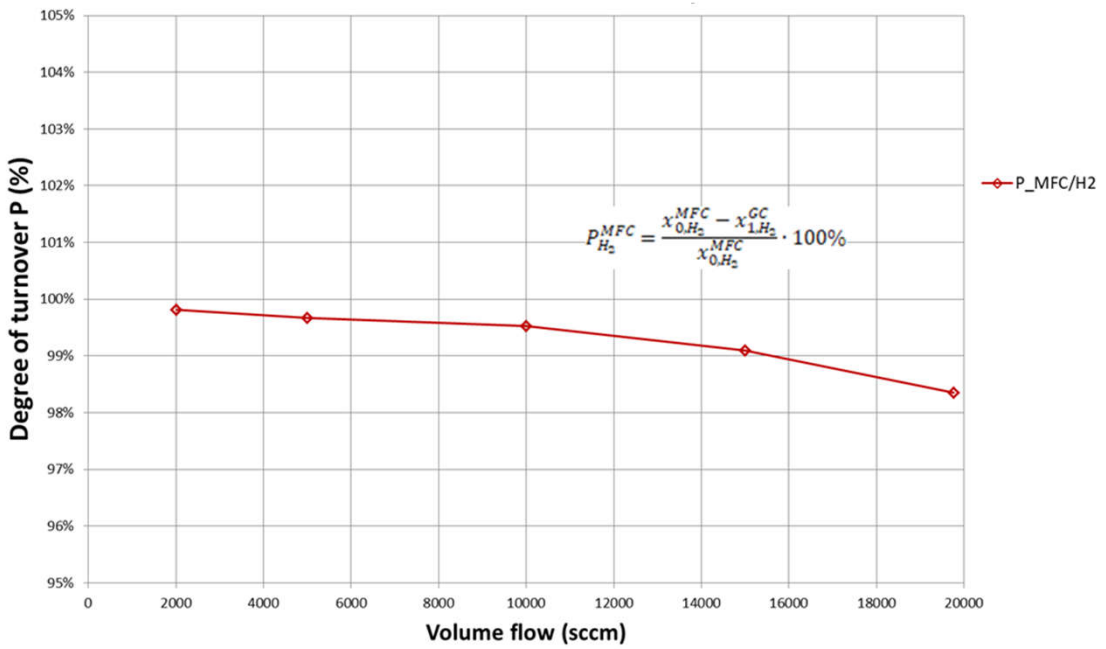
- Monitoring of hydrogen concentration in a Spanish plant over three years
  - Annual peak in summer
  - Effect of simple countermeasures confirmed
- Equipment for hydrogen monitoring developed and qualified over 28 months
- Model developed and validated with monitoring data
  - Trends and levels are satisfactorily predicted
  - Specific hydrogen removal techniques and dynamic processes to be embedded in follow-up project



Hydrogen monitoring in a parabolic trough plant

Key outcomes, results and benefits - Hydrogen Removal

- Hydrogen removal with nanostructured catalyst developed
- Complete hydrogen removal confirmed in presence of HTF vapor
- Data for demo study prepared



Degradation of 2000 ppm hydrogen/1000 ppm oxygen at 220 – 142 °C

Dissemination and exploitation

- Simulation model for hydrogen in parabolic trough systems
  - Basic version available for optimization studies
- Equipment for on-site monitoring available
  - Demonstration within follow-up project
- Nanostructured catalyst for hydrogen removal qualified
  - Demonstration within follow-up project
- Follow-up project Hyrec³ since May 2021
  - Only with German partners due to lack of opportunity within SOLAR-ERA.Net
    - Demonstration unit for catalytic removal in a CSP plant
    - Lab studies regarding data on hydrogen distribution
    - Additional features for simulation model
    - New developments for testing hydrogen saturation

Experiences gained in transnational set-up

- Cooperation with Spanish partners was intensive and efficient
  - Regular online meetings and exchange of data via TeamSite
  - Annual meetings in Spain
  - Associated partner in follow-up project (without funding)

Critical factors and lessons learned

- Project acquisition
  - Three application steps
    - Pre-proposal, full proposal, national proposal

- Project management
  - Extra reports to Solar-ERA.Net

  - National projects run independently
    - Timelines of projects can be different

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