HYDROSOL-3D
(FCH JU-2425224)

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HYDROSOL 3D & Partnership description

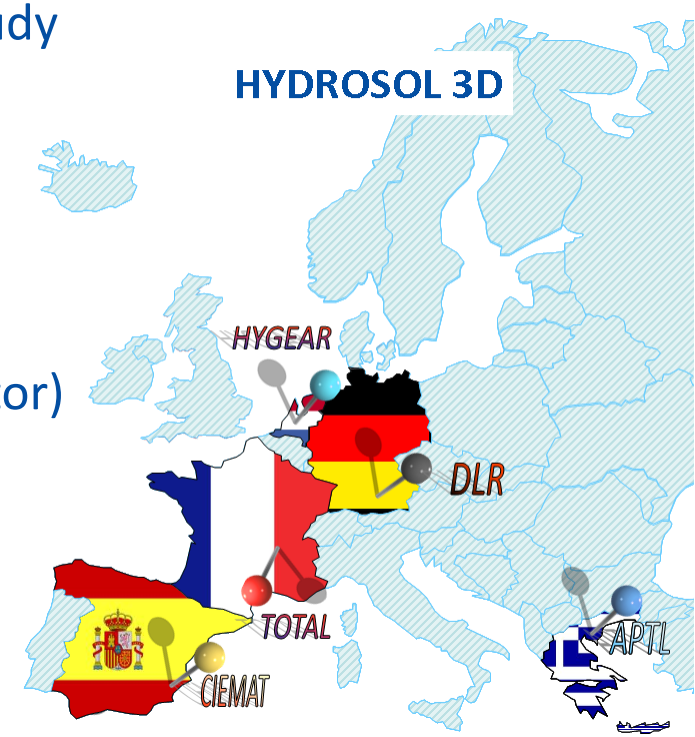
HYDROSOL 3D

Scale Up of Thermochemical **HYDRO**gen Production in a **SOL**ar Monolithic Reactor: a **3rd** Generation **D**esign Study

Duration: 01/01/10-31/12/12

Design of a 1MW Pilot Plant

FCH JU Budget: 1.73M€, EU Funding: 0.98M€



- Aerosol & Particle Technology Laboratory (Coordinator)
- DLR, Deutsches Zentrum für Luft und Raumfahrt
- CIEMAT, Centro de Investigaciones Energéticas, MedioAmbientales Y Tecnológicas
- TOTAL S.A.
- HYGEAR

HYDROSOL-3D achievements

- Fine-tuning of metal oxide redox materials
- Shaping into an absorber/monolithic structure

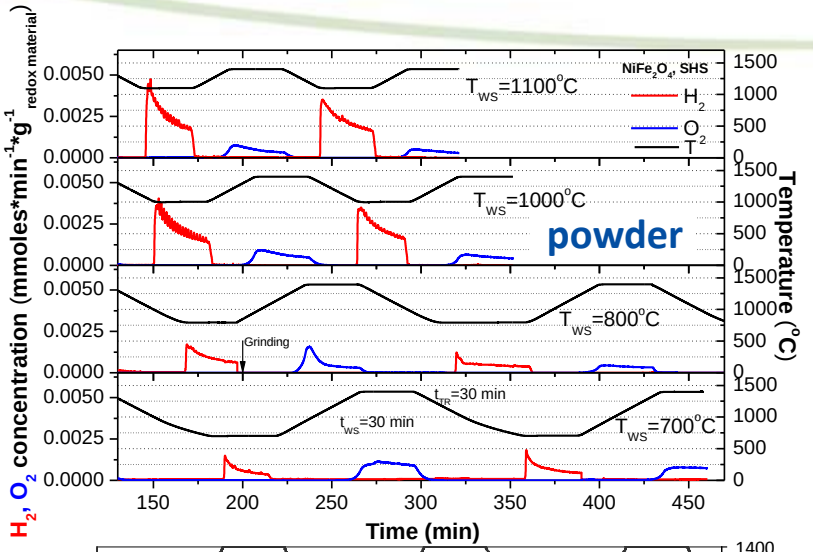
redox material

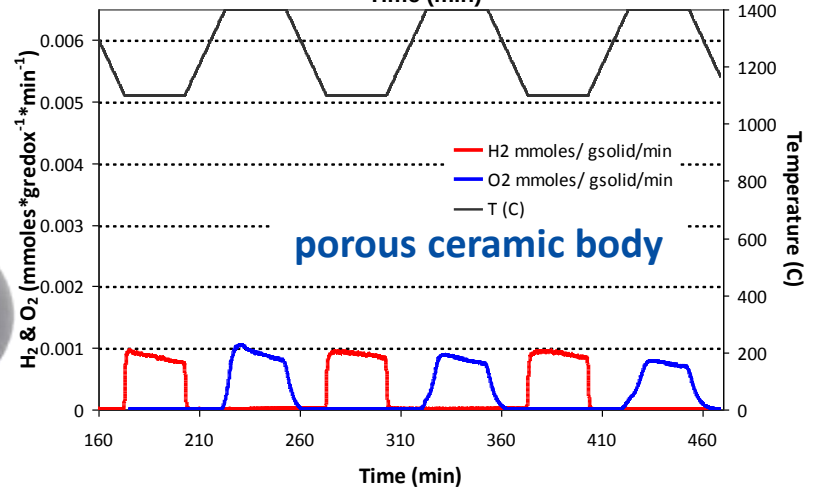
in-house designed hydraulic press

redox material shaped bodies

coated monolith

redox material shaped bodies

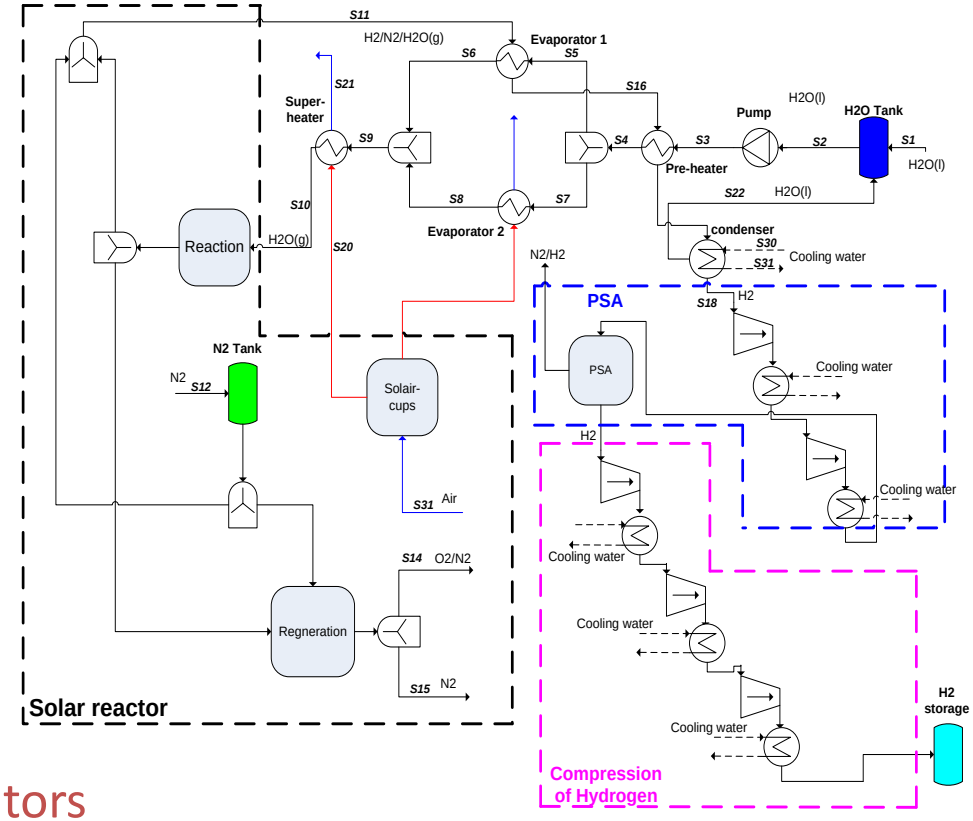




HYDROSOL-3D achievements

- Steady state simulation of the process
- Exergy analysis

Process unit	E_f [kW]	E_P [kW]	E_D [kW]	ε_k [%]	y_k[%]
Solar reactor	896	283	613	31.59	**60.51**
Pre-heater	3.26	1.26	2	38.65	0.19
Evaporator 1	35.89	14.02	21.87	39.06	**2.15**
Evaporator 2	41.03	20.59	20.44	50.18	**2.01**
Super-heater	4.69	3.97	0.7	84.64	0.1×10^{-3}
PSA	16.05	3.84	12	23.92	1.18
H_2 compression	16.04	7.06	8.98	44.01	0.88
Overall system	**1013**	**334**	**679**	**32.95**	

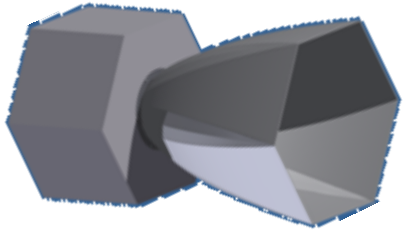


- High exergy destruction ratio

→ Optimization of solar reactor & evaporators

HYDROSOL-3D achievements

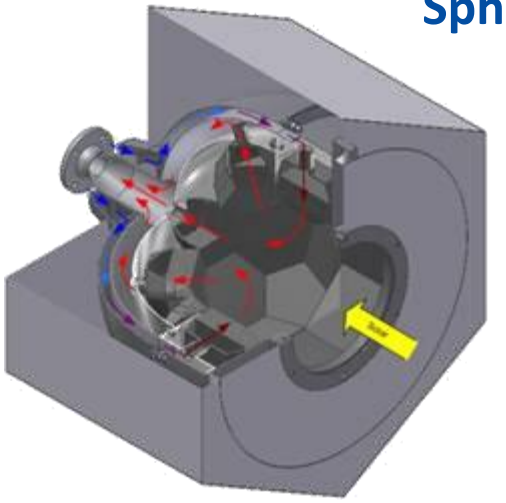
- **Design of secondary concentrator**

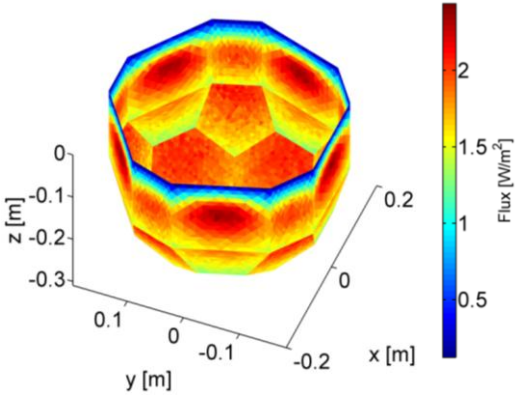


- **New Receiver/Reactor Design**

Absorber Possible shapes	Max. Quality value [-]
Flat	0,26
Conical	0,72
Spherical	0,94

Spherical shape



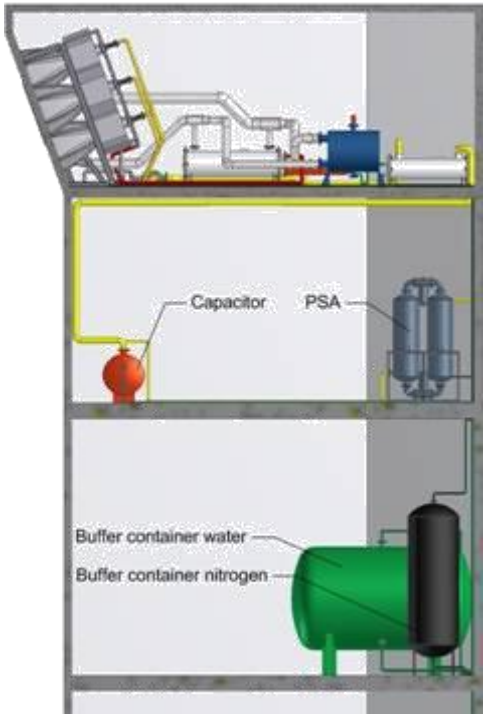


Integration of the HYDROSOL plant into a solar tower

Reactor Chamber

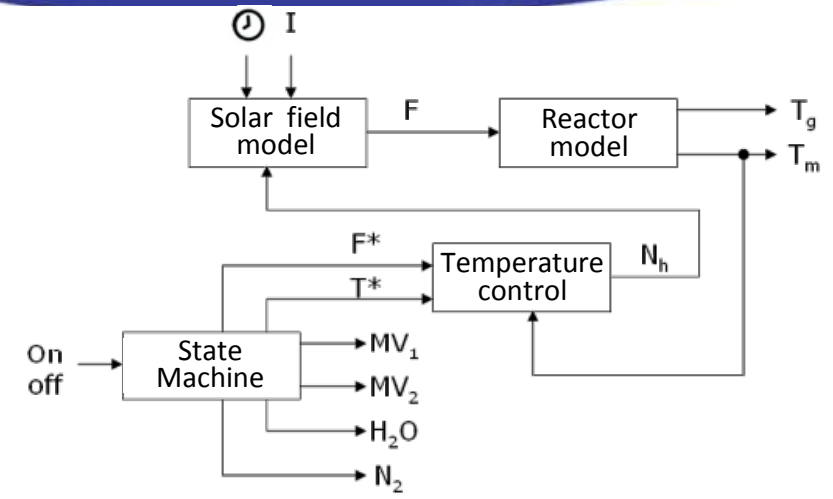
Outlet level

Buffer level

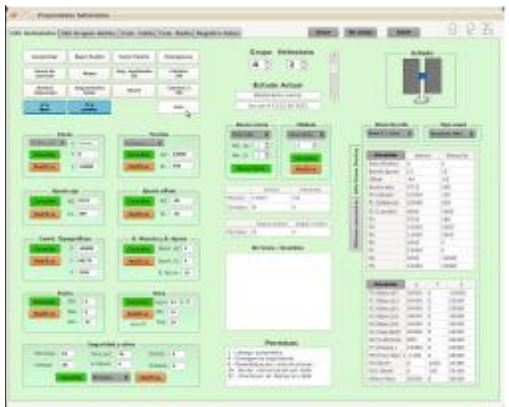


HYDROSOL-3D achievements

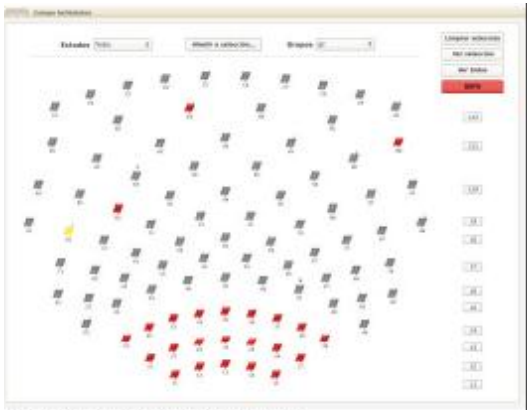
- Control concept based on HYDROSOL-II experience
- Development of a control/system program
- Steady state simulation of the process
- Pilot plant operation for validation of process strategies and optimization of critical process parameters



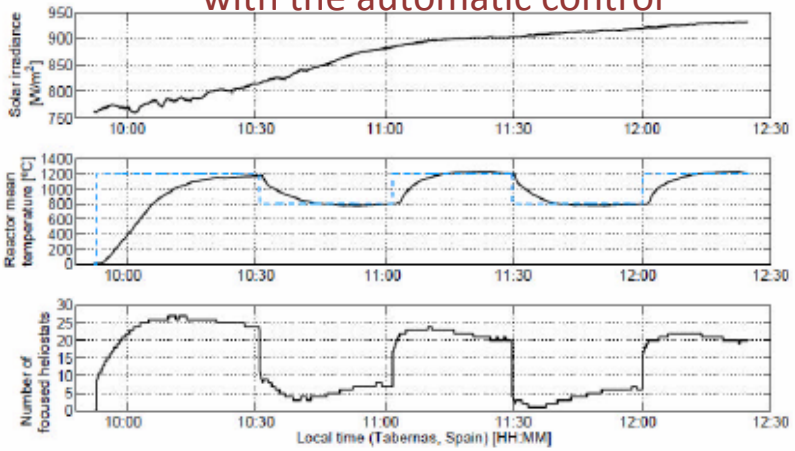
Supervisory control and data acquisition interface



Heliostat field distribution

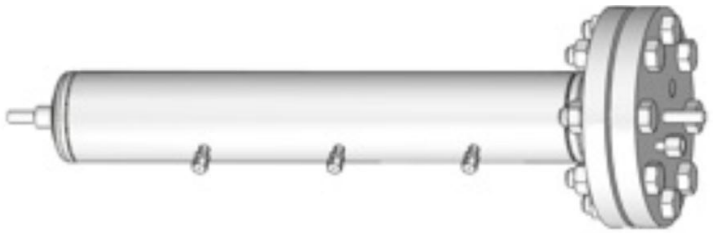


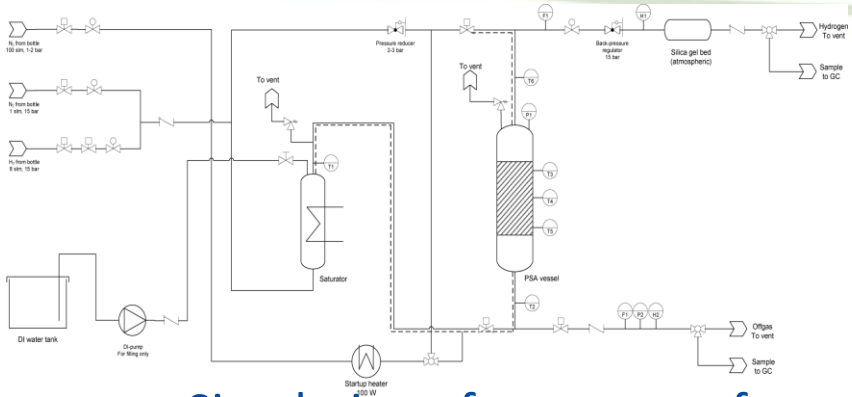
Experimental test in Hydrosol facility with the automatic control



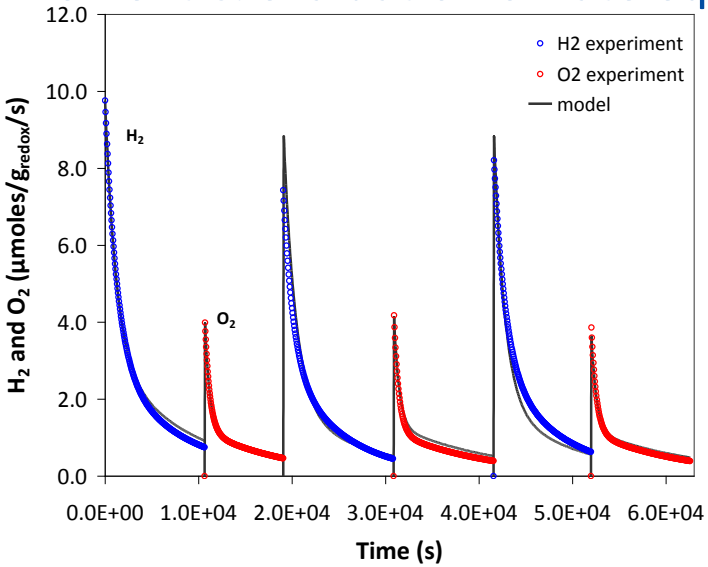
HYDROSOL-3D achievements

- Development, construction and operation of a lab-scale H_2 drying unit (PSA-based)

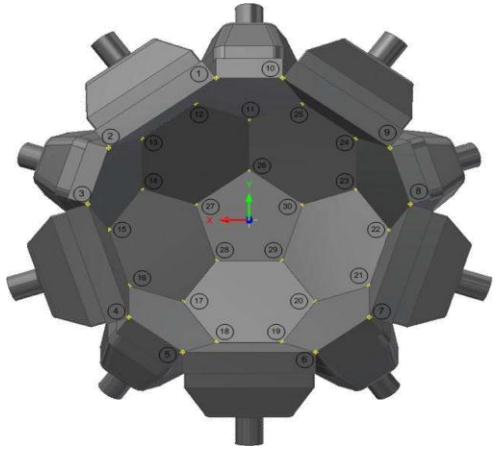




- Refinement & evaluation of rate equations



- Simulation of reactor performance



HYDROSOL-3D achievements

Technical Accomplishments & Progress towards overall project and SoA

Anticipated advances (beyond the SoA) after the completion of the project include:

- Redox reactor with long-term cyclic operation stability (a total of over 70 cycles) under operation at high temperature solar irradiation (up to 1200^{o}C)
- Ability to construct monolithic porous structures consisting entirely of the redox material
- Ability to construct a redox reactor with increased thermal uniformity
- A software tool for process engineering simulation at the MW scale
- Complete layouts of the whole plants and design of all specific components

Alignment to MAIP/AIP

AIP 2008 objective: Development of new reactor concepts with enhanced efficiency and scalability for future application

- Design of a new solar receiver/reactor for the production of H_2O via H_2O-splitting.
  - Improved, more efficient, scaled up version (1 MW) of the established HYDROSOL reactor concept.
  - Optimized Hydrogen production
  - Enhanced transport, thermal and heat recovery properties

AIP 2008 objective: Simulation of the reactor-system

- The control procedure of the pilot plant was simulated. The operational ranges and the process parameters were optimized, while process strategies were validated through pilot plant operation
- Modeling/simulation of core components and of the process as a whole

Alignment to MAIP/AIP

AIP 2008 objective: Design and simulation of a scaled-up system for a demonstration in the MW range

- Design of an integrated solar system of 1 MW scale
- A new improved solar reactor
  - A reactor dedicated to solar thermochemical water splitting, customized to the solar tower plant design
  - Extensive modeling & simulation activities
  - A secondary concentrator for the reduction of radiation losses
  - A design that minimizes heat losses and enhances heat recovery

Comparison with the expected outcome AIP

Topic: SP1-JTI-FCH.2.3: Water decomposition with solar heat Sources (Call: 2008)			
AIP expected outcome	**Project Objectives**	**Status**	**M**
Development of new high temperature reactors, component improvements	*Design of a reactor integrated with a solar tower*	✓	12
Simulation of the components and systems	*Simulation of the Pilot Plant*	✓	24
	Simulation of core components and of the process as a whole	✓	33
Design study of a scaled up reactor	*Design of 1 MW reactor for high-temperature H_2O-splitting, according to the following targets:*	✓	33
	Integrated process concept	✓	33
	Automation and control concept	✓	33
	Techno-economic study to determine the feasibility of the scale up of the process to industrial application.	⇨	36

Dissemination Activities

Within the 3 years of the project, the HYDROSOL consortium

- Has presented HYDROSOL-3D results so far in
  - 6 scientific journals
  - 12 Scientific conferences
  - 3 exhibitions & fairs
- Has supervised 4 Diploma thesis , 1 Master thesis
- Has supervised 1 PhD thesis

Technology Transfer / Collaborations

Technology transfer from the **HYDROSOL-3D** :

- Partners of the consortium have proceeded with the submission of the **HYDROSOL-PLANT** proposal which is the natural evolutionary step after HYDROSOL-3D, has received a high grade during the FCH-JU evaluation procedure and is in the pending list
- Partners of the consortium are participating in the **RESTRUCTURE** project which is based on the concept of honeycomb reactors for thermochemical processes
- National projects and regional collaborations have occurred

Acknowledgments

European Commission and FCH-JU

for supporting our project

Thank you for your attention!

More Info at: http://www.hydrosol3d.org/ & http://www.hydrosol-project.org/