# SOL2HY2
# Solar To Hydrogen Hybrid Cycles

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***Programme Review Days 2016***
***Brussels, 21-22 November***

# PROJECT OVERVIEW

| Project Information | |
|---|---|
| Call topic | SP1-JTI-FCH.2012.2.5 – Thermo-electrical-chemical processes with solar heat sources |
| Grant agreement number | 325320 |
| Application area (FP7) | Hydrogen Production |
| Start date | 01/06/2013 |
| End date | 30/11/2016 |
| Total budget (€) | 3,701,300 |
| FCH JU contribution (€) | 1,991,115 |
| Other contribution (€, source) | 214,000 (Tekes, FI) |
| Stage of implementation | 99% project months elapsed vs total project duration, at date of November 1, 2016 |
| Partners | Enginsoft (IT), Aalto (FI), ENEA (IT), DLR (DE), Outotec (FI), Erbicol (CH), Woikoski (FI) |

# PROJECT SUMMARY

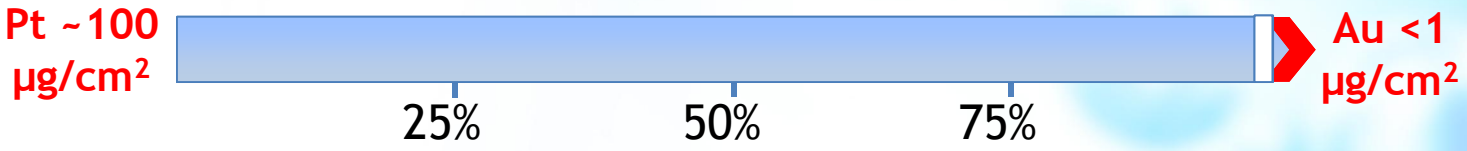
SOL 2HY2
Solar To Hydrogen Hybrid Cycles

- The project focuses on applied R&D and demo of the relevant-scale key components of the solar-powered, $CO_2$-free hybrid water splitting cycles, complemented by their advanced modeling and process simulation and site-specific optimization
- Solar-powered thermo-chemical cycles are capable to directly transfer concentrated sunlight into chemical energy. Of these, hybrid-sulfur (HyS) cycle was identified as the most promising, but its challenges remain in materials and the whole flowsheet optimization, tailored to specific solar input and plant site location.
- In the project, consortium developed solutions for the $SO_2$-depolarized electrolyser, sulfuric acid handling and for the BoP.
- The on-Sun demo has proven the said concepts and a new software tool were created, allowing the tailoring of such flexible plant at any worldwide location, leading to $H_2$ plants and technology “green concepts” commercialization.

# PROJECT PROGRESS/ACTIONS - Aspect 1

Achievement to-date

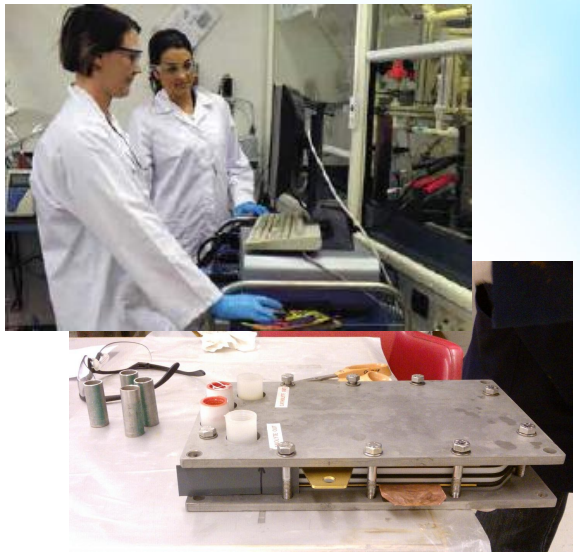
% stage of implement.




| Aspect addressed | Parameter (KPI) | Unit | SoA 2016 | FCH JU Targets | | |
|---|---|---|---|---|---|---|
| | | | | Call topic | 2017 | 2020 |
| Electrocatalysts | Pt/Pd load | µg/cm² | 100-500 | | | |

**Target achieved:**

- *Pt/Pd catalysts are substituted to gold nanoparticles and the load is decreased even by 100-500 times*
- *The activity of the catalyst towards $SO_2$ oxidation was respectively increased - note the values cannot be compared with water electrolysis due to different chemistry involved*
- *At the same time, parasitic reaction (sulfur formation at cathode due to carry-over) was analyzed and its suppression methods developed and tested*

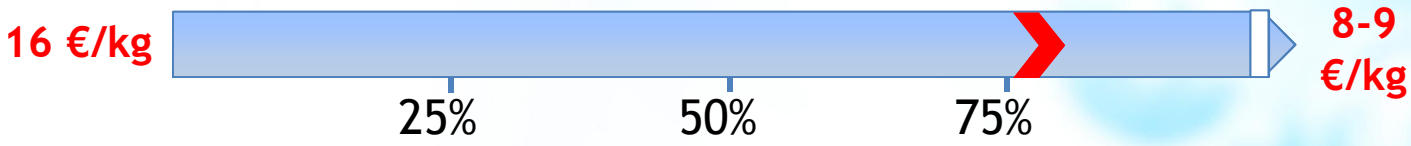


# PROJECT PROGRESS/ACTIONS - Aspect 2

Solar To Hydrogen Hybrid Cycles

Achievement to-date

% stage of implement.




| Aspect addressed | Parameter (KPI) | Unit | SoA 2016 | FCH JU Targets | | |
|---|---|---|---|---|---|---|
| | | | | Call topic | 2017 | 2020 |
| Excpected $H_2$ costs | Cost | €/kg | 10-16 | <5 | | |

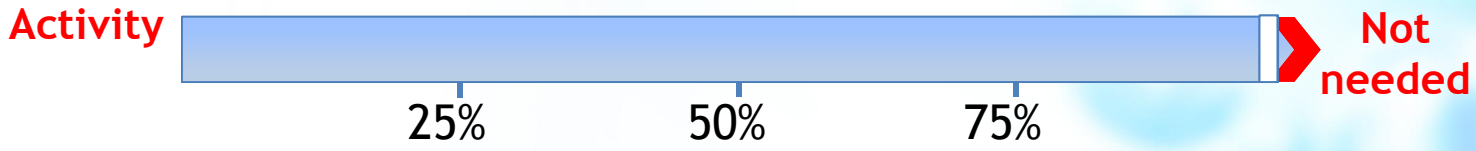
**Details:**

- *For Almeria plant with 50MW on mirrors, cost of hydrogen was analyzed vs. cycle opening, demand and power options:*
  - *Cycle opening by 30% drops $H_2$ costs twice (all scenarios)*
  - *Off-grid option with power block drops costs by ~30%*
  - *Full 100% RES use is possible even for fully open cycle*
- *New options with combination of PV and sulfur burning allow optimal solution vs. demand, %RES and plant location constrains*
- *A special optimization software tool produced*

# PROJECT PROGRESS/ACTIONS - Aspect 3

Achievement to-date

% stage of implement.




| Aspect addressed | Parameter (KPI) | Unit | SoA 2016 | FCH JU Targets | | |
|---|---|---|---|---|---|---|
| | | | | Call topic | 2017 | 2020 |
| Redox materials | Activity | - | | +50% efficiency | | |

**Target achieved:**

- *Redox materials are not used in the SOL2HY2 cycle*
- *Sulfuric acid cracking only utilize simple $Fe_2O_3$ catalysts, but the conversion rate depend more on cracker parameters and dynamics than catalysts presence*
- *Introduction of the flexible opening of the HyS cycle allows balancing between hydrogen and acid demand and the RES energy availability, which is impossible in traditional HyS cycle flowsheet*

# SYNERGIES WITH OTHER PROJECTS AND PROGRAMMES

| Interactions with projects funded under EU programmes | |
|---|---|
| *HYDROSOL-PLANT* | DLR as project partner develops a demo plant in Almeria, Spain for $H_2$ production via metal oxide thermochemical cycle. There is an intensive exchange with SOL2HY2. |
| *HYTHEC (2004-2007)* | Development of single-chamber solar reactor for sulphuric acid cracking in DLR's solar furnace |
| *HycycleS (2008-2011)* | Development of two-chamber solar reactor for sulphuric acid cracking in DLR's solar furnace. Catalyst development and characterization. Materials long-term corrosion testing. |
| **Interactions with national and international-level projects and initiatives** | |
| *US DOE SunShot (2010-2013)* | DLR acted as a subcontractor in this project. A joint workshop with SOL2HY2 consortium and Savanna River National Laboratory (SNRL), USA, was organized at DLR in December 2015. |

# DISSEMINATION ACTIVITIES

## Public deliverables

- D2.4 Results of testing of advanced SDE coatings and their selection
- D3.6 Stability of catalysts for SAC
- D4.8 Selected STH/STE concept
- D5.10 Selection of BOP components and interfaces for plant integration
- D7.12 Results of the demonstration of the components and plant concepts

## Conferences/Workshops

- 5 organised by the project
- 51 in which the project has participated (but not organised)

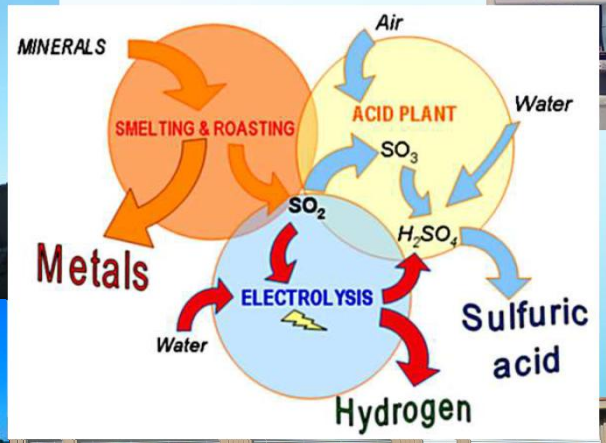
## Social media

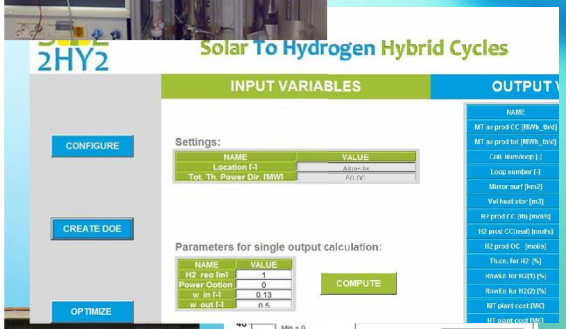
## Publications: 21

- *Performance of electrocatalytic gold coating on bipolar plates for SO2 depolarized electrolyser - AALTOA - Santasalo-Aarnio 1, A. Lokkiluoto, J. Virtanen1,M.M. Gasik -Journal of Power Sources, Vol. 306, Elsevier*
- *Process modelling and heat management of the solar hybrid sulfur cycle - DLR - A. Guerra Niehoff, N. Bayer Botero, A. Acharya, D. Thomey, M. Roeb, C. Sattler, R. Pitz-Paal - International Journal of Hydrogen Energy, Vol. 40 Issue 13, Elsevier*

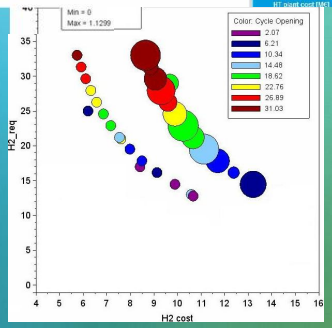
## Patents:

# Thank You!





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