

*SolarPACES ExCo Meeting  
Marrakech, Morocco, September 9, 2012*

## ***Task II – Solar Chemistry Research OA Report***

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## **Purpose**

The primary purpose of Task II (Solar Chemistry Research) is to

- develop and optimize solar-driven thermo-chemical processes for the production of fuels and materials

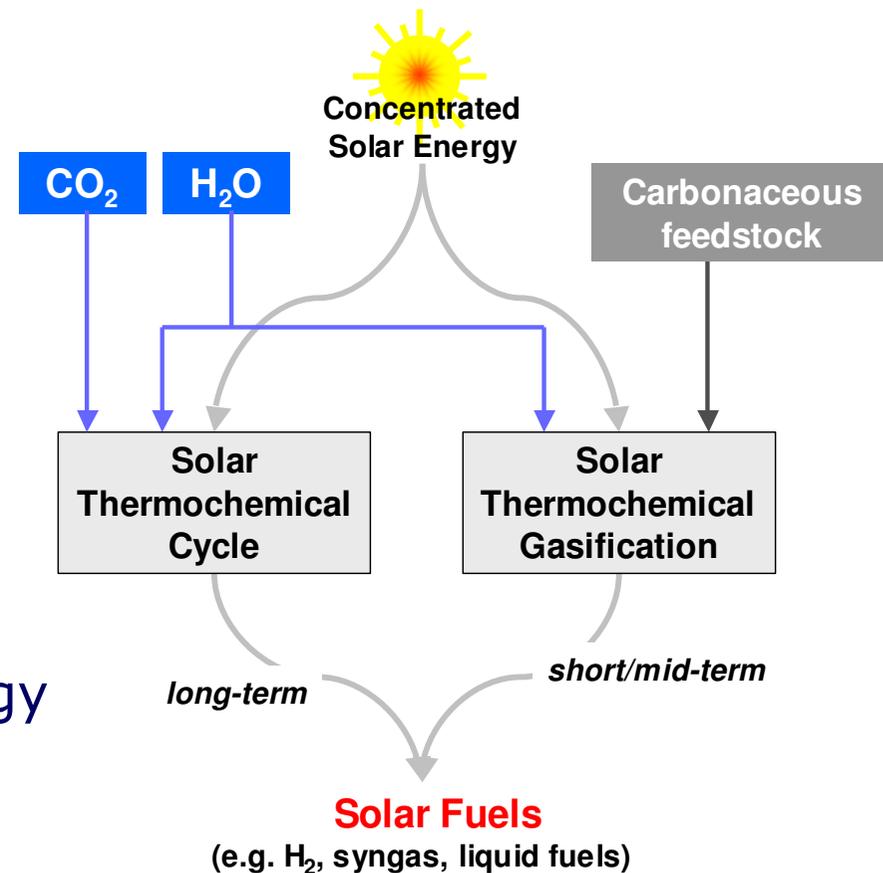
and

- demonstrate—at an industrial scale—their technical and economic feasibility

Task II Activities reflect the future challenges and foster active participation of SolarPACES member countries

## Activity 1: Solar Fuels (SF)

- **Near-term:**  
Demonstrate—at pilot scale—most advanced processes for solar production of synthetic fuels (e.g., cracking or steam reforming of NG, gasification of carbonaceous materials, carbo-thermal reduction of metal oxides)
- **Long-term:**  
Scale up solar reactor technology of promising two-step  $\text{H}_2\text{O}/\text{CO}_2$ -splitting processes for  $\text{H}_2$  and syngas production (e.g., Zn/ZnO & ferrite cycles)



# Task Activities

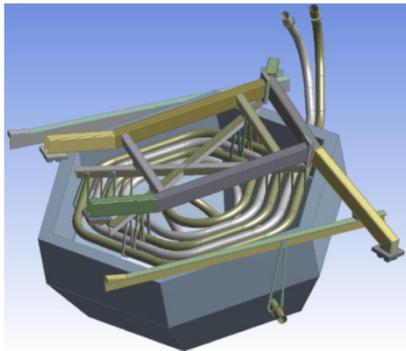
## Near-term: Solar production of syngas ( $H_2$ and CO)

Pilot plants have been built in the power range of 200-500 kW<sub>th</sub>

Steam reforming of  
natural gas / methane

Steam gasification of  
carbonaceous feedstock

SOLGAS (200 kW<sub>th</sub>)



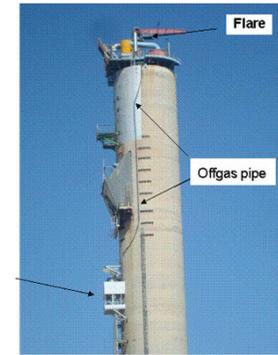
SOLREF (400 kW<sub>th</sub>)



SYNPET (500 kW<sub>th</sub>)



SOLSYN (250 kW<sub>th</sub>)



## Long-term: Solar production of H<sub>2</sub> and syngas

Metal oxide based thermo-chemical processes for H<sub>2</sub> and syngas production have been scaled up to the 100 kW<sub>th</sub> power level, e.g.:

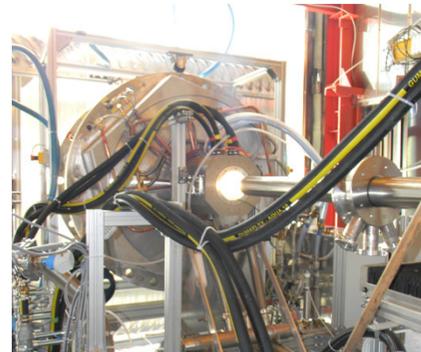
H<sub>2</sub> production using  
Ferrite H<sub>2</sub>O-splitting cycle

HYDROSOL (100 kW<sub>th</sub>) at PSA, Spain



H<sub>2</sub>/CO (syngas) production using  
Zn/ZnO H<sub>2</sub>O/CO<sub>2</sub>-splitting cycle

Solar2Zinc (100 kW<sub>th</sub>) at Odeillo, France



## **Activity 2: Solar Materials (SM)**

- Process chemical commodities using concentrated sunlight (e.g., aluminum production; EU project ENEXAL)

## **Activity 3: Thermo-chemical Storage (TS)**

- Develop novel thermo-chemical storage systems (e.g., EU project TCSPower)

## **Activity 4: Technology Innovation (TI)**

- Engineer improved reactor materials and components
- Design advanced heat recovery systems
- Implement concentrating optics for high solar flux intensities and high temperatures

## **Activity 5: Research Infrastructure (RI)**

- Optimize dedicated research infrastructure (e.g., EU project SFERA)

## **Activity 6: Market Penetration (MP)**

- Develop “Roadmap to Solar Fuels – Strategy for Industry Involvement and Market Penetration” (ExCo funding approved 2012)
- Involve industry in developing commercial applications of the most mature solar fuels technologies

# ***Task II Activity 6 with ExCo Funding***

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## **Roadmap to Solar Fuels**

### **Phase 1: Project Initiation and Concept Preparation (2012-2013)**

- Identify potentially interested industries—primarily from oil, gas, and coal sectors—and responsible governmental representatives in two selected host countries (Australia and South Africa)
- Prepare documents and presentations illustrating CO<sub>2</sub> mitigation and market potential of specific solar fuels (e.g., H<sub>2</sub>; syngas; liquid fuels)
- Organize workshops with interested high-level industrial and governmental representatives in the selected host countries
- Present “Solar Fuels Science and Technology” with well-developed showcase, e.g., “solar reforming and gasification” (SolarPACES experts)
- Initiate “Roadmap to Solar Fuels” (local and external SolarPACES experts together with identified industries and other interested bodies)
- Collect requisitions and pre-conditions for implementing the roadmap that will serve as a feedback for further development works to supply the country-specific needs.

## ***Task II Activity 6 with ExCo Funding***

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### **Roadmap to Solar Fuels**

#### **Phase 2 (anticipated for 2013-2014):**

- Perform screening analysis to identify the most promising options for solar fuels
- Develop a detailed and complete “Roadmap to Solar Fuels” (local and external SolarPACES experts, interested industries, and responsible governmental representatives).

# Task II Activity 6 with ExCo Funding

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## Workshop in South Africa:

Location – NWU, Potchefstroom (~150 km west of Johannesburg)

Date – Week 13<sup>th</sup>-15<sup>th</sup> February 2013

### Proposed Agenda:

1. Welcome/Introduction
2. Overview of Solar Fuels (SolarPACES Experts)
3. Solar Fuels Opportunities in RSA [TBD]
  - a. Petrochemical Industry (H<sub>2</sub>, syngas & liquid fuels)
  - b. Chemicals and Materials Production/Refinement
  - c. Thermo Chemical Storage & Thermal Storage
  - d. Coal Conversion
4. Panel Discussion
5. Closure

### Participants in Workshop:

1. Industry:
  - a. Eskom
  - b. Sasol
  - c. Refineries (PetroSA, Natref, Sapref)
  - d. Aluminium industry
  - e. Coal mining companies (Anglo American, Exxaro)
2. Government:
  - a. Department of Energy / SANEDI
  - b. Department of S&T / TIA
  - c. Provincial government reps
3. Academic/Research Institution:
  - a. CSIR
  - b. Mintek
  - c. Universities (U. Stellenbosch, U. Pretoria)
  - d. Technical Universities

# ***Task II Activity 6 with ExCo Funding***

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## **Workshop in Australia (1):**

Location and Date – CSIRO Newcastle, 18<sup>th</sup> April 2013

### Proposed Agenda:

1. Welcome/Introduction – (Stein / McNaughton)
2. Solar Fuels Science & Technology– (SolarPACES Experts)
3. Solar Thermal Fuels opportunities in Australia – (Stein / Lovegrove / McNaughton / Hinkley)
  - a. Remote Power
  - b. Coal Steam Gas Conversion
  - c. Natural Gas Processing
  - d. Coal Conversion
  - e. Remote Energy Storage
4. Panel discussion
  - a. Michael Epstein, WIS
  - b. Christian Sattler, DLR
  - c. Anton Meier, PSI
  - d. Stein, CSIRO / Lovegrove, ITP
5. Wrap (Stein / McNaughton)

#### **Audience:**

1. ARENA (Australian Govt)
2. State Governments
3. Australian Universities
4. Range of Industry but targeting
  - a. Coal Steam Producers
  - b. Mining Companies

## ***Task II Activity 6 with ExCo Funding***

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### **Workshop in Australia (2):**

Location and Date – Canberra, 19<sup>th</sup> April 2013 (morning)

Tentative plan:

1. High level meeting with key government persons
2. SolarPACES experts discuss solar fuels

## ***Task II Activity 6 with ExCo Funding***

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### **Time Schedule and Deliverables**

(Revised August 2012)

<b>Date</b>	<b>Activity</b>	<b>Deliverable</b>	<b>Responsible</b>
Jul / Aug 2012	Identification of industry; Preparation of workshop concept	List of interested industries, governments, academia, etc.; date and location of workshop	NC RSA & AUS; Task II OA
Sep 10, 2012	Meeting Marrakech	Approval of workshop concept	Task II OA
Oct / Nov 2012	Invitation of participants; workshop preparation	Flyer "Solar Fuels"; ppt-Presentation "Solar Fuels"	NC RSA & AUS; Task II OA
Feb 13-15, 2013	Workshop South Africa; Initial roadmap concept	Participants list; Meeting minutes; "Roadmap to Solar Fuels" concept	NC RSA
Apr 18-19, 2013	Workshop Australia; Initial roadmap concept	Participants list; Meeting minutes; "Roadmap to Solar Fuels" concept	NC AUS
Jun 2013	Preparation of initial roadmap document	Initial "Roadmap to Solar Fuels" document; Final report to ExCo	Task II OA

# Task II Activity 6 with ExCo Funding

## Budget Overview

Responsible (Institution)	Activity	Expenses	Initial Budget * (€)
Task II OA (PSI)	Coordination; Workshop participation; Initial roadmap concept	Documents (layout and printing); Reporting (technical, financial); Travels to workshops (max. 2)	5.000
SP expert (DLR)	Workshop participation; Initial roadmap concept	Travels to workshops (max. 2)	5.000
SP expert (WIS)	Workshop participation; Initial roadmap concept	Travels to workshops (max. 2)	5.000
NC AUS (CSIRO)	Preparatory work for workshop in AUS; Initial roadmap concept	Organization of 1-2 workshops with interested industries, governmental representatives, and SP experts	5.000
NC RSA (CSIR)	Preparatory work for workshop in RSA; Initial roadmap concept	Organization of 1-2 workshops with interested industries, governmental representatives, and SP experts	5.000

**\* Remark:** The initial budget is equally distributed among all participating institutions, assuming that travel costs approximately match expenses for workshop organization, and the amount of working hours will be similar for all participants. Note that own resources will be needed to fully cover salary costs.

## **Main focus of Task II**

Enable research and development (R&D) and—increasingly—pilot and demonstration (P&D) projects.

– **Information sharing (IS):**

- Reporting results from national and transnational projects (Task II Annual Meeting; SolarPACES Annual Report)

– **Active participation (AP):**

- Partnership within EU projects facilitated by SolarPACES contacts.
- Recently, an **EU-FP7 Call (FP7-ENERGY-2013-IRP)** for Integrated Research Programs (IPR) has been launched, explicitly addressing the European Energy Research Alliance (EERA), among them the EERA Joint Program CSP. The Task II OA is leading the Subprogram “Solar Thermochemical Production of Fuels” (STPF) and has been asked to coordinate the pertinent Work Package.
- Activity 6 (active participation of five countries)

## Task Activity / Country Matrix

Activity Country	1 Solar Fuels (SF)	2 Solar Materials (SM)	3 Thermochem. Storage (TS)	4 Technology Innovation (TI)	5 Research Infrastructure (RI)	6 Market Penetration (MP)
Australia	IS		IS	IS	IS	AP
(China)						
(EU)	(AP)	(AP)	(AP)	(AP)	(AP)	
France	AP, IS	AP	AP	AP	AP, IS	
Germany	AP, IS	AP	AP	AP	AP, IS	AP
Israel	AP, IS	AP	AP	IS	AP, IS	AP
Italy	AP, IS	AP	AP	AP	AP, IS	
Mexico					IS	
(Mitsubishi)						
R. Korea	IS			IS	IS	
South Africa		AP				AP
Spain	AP, IS	AP	AP	AP	AP, IS	
Switzerland	AP, IS	AP	AP	AP	AP, IS	AP
USA	IS	IS		IS	IS	
<b>AP through ... (IS resulting from national projects)</b>	EU projects HYDROSOL SOLARJET  EERA JP CSP	EU project ENEXAL	EU project TCSPower  EERA JP CSP	   EERA JP CSP	EU project SFERA  SOLLAB EERA JP CSP	Roadmap to Solar Fuels (ExCo funding approved in 2012)

### **Future prospects**

Further promote the development and deployment of promising solar thermo-chemical technologies and related solar infrastructure:

- Solar production of **liquid fuels** from water and CO<sub>2</sub>
- Solar processing of **materials**
- Thermo-chemical **storage** of solar energy
- Concentrating solar research and demonstration facilities (1-10 MW<sub>th</sub>) for **pre-commercial testing** of high-temperature thermo-chemical processes to produce solar fuels and materials

### Contacts with hydrogen community

- IEA's Hydrogen Implementing Agreement (**IEA-HIA**) Task 25 "High Temperature Processes for Hydrogen Production" (2007-2011):
  - Complementary activities have been pursued in developing a research roadmap for massive hydrogen production
- International Partnership for Hydrogen and Fuel Cells in the Economy (**IPHE**):
  - Two collaborative projects have been initiated towards the development of the most promising technologies for massive solar hydrogen production (reforming of methane; thermo-chemical cycles). However, loss of political support and shift away from research has stopped these promising projects.
  - Continuation of this initiative is warranted by pooling the expertise in solar hydrogen production from the US, Europe, Australia, and Japan (and maybe from more countries in the future)—potentially under the umbrella of SolarPACES.

### **Contacts with fuels community**

- So far, contacts with the **fuels community** are limited to collaborations with targeted industries in individual projects:
  - Examples:
    - Shell (EU project SOLARJET);
    - PDVSA, Petróleos de Venezuela (industrial project SYNPET)
  - In Activity 6, potential industrial players shall be identified:
    - SASOL
    - Refineries (PetroSA, Natref, Sapref)

## Structure

- Maintain network of **national coordinators**
  - Coordination of international solar chemical research, development and demonstration efforts
  - Exchange of technical and scientific information
  
- Keep **annual meeting** schedule
  - Forum for presenting and discussing major technological achievements in member countries
  - Task II Meeting, Granada, Spain, September 19, 2011
    - 17 attendees from 9 countries
  
- Organize targeted **workshops** with industrial and governmental representatives (see Activity 6)

### Task II Operating Agent

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