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Operating Agent IEA SolarPACES Task II (Solar Chemistry Research) 2016 - 2022

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SolarPACES
Solar Power & Chemical Energy Systems



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The author of this report bears the entire responsibility for the content and for the conclusions drawn therefrom.



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List of abbreviations

SFOE	Swiss Federal Office of Energy
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1 Introduction

BFE is contracting party of the International Energy Agency (IEA) SolarPACES Implementing Agreement and has designated Dr. Philipp Furler from Synhelion SA (until 2019 at ETH Zurich) as the Operating Agent (OA) of IEA-SolarPACES Task II (Solar Chemistry Research). The international activities of the OA are supported by the BFE.

SolarPACES – Solar Power and Chemical Energy Systems – is an Implementing Agreement of the IEA (International Energy Agency) to facilitate technology development, market deployment and energy partnerships for concentrating solar technologies. SolarPACES Task II addresses the demonstration, scale-up, and market penetration of solar-driven thermochemical processes for the production of fuels (e.g. hydrogen, syngas, methanol, kerosene, diesel) and materials (e.g. metals – Zn, Al, Fe) as well as thermochemical energy storage. Figure 1 shows the different Task II technology pathways.

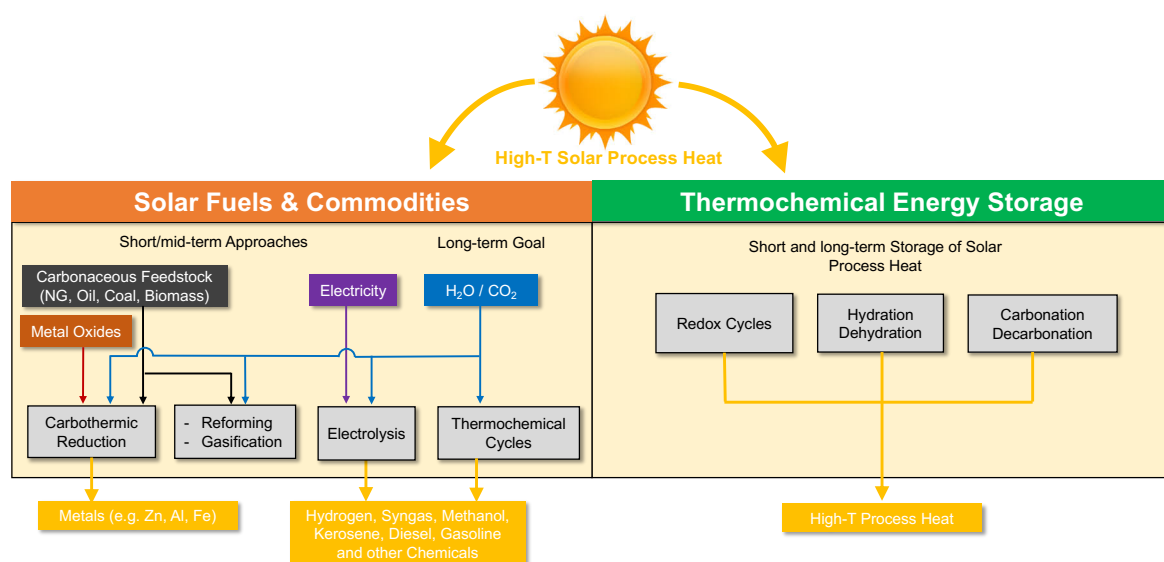


Figure 1: SolarPACES Task II technology pathways

2 Status of the Technology

Solar thermochemical processes offer efficient pathways for the conversion of carbonaceous feedstocks, minerals or pure water and carbon-dioxide into fuels and valuable materials with significantly lower greenhouse gas emissions compared to conventional processes. Concentrated solar radiation serves thereby as cheap and clean high-temperature process heat to drive the chemical reactions.

At present, solar thermochemical processes are at R&D state and not commercially implemented yet. Solar hybrid technologies, which combine solar energy with a carbonaceous feedstock, such as biomass or natural gas are closest to maturity. First pilot plants have been built and successfully tested. Synhelion SA is currently constructing the world's first industrial-scale solar fuels pilot plant in Jülich, Germany, that converts a bio-waste from the local paper industry with solar heat into sustainable transportation fuels. These hybrid technologies will be the first on the market and will path the way for the more challenging H₂O/CO₂ splitting processes. Those technologies will need more time to become economical as the technical complexity is higher. Nevertheless, substantial progress was achieved for the H₂O/CO₂ splitting processes over the last years, for example in the framework of the EU-funded research project Sun-to-Liquid, the entire production chain to clean jet fuel (kerosene) via thermochemical splitting of water and



carbon-dioxide was demonstrated at the 50 kW_{th} scale on a small tower system at IMDEA Energiea near Madrid. Furthermore, in the framework of the SFOE-funded project “Solar Dish-Reactor Technology for the Production of Liquid Transportation Fuels from H₂O and CO₂” (SI/501213-01) the production of CO₂-neutral fuels from air and sunlight was successfully demonstrated with a unique solar dish reactor system.

3 Executed work and results achieved in the period 01.08.2026 to 31.03.2022

In the period 01.08.2016 – 31.03.2022 substantial progress was achieved. 1) The Task II organization was strengthened by expanding the network of National Coordinators and through the introduction of appointed Technology Experts. 2) The Task II objectives and program of work has been updated and adjusted to reflect the current situation and 3) joint Task II activities have been defined and initiated. Finally, the leadership of Task II has been successfully handed over on March 31, 2022 to Dr. Woei Saw from the University of Adelaide, Australia, who will drive the activities further.

1) Task II organization and structure:

The operating agent is responsible for the organization and reporting of Task II activities. Currently, 14-member countries are active in Task II. Each member country is represented by a National Coordinator, which reports the individual country activities to the operating agent and the Task II community. Furthermore, appointed Topic Experts are in charge of tracking / reporting the status of the core technology routes and are coordinating sub-task activities. Figure 2 shows the current National coordinators and Topic Experts.

The operating agent organizes once a year a Task II meeting in conjunction with the SolarPACES conference, where the status of the Task II activities are discussed, the National Coordinators present the status of the individual country activities, and the Technology Experts report about the latest development, grand challenges, and roadmaps towards commercialization of the different technology routes. Furthermore, the operating agent reports the progress of Task II to the Executive Committee twice a year.



Operating Agent (2016-2022)		Dr. Philipp Furler Synhelion SA, Switzerland			New Operating Agent (from March 2022 onwards)	Dr. Woei Saw University of Adelaide	
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National Coordinators				
Australia		Dr. Woei Saw University of Adelaide		woei.saw@adelaide.edu.au
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Technology Experts / Activity Leaders			
Solar Fuels & Materials	Prof. Dr. Christian Sattler DLR, Germany		Christian.Sattler@dlr.de
Technology Innovation	Prof. Dr. Ivan Ermanoski Arizona State University, USA		iermano@sandia.gov
R&D Infrastructure	Dr. John Pye ANU, Australia		John.pye@anu.edu.au
Standards & Protocols	Prof. Dr. Ellen Stechel Arizona State University, USA		Ellen.Stechel@asu.edu
Techno-Economics	Dr. Christoph Falter Bauhaus-Luftfahrt, Germany		Christoph.Falter@bauhaus-luftfahrt.net
Mapping of R&D Activities	Dr. Andrea Ambrosini Sandia National Laboratories, USA		aambros@sandia.gov

Figure 2: Organization of Task II

2) Re-definition of Task II objectives and program of work

The purpose and activities of Task II have been revised and adjusted.

Old purpose and activities:

Develop and optimize solar thermochemical processes for the production of fuels and materials, and to demonstrate – at an industrial scale – their technical and economic feasibility.

Activities. Six Task II activities reflect the future challenges and foster active participation of SolarPACES member countries:

1. Solar Fuels (SF)
2. Solar Materials (SM)
3. Thermo-chemical Storage (TS)
4. Technology Innovation (TI)
5. Research Infrastructure (RI)
6. Market Penetration (MP)

=> SolarPACES is a platform for exchanging / discussing the latest results, grand challenges of the different technology routes, and determining ways to advance solar thermochemical process towards commercialization. However, Task II is not performing experimental activities, thus the demonstration of solar thermochemical processes is not part of Task II but carried out by the R&D institutions within the member countries. Therefore, the aim of Task II has been adjusted.



New aim of Task II:

Task II addresses the demonstration, scale-up, and market penetration of solar-driven thermochemical processes for the production of fuels (e.g. hydrogen, syngas, methanol, kerosene, diesel) and materials (e.g. metals – Zn, Al, Fe) as well as thermochemical energy storage.

3) New joint Task II activities

Four new core activities evolved from the discussion in the Task II plenum. For each activity a sub-task group was formed which will define the scope of work, work plan, and the time line.

a) Definition of standards, procedures, and protocols:

Today, every R&D institution is using its own definitions for key metrics (e.g. efficiencies) and is applying their own procedures and protocols for measurements. The aim of this activity is to define standards for the most relevant performance indicators in the field of solar chemistry and to work-out practical guidelines for experimental procedures and protocols to ensure the comparability of experimental data. The exact scope of the activity and work plan will be defined and by the sub-task group, which consists of the following experts:

- Ellen Stechel, ASU, USA (**Activity Leader**) - ellen.stechel@asu.edu
- Ivan Ermanoski, ASU, USA - Ivan.Ermanoski@asu.edu
- Christoph Falter, Synhelion SA, Switzerland – christoph.falter@synhelion.com
- José Gonzales Aguilar, IMDEA, Spain - jose.gonzalez@imdea.org
- Hernando Romero Paredes, UAM, Mexico - hrp@xanum.uam.mx

b) Techno-economic assessments and bench-marking

It was concluded that Task II will perform a techno-economic analysis of the thermochemical routes and their bench marking against alternative routes (e.g. PV-Electrolysis). Similar to activity 1, it will be important to develop standards for techno-economic assessments in order to ensure the comparability of different studies. Furthermore, the implementation of an open-source platform for techno-economic studies will be assessed. The scope of work will be defined in detail by the sub-task group, which consists of the following experts:

- Christoph Falter, (**Activity Leader**) – christoph.falter@synhelion.com
- Ellen Stechel, ASU, USA - ellen.stechel@asu.edu
- Ivan Ermanoski, ASU, USA - Ivan.Ermanoski@asu.edu
- Luca Turchetti, ENEA, Italy - luca.turchetti@enea.it
- Woei Lean Saw, University of Adelaide, Australia – woei.saw@adelaide.edu.au

c) Mapping of R&D activities and R&D infrastructure

The existing data bases for (1) global R&D activities and (2) relevant R&D infrastructure will be further improved / expanded. The data-base is published on the SolarPACES website:

<https://www.solarpaces.org/capabilities-of-each-of-the-solar-fuels-research-institutions/>

The scope of work will be defined in detail by the sub-task group, which consists of the following experts:

- Andrea Ambrosini, Sandia, USA (**Activity Leader**) - aambros@sandia.gov
- John Pye, ANU, Australia - John.Pye@anu.edu.au
- Gus Nathan, University of Adelaide, Australia - graham.nathan@adelaide.edu.au
- José Gonzales Aguilar, IMDEA, Spain - jose.gonzalez@imdea.org
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4 Meetings and Conferences

In the following a list of all the meetings and conferences is presented, which have been organized or attended as part in Operating Agent II project. The details of the meetings have been provided in separate update reports.

Date	Meeting	Place
10.10.2016	SolarPACES Task II Meeting	Abu Dhabi, UAE
16.10.2016	SolarPACES ExCo Meeting	Abu Dhabi, UAE
11-14.10.2016	SolarPACES Conference	Abu Dhabi, UAE
04-06.04.2017	SolarPACES ExCo Meeting	Thessaloniki, Greece
25.09.2017	SolarPACES Task II Meeting	Santiago, Chile
01.10.2017	SolarPACES ExCo Meeting	Calama, Chile
26-29.09.2017	SolarPACES Conference	Santiago, Chile
21-22.03.2018	SolarPACES ExCo Meeting	Aachen, Germany
01.10.2018	SolarPACES Task II Meeting	Casablanca, Morocco
06.10.2018	SolarPACES ExCo Meeting	Casablanca, Morocco
02-05.10.2018	SolarPACES Conference	Casablanca, Morocco
30.09.2019	SolarPACES Task II Meeting	Daegu Korea
05.10.2019	SolarPACES ExCo Meeting	Daegu Korea
01-04.10.2019	SolarPACES Conference	Daegu Korea
23.09.2020	SolarPACES Task II Meeting	Virtual
19.03.2020	SolarPACES ExCo Meeting	Virtual
28.09-02.10.2020	SolarPACES Conference	Virtual
05.10.2020	SolarPACES ExCo Meeting	Virtual
20-21.04.2021	SolarPACES ExCo Meeting	Virtual
21.09.2021	SolarPACES Task II Meeting	Virtual
28.09.2021	SolarPACES Conference	Virtual
22-23.03.2021	SolarPACES ExCo Meeting	Virtual
19.09.2022	SolarPACES Task II Meeting	Virtual

