



# Solar Energy for a Circular Economy

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**[www.sunriseaction.eu](http://www.sunriseaction.eu)**



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# Coordination and Support Action - Objectives

**Collective Human **Catalysis** to prepare a European large-scale research initiative**

- ❖ **Develop the Science & Technology roadmap of the large-scale project aimed at solar-to-chemical conversion**
- ❖ **Build the community: scientific, industrial, general public**
- ❖ **Structure an effective governance scheme**

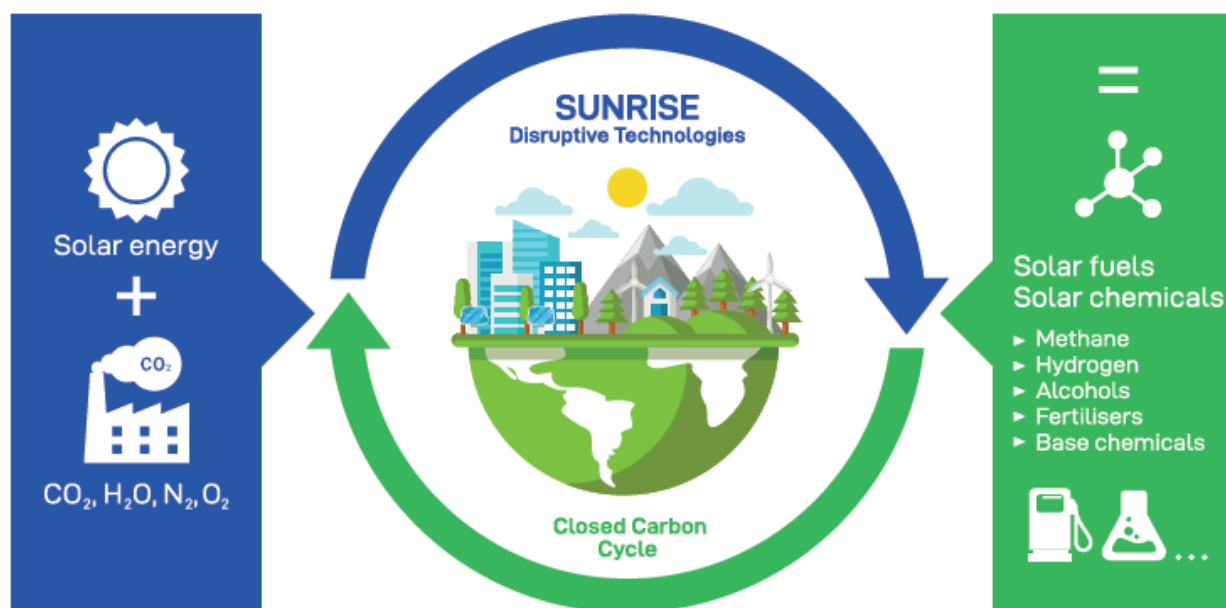


# Solar Energy for a Circular Economy

## Vision and Goals



**SUNRISE** targets the ultimate alternative to the fossil-based, energy-intensive production of fuels and base chemicals. The energy will be provided by **sunlight**. The raw materials will be **molecules abundantly available** such as water, carbon dioxide, oxygen and nitrogen.



# THE THREE GOALS OF SUNRISE

## Goal 1 – SOLAR FUELS

(e.g., hydrogen, ethanol)

## Goal 2 – SOLAR CHEMICALS

(e.g., N-fertilizers)

**Goal 3 – Removing and recycling CO<sub>2</sub>  
FROM THE ATMOSPHERE**  
(long term, 2050)



**SUNRISE IS INSTRUMENTAL  
TO IMPLEMENT  
A CIRCULAR ECONOMY**



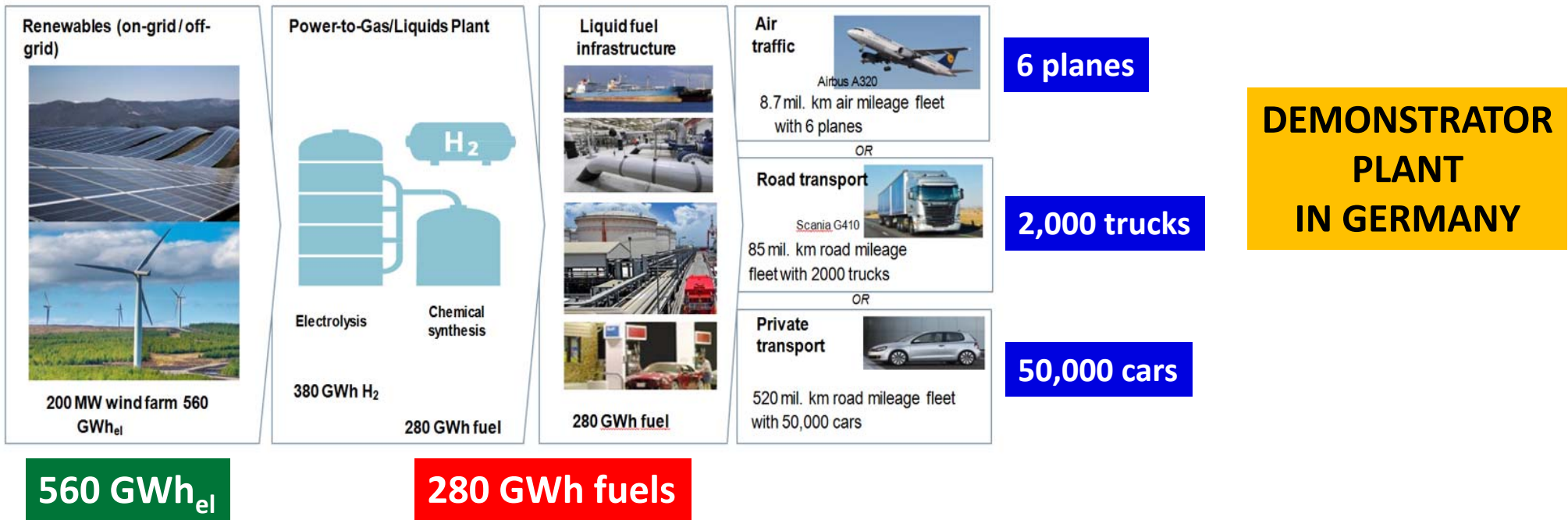
# Solar Energy for a Circular Economy

## Technical Approaches



# SUNRISE: APPROACH 1

## 1- Electrocatalytic conversion with renewable power



Technical Approaches

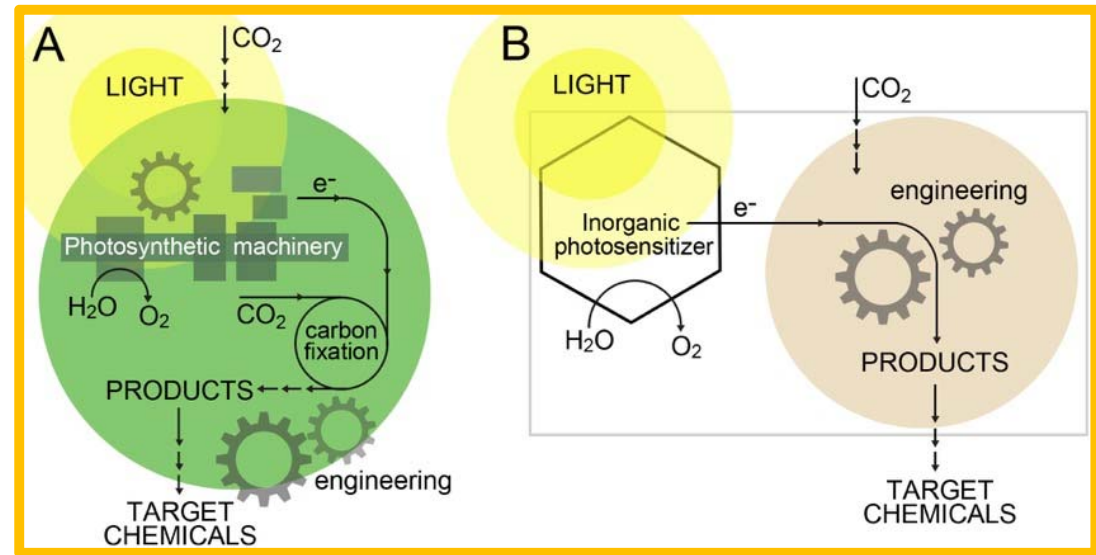
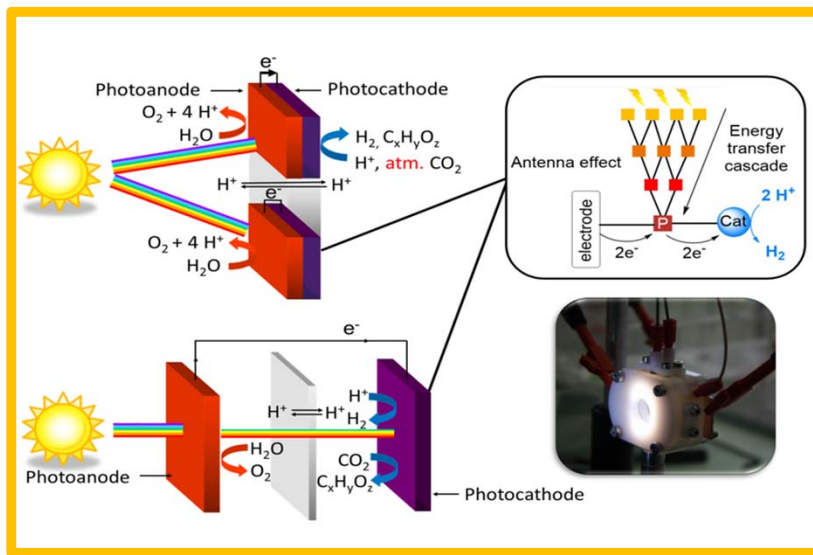




# SUNRISE: APPROACH 2 and 3

2- Direct conversion *via* integrated artificial and semi-artificial photosynthetic systems

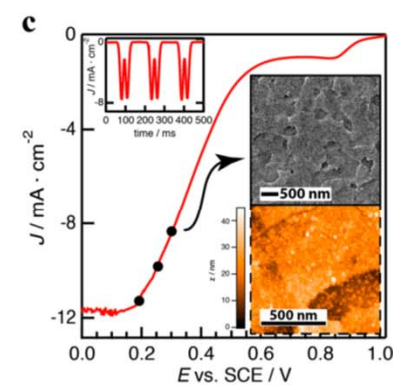
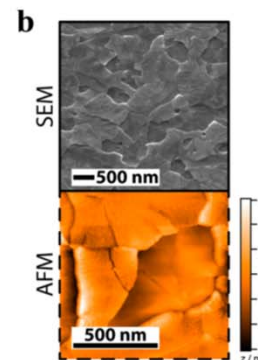
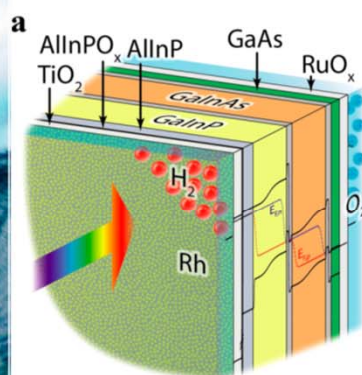
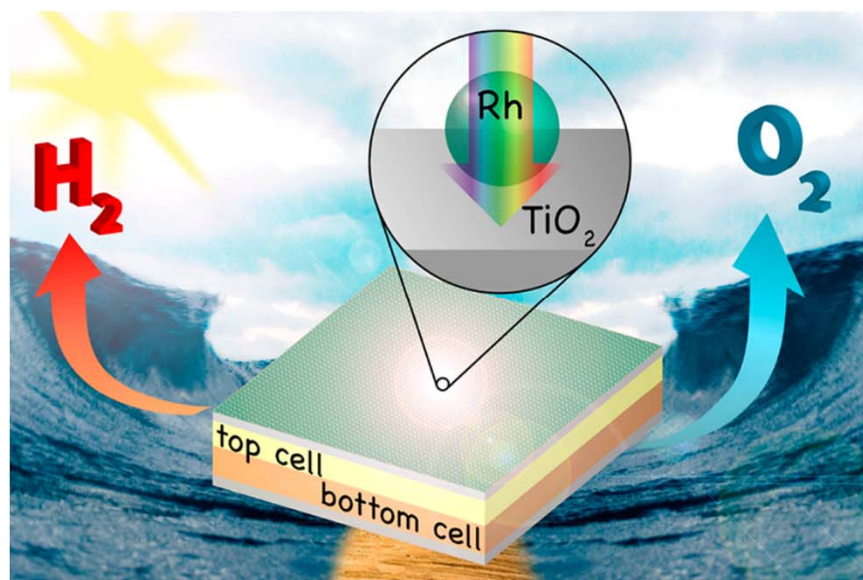
3- Direct conversion *via* biological and biohybrid systems



Technical Approaches



# SUNRISE: State of the art



STATE OF THE ART: PEC tandem heterojunction device with 19% STH efficiency, ACS Energy Lett. 2018, 3, 1795-1800

## Technical Approaches





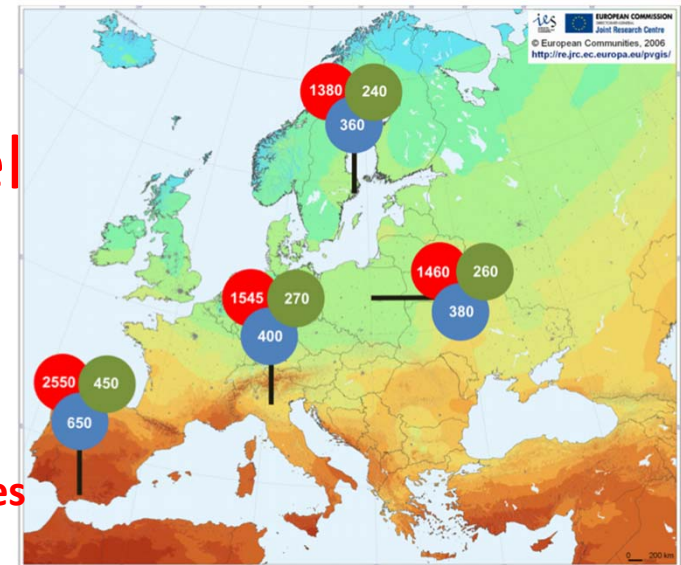
# Solar Energy for a Circular Economy

## Targets, Challenges

# TARGETS AND PHYSICAL CONSTRAINTS: CHEMICAL REACTIONS AND SITE-SPECIFIC IRRADIATION



HCOOH  
CO, syngas, jet fuel  
H<sub>2</sub>CO  
CH<sub>3</sub>OH  
CH<sub>4</sub>  
CH<sub>3</sub>CH<sub>2</sub>OH  
biodegradable plastic substitutes  
artificial wood for CO<sub>2</sub> storage



From lab devices to hectare scale pilot plants linked to targets (fuel, chemicals and CO<sub>2</sub> removal)

- Ethanol (ton/ha.yr)
- Ammonia (ton/ha.yr)
- CO<sub>2</sub> (ton/ha.yr)

# (SOME) CHALLENGES

Highly efficient **harvesting** of solar photons (90%)

Robust **materials** under different irradiation conditions

Catalysts based on **earth abundant** elements

Advanced **modelling** and HPC for materials design

**Scaling up** at the industrial level on a large scale

Efficient use of the **Earth's surface** and urban space

High Energy Return of Energy Invested (**EROI**)

Consolidation of **social acceptance**

AN  
INTERDISCIPLINARY  
ENDEAVOR







# Solar Energy for a Circular Economy

## Partnership

# SUNRISE: 20 PARTNERS



1 – LEIDEN UNIVERSITY (NL)	11 – SIEMENS AKTIENGESELLSCHAFT (DE)
2 – CEA (FR)	12 – UNIVERSITY OF TURKU (FI)
3 – CNR (IT)	13 – UNIVERSITY OF WARSAW (PL)
4 – EMPA (CH)	14 – CZECH ACADEMY OF SCIENCES (CZ)
5 – UNIVERSITY OF UPPSALA (SE)	15 – JOHNSON MATTHEY PLC (UK)
6 – IMDEA (ES)	16 – ICIQ (ES)
7 – FRAUNHOFER GESELLSCHAFT (DE)	17 – EERA
8 – FORSCHUNGSZENTRUM JÜLICH (DE)	18 – NORWEGIAN UNIV. OF S&T (NO)
9 – IMPERIAL COLLEGE (UK)	19 – UNIV. CATHOLIQUE DE LOUVAIN (BE)
10 – EMIRI (BE)	20 – ENGIE

- Some of the largest EU public R&T org. (**CEA, CNR, Fraunhofer, Helmholtz**)
- 3 big companies (**Siemens, Johnson Matthey, ENGIE**)
- An industry-led initiative (**EMIRI**)
- The EU Energy Research Alliance (**EERA**)
- **11 Universities and Res. Centers**

Community







## CSA: Supporters, a growing community

**24** Companies Energy and  
Oil&Gas sectors

**4** Non-governmental  
organisations (NGO)

**56** Universities

**13** Companies Chemical and  
Material sectors

**20** European and National Associations  
& Networks

**9** Funding &  
Governance  
bodies

**31** Research &  
Technological  
Centres

**4** Companies Project  
Management, Innovation and  
Dissemination

# SUNRISE HAS OVER 200 SUPPORTERS WORLDWIDE



Community





**Solar Energy for a Circular Economy**

**Roadmap and blueprint**

# Roadmap 2020-2030

Defining objectives (and bottlenecks)  
in 1, 2, 5, 10 years



**M2:** Initial working document

**M6:** Advanced draft, to be shaped also through a dedicated workshop

**M12:** Final shared document, validated by the Strategic Advisory Board

Aspects to be considered: *science breakthroughs, prototypes, large-scale demonstrators, EROI, LCAs, generation of revenues, educational progress, society involvement, criteria for continuous update*



## CSA: Building the Roadmap - PRDs

### **SUNRISE APPROACH 1:**

Hydrogen  
CO<sub>2</sub>-to-chemicals  
Ammonia  
Jet Fuel

### **SUNRISE APPROACH 2:**

Molecular  
Systems;  
Photon  
Management

### **SUNRISE APPROACH 3:**

Biocatalysts  
Biohybrid Tech  
Synthetic Biology

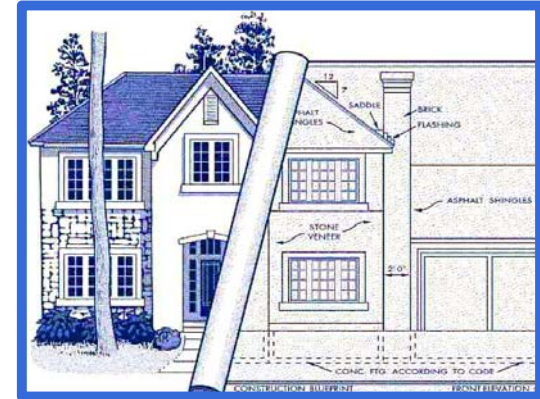
### **KEY ENABLERS:**

Modelling;  
Qualitative  
System  
Analysis

# Blueprint

**Goal: SUNRISE map**, a public document identifying the necessary resources to accomplish our goals:

- **Human capital** (S&T competences)
- **EU facilities and infrastructures** (public and private)
- **Big companies and SMEs** that can offer and/or develop products
- **Financial resources** already invested and to be further mobilized (public & private)
- Criteria to make SUNRISE **an open and inclusive initiative**







**Thank You!**

