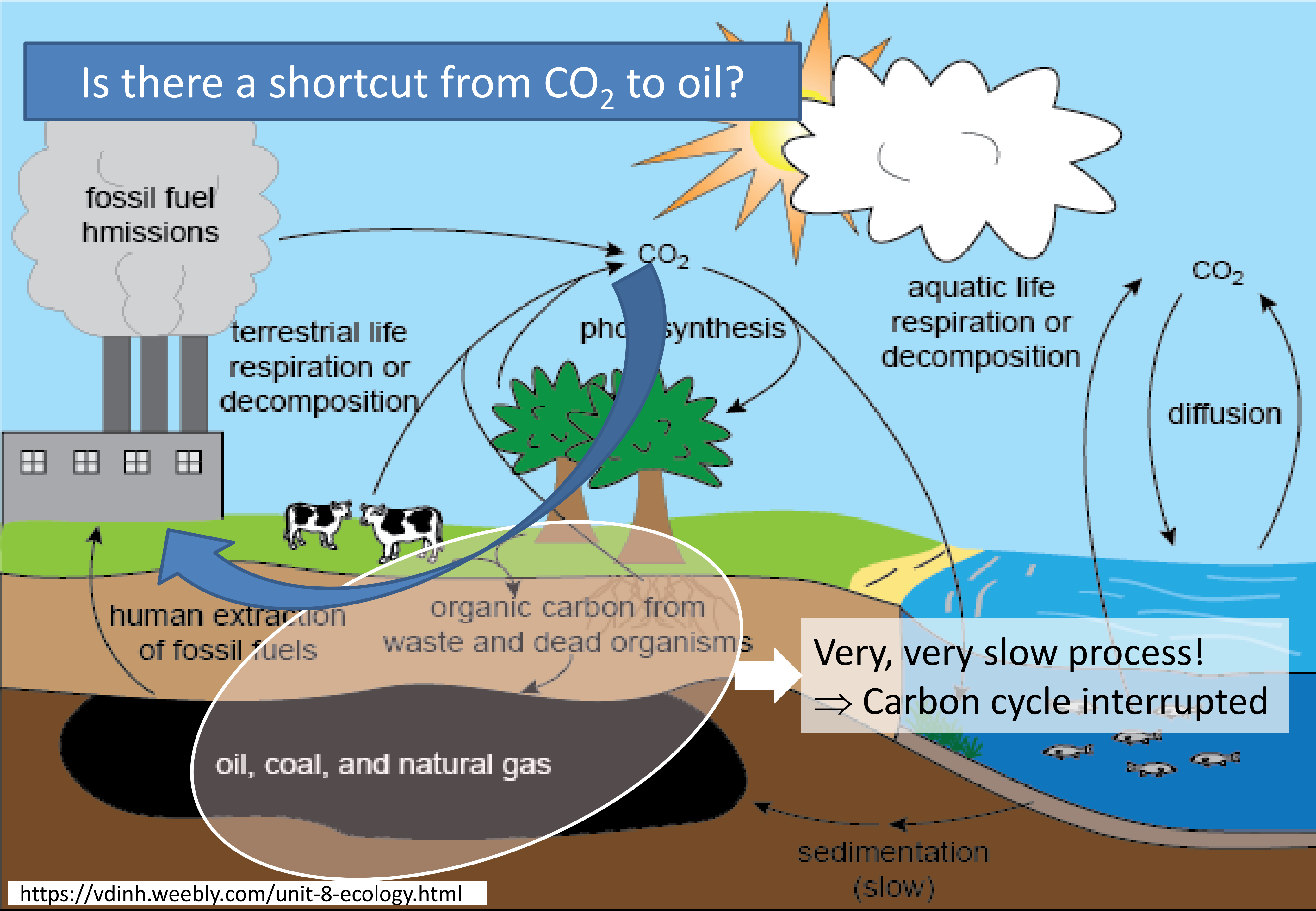
EuCheMS
European Chemical Sciences

Solar-Driven Chemistry

A vision of using sunlight to make fuels from carbon dioxide

Is there a shortcut from CO_2 to oil?



https://vdinh.weebly.com/unit-8-ecology.html

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The Problem

In natural photosynthesis, carbon dioxide is converted into complex chemical compounds by using sunlight (photons) as the energy source. Solar energy is thus stored in chemical bonds. *When using fossil fuels, the energy and carbon dioxide stored millions of years ago are released*.

The Vision

Generation of feedstocks and fuels directly from air components (CO_2, N_2) and water with (only) solar radiation as the energy source („solar fuels“, „artificial photosynthesis“).

Developing such processes would transform our energy options in the future by providing an alternative to fossil fuels. This “is the greatest energy opportunity of our lifetime” (Solar Fuels Institute).

Ideally, such man-made, ecologically friendly systems should be more efficient than their natural counterparts.

Opportunities

- Chemical compounds as a robust storage medium for solar energy
  - ➢ high energy density
  - ➢ high energy conversion efficiency upon use
- CO_2 as alternative feedstock $\Rightarrow$ circular CO_2 economy
- Direct conversion of photons (solar energy); no intermediate storage or transport of electrons (electricity)
- Existing infrastructure for transport, distribution and storage of fuels
- Energy supply for areas in the world without access to centralized energy delivery systems

Active Players

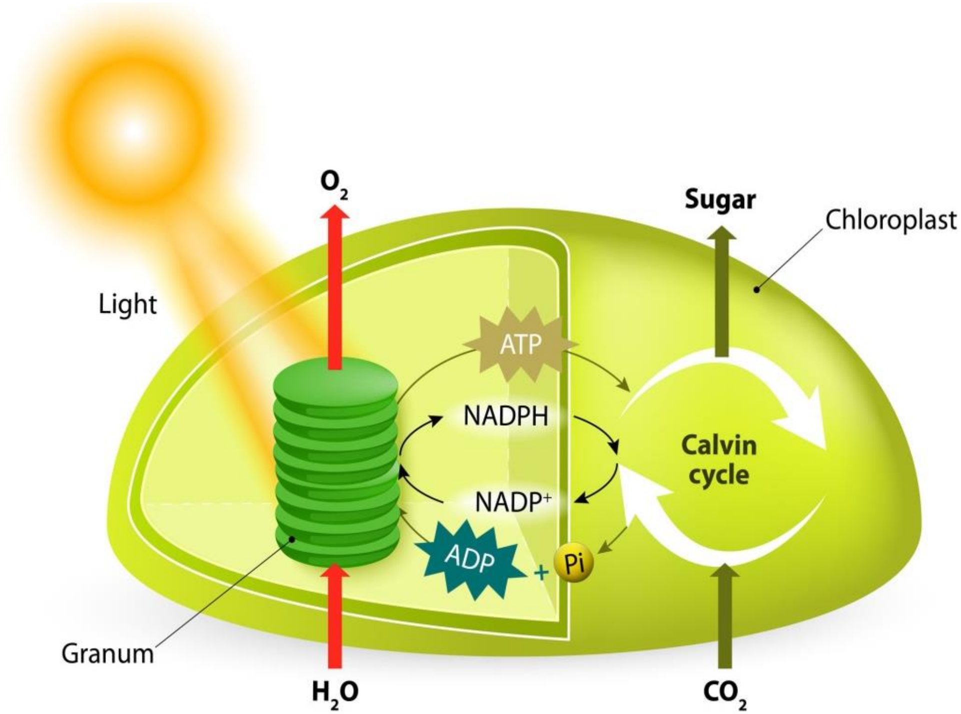
Dedicated networks and institutes in

Netherlands, Germany, UK, Sweden, Spain, etc.

EU flagship proposal

US, Japan, China, South Korea, etc.

Natural photosynthesis



Designua/123RF Stock Photo

Light-dependent reactions capture the energy of light and use it to make molecules for energy storage and transport by water splitting

Energy transport

The energy is used to convert CO_2 into organic compounds (CO_2 reduction)

Develop artifical systems which mimic the separate reactions (water splitting and CO_2 reduction) in an integrated fashion

Roadmap

Stage 1

Photovoltaic devices are coupled with water electrolysers. The thus generated hydrogen is used as such or reacted with CO_2 to give carbon-based compounds.

Stage 2

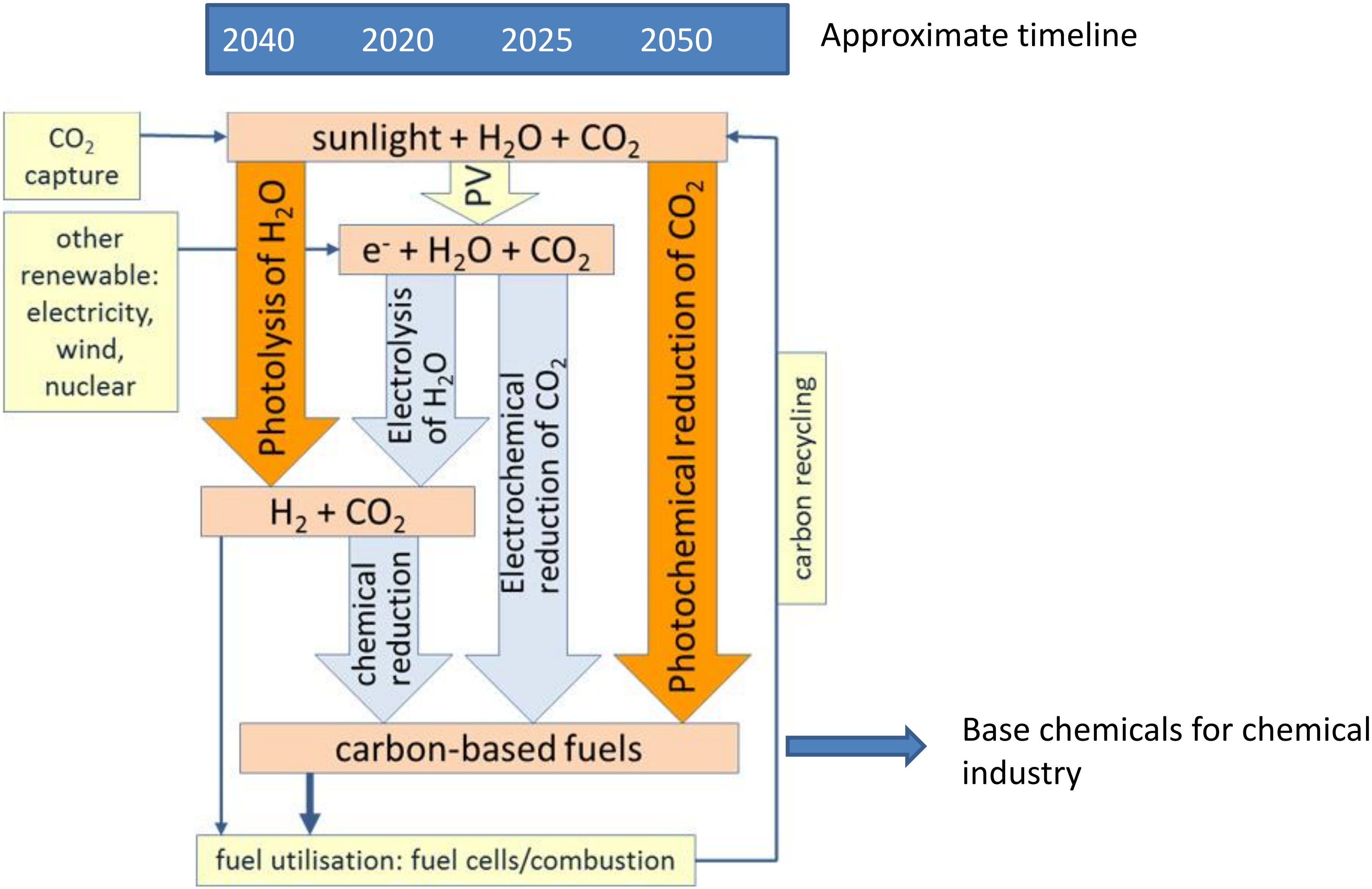
Photovoltaic devices are coupled with electrochemical reduction of CO_2 (without intermediate hydrogen production).

Stage 3

Photolysis of water (without interposed photovoltaics). The thus generated hydrogen is used as such or reacted with CO_2 to give carbon-based compounds.

Stage 4

Capture of sunlight and use in an integrated system to give carbon-based compounds from CO_2 and water („artificial photosynthesis“).



http://solarfuelsnetwork.com/solar-fuels/

Challenges

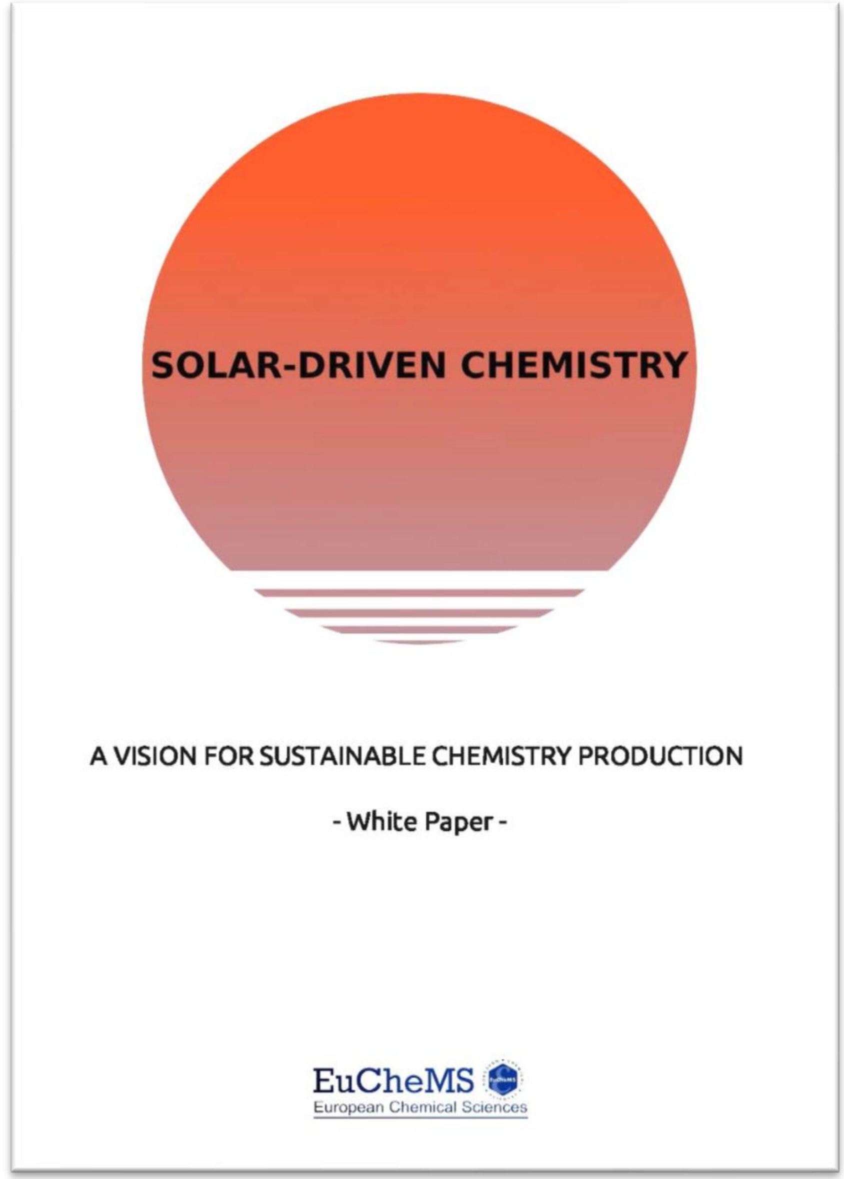
- Significant breakthroughs in our understanding of the molecular mechanisms in natural photosynthesis and catalysis.
- Develop new materials that harvest sunlight efficiently and channel it to produce fuels.
- Develop cheaper, more efficient and more stable electro- and photocatalysts.
- Create an „artificial leaf“ by coupling water splitting and CO_2 reduction in a way that eliminates the need of an external, sacrificial electron donor.
- The materials to be used in industrial processes based on solar-driven chemistry must be made from abundant raw materials.
- The systems to produce solar fuels and feedstocks must be efficient, durable and cost effective.

Summary

“Solar-driven chemistry” is an ambitious **long-term innovative scientific and technological endeavour**. It will have huge environmental, societal and economic benefit.

Realising solar-driven chemical technologies requires an integrated and synergetic approach and strong support. A broad and inclusive action is needed.

It will take several decades to reach all the goals, but short-term and intermediate results will already generate huge benefits. **The science today is the technology of tomorrow**.



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