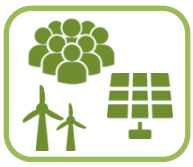
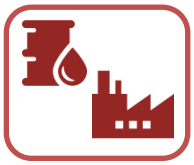
SUNRISE
Solar energy for a circular economy

Today's Challenges

With the **Paris climate agreement**, the European member states engaged to mitigate global warming and to play a leading role in the fight against climate change. The necessary reduction of CO_2 emissions implies profound societal changes and technological breakthroughs. The **Energy Union** is a big step to establish a sustainable, low-carbon and climate-friendly economy and offers an exquisite opportunity for the modernization of Europe's entire economy.



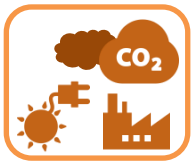
In the decade since the **2007 Strategic Energy Technology Plan**, the production of renewable energy continued its steady growth in Europe. Storing efficiently and reliably surplus electric energy is one of today's top challenges. For the foreseeable future, we will also depend on **fuels with high energy density** for air and road transport, and for heavy industries, such as steel manufacturing. **Storage processes** converting electricity and sunlight into chemical energy would be highly desirable.



Chemicals are essential in everyday life. Fertilizers ensure food security, pharmaceuticals are indispensable for public health and fuels literally drive our society forward. They are produced by the **chemical industry, which is an essential pillar of the European economy** and generates nearly 20% of the global turnover. Through innovative compounds and materials, the chemical industry directly contributes to reducing Europe energy demand and greenhouse gas emissions. However, it remains a heavy user of fossil fuels as energy source and as the main raw materials for a variety of chemical products.

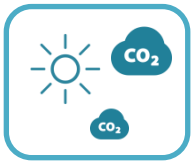
A **replacement of fossil-based raw materials and a modernization of the production processes** are crucial for Europe's vision of a zero-emission society and the global competitiveness of its industry.

Future Flagship: Sustainable Fuels and Chemicals via a Circular Approach



The goal of the proposed Flagship is to provide a **sustainable alternative to the fossil-based, energy-intensive production of chemicals, including energy carriers**. The needed energy will be provided by sunlight, the raw materials will be plentiful low-cost molecules, *i.e.*, **CO_2, H_2O, N_2** and **O_2.**

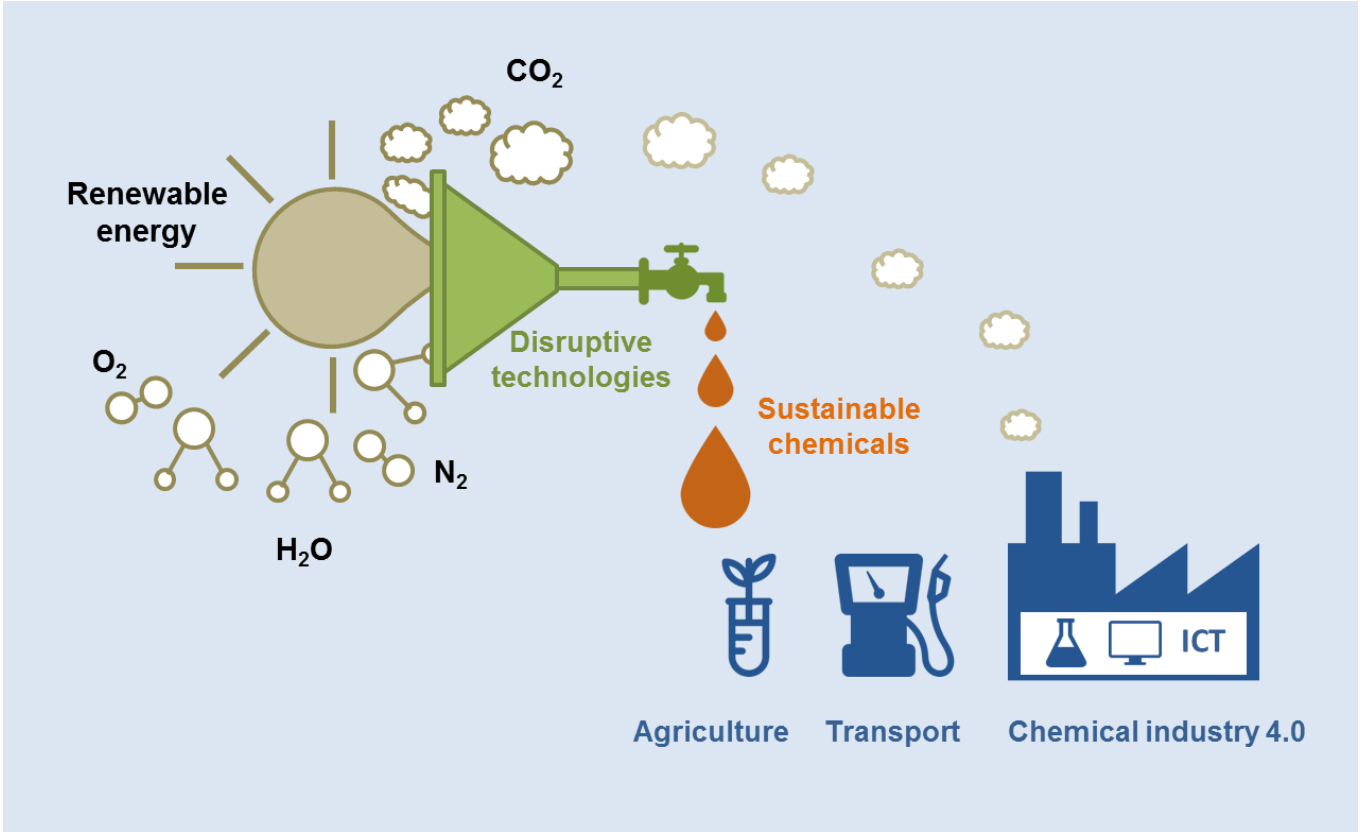
In the short term, the flagship project primarily aims at providing value chemicals **using renewable electricity sources and waste CO_2** from industrial processes as raw material for circular production of chemicals and fuels. The energy return on energy invested (EROI), which is not yet maximized, in particular due to use of electricity at the intermediate stage, will be improved step by step while closing cycles.



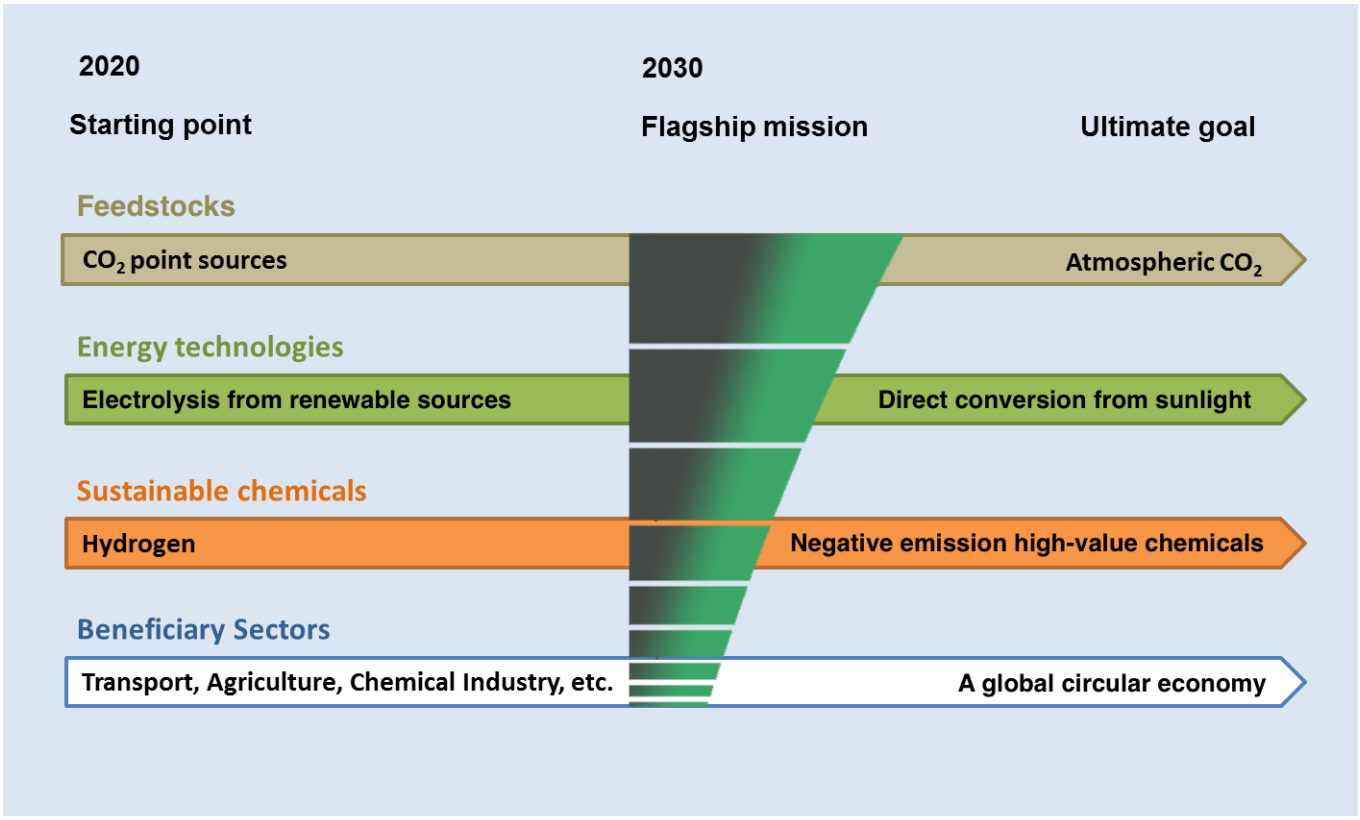
In the long term the energy input for the chemical processes is **directly provided by sunlight**, which is converted following **radically new approaches (*e.g.*, photochemical, electrochemical, biological) of dragging CO_2, H_2O, N_2 and O_2 into chemical products**. Final targets are sustainable high value products that can be concentrated to any desired level, going beyond the natural photosynthesis process with higher efficiency and a wide selection of target molecules. Due to the modernization of the EU industry and the expected decline of climate-altering emissions, the CO_2 raw material will have to come ultimately from non-concentrated sources. For a wider variety of chemical products, resources will be recycled from the environment: air, water and land.

The key enablers for such an ambitious paradigm shift are **information technology** and **new advanced materials**. The former will enable optimized production processes, with savings of energy and feedstocks. New materials will allow cost-competitive, efficient and durable solutions across a number of renewable energy technologies. Given the interdisciplinary character of solar energy research and its intrinsic societal and economic implications, **this flagship initiative requires key contributions from a wide spectrum of disciplines**, including: chemistry, biology, physics, engineering as well as social and environmental sciences and humanities.

The production of chemicals by sunlight and widely available feedstocks (CO_2, H_2O, N_2 and O_2) is a key milestone towards a **circular economy**. In particular, we target **a sustainable CO_2 cycle**, where the concentration in the atmosphere is decreased and then maintained at a level compatible with climate stability, with **sustainable use of natural resources and land**. The 10-year flagship innovation program will allow European economies to convert of up to 1000-2500 ton atmospheric CO_2 per hectare per year, depending on the latitude, at an unprecedented level of systems absorbing 90% of incoming photons and delivering 80% into products. The technology development will take into account key constraints such as the **EROI and availability and durability of critical materials**.



VISION. SUNRISE will foster the transition to a circular economy and a carbon-neutral society. The disruptive energy technologies developed by the project will transform carbon dioxide, water, nitrogen and oxygen feedstocks into agrochemicals, fuels, and high-value chemicals with the use of sunlight.



MISSION. Starting in 2020 from available energy technologies, the flagship affords solutions to the energy problem already in the short-term, by pushing existing technologies to industrial maturity. Major milestones are targeted for 2030, where novel disruptive energy technologies (e.g., photochemical, electrochemical, biological) will make an important step forward to the ultimate goal of radically converting the entire chemical industry to the new paradigms of circular economy and carbon-neutral society.