Bacterial conversion of CO₂ and renewable H₂ into biofuels

Development of novel visible light photocatalysts based on Atomic Quantum Clusters

Photocatalytic production of H₂ from sunlight and water

Microbial production of biofuels from CO₂ and renewable H₂

Project title: **BACterial conversion of CO₂ and renewable H₂ into bioFUELs**

**Main Category of the Project:** **Renewable Fuel**

**TRL:** 5

**Keywords:** Bioenergy, photocatalysis, microbial electrosynthesis, atomic quantum clusters, enriched mixed cultures, bacterial conversion

**Technological approach of the Project:** Development of novel visible light photocatalyst. Photocatalytic production of H₂ from sunlight and water. Microbial production of biofuels from CO₂ and H₂

**Expected Impact of the Project:** Reduced dependency on fossil fuels and contribution to decarbonization of the transport sector

**Highlights (technological/non-technological):** Mimics the photosynthesis process of plants. Uses enhanced bacterial media to convert CO₂ and renewable H₂ into bio ethanol. No impact on land for food crops. Can utilize waste water and waste CO₂ streams

**What is needed in future:** Engaging with end-users: Fuel Producers, Fuel Users, CO₂ Producers……

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 825999
Paving the way towards clean energy and fuels in Europe
Talks with research, industry and EU Member States on bioenergy, advanced biofuels and renewable fuels
This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 763911
The FReSMe concept demonstrates SEWGS technology which captures CO₂ and H₂ in Blast Furnace Gas which are then transformed into methanol in the reactor unit. Special focus will be made on the integration in current steel mills and increasing methanol production with renewable H₂ from electrolysis. Methanol fuel will be used as bunker fuel in a ferry which operates in Emission Control Areas.
**Main Category of the Project:** Carbon recycled fuels /renewable fuel of non-biological origin  
**TRL:** 6  
**Keywords:** Methanol, Carbon Recycled Fuel, Blast Furnace Gas, Hydrogen, CCS, CCU, SEWGS  
**Technological approach of the Project:** FReSMe demonstrates state of the art methanol synthesis from CO₂ and Hydrogen captured from blast furnace gas using SEWGS technology. Integration of renewable hydrogen from water electrolysis increases methanol production capacity and lowers its carbon footprint.  
**Expected Impact of the Project:** FReSMe aims to develop a more attractive business case for CCS+CCU lowering the CO₂ abatement costs. The FReSMe concept can contribute to the decarbonisation of the, so far, hard to decarbonize steel sector.  
**Highlights (technological/non-technological):** FReSMe builds on the synergies of the SEWGS Carbon Capture solution demonstrated in the STEPWISE project and the methanol synthesis solution demonstrated in the MefCO₂ project. The overall concept maximizes the value of steel production off-gases through methanol production and enables large scale CO₂ capture with a solution that can be retrofitted in existing steel mills. The deployment of the FReSMe could contribute to the cost reduction of renewable hydrogen electrolysis technology which is key to long term renewable energy storage and the decarbonisation of other sectors.  
**What is needed in future:** FReSMe requires an stable incentive framework for methanol fuel production an, in a more broad perspective, for Carbon Capture which are the key for the scale-up of technologies and the improvement of their competitiveness.
Production of Sustainable aircraft grade kerosene from water and air, powered by renewable electricity through the splitting of CO$_2$, formation of Syngas and Fischer-Tropsch synthesis, producing sustainable fuel in decentralised container sized units.
This project has received funding from the European Union’s Horizon 2020 Research and Innovation Programme under Grant Agreement No 763909.

**Main Category of the Project:** Renewable Fuel. **TRL:** 3 -> 4

**Keywords:** Sustainable Aircraft grade fuel, plasma chemistry, CO₂ splitting, renewable electricity, Fischer-Tropsch synthesis, container sized module, P2X, sector coupling, energy storage.

**Technological approach of the Project:** Plasma driven CO₂ dissociation and Solid Oxide Cell gas separation based on perovskite membranes to enhance CO productivity. System integration with Fischer-Tropsch kerosene synthesis in container sized module sized to scale of wind turbine or PV-array. Direct Capture from Air of CO₂ emitted to create a carbon neutral fuel cycle. Close coupled to remote (off-shore) location to produce Carbon Neutral Fuel onsite.

**Expected Impact of the Project:** CO₂ emission reduction of the Aviation Industry based on existing infrastructure and qualified engine technology meets the UNFCCC Paris climate targets of 2050. Reduction of soot and Sulphur at the airports and in the upper troposphere meets future air pollution standards. On site fuel production at off-shore wind turbine or remote PV array avoids expensive inshore electricity transport.

**Highlights (technological/non-technological):** Plasma enhanced CO productivity, perovskite based gas separation, strong interest in renewable aviation fuel from airports, airlines and public at large.

**What is needed in future:** Long term, consistent R&D programme phased with milestones.
Solar-thermochemical synthesis of hydrocarbon fuels

2H₂O + CO₂ → 2H₂ + CO

SUN to LIQUID
Fuels from concentrated sunlight

Solar Redox Cycles

Gas-to-Liquid Synthesis

Ceria reactor core

"CH₂"

Dr. Arne Roth, Bauhaus Luftfahrt, Munich (Taufkirchen), Germany
29 May 2019, Lisbon, organized in the framework of the 27th European Biomass Conference and Exhibition EUBCE

Paving the way towards clean energy and fuels in Europe
Talks with research, industry and EU Member States on bioenergy, advanced biofuels and renewable fuels
Project Acronym: **SUN-to-LIQUID**  
Project Number: **654408**  
Call: H2020-LCE-2015-1-two-stage  
Topic: LCE-11-2015 Developing next generation technologies for biofuels and sustainable alternative fuels  
Project title: **SUNlight-to-LIQUID: Integrated solar-thermochemical synthesis of liquid hydrocarbon fuels**

<table>
<thead>
<tr>
<th>Main Category of the Project:</th>
<th>Renewable hydrocarbon fuels;</th>
<th><strong>TRL:</strong> 5</th>
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<tbody>
<tr>
<td>Key words:</td>
<td>Solar-thermochemical conversion, renewable hydrocarbon fuel, non-biomass non-fossil sources</td>
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<td>Technological approach of the Project:</td>
<td>SUN-to-LIQUID establishes a radically different non-biomass non-fossil path to synthesize renewable liquid hydrocarbon fuels from abundant feedstock of H₂O, CO₂ and solar energy. Concentrated solar radiation drives a thermochemical redox cycle, which inherently operates at high temperatures and utilizes the full solar spectrum.</td>
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<td>Expected Impact:</td>
<td>New feedstock sources are used that do not compete for resources with food or feed production. The new technology is beneficial in terms of GHG performance, energy balance, efficient use of natural resources, decentralised energy production, and job creation in economically challenged areas, and in terms of secure and affordable energy supply worldwide.</td>
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<td>Highlights (technological/non-technological):</td>
<td>Expected key innovations include an advanced high-flux ultra-modular solar heliostat field for the concentration of solar energy, a 50 kW solar thermochemical reactor, and optimized redox materials based on ceria to produce solar synthesis gas from H₂O and CO₂. The synthesis gas is processed on-site to liquid hydrocarbon fuels. The thermodynamically favourable path to solar fuel production has the potential of economic competitiveness and &gt;80% GHG emission reduction.</td>
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<td>What is needed in the future:</td>
<td>Research and development towards higher solar-thermochemical reactor energy efficiency and solar plant size. This requires advanced heat management concepts, advanced materials and geometry as well as Mega- to Giga-Watt scale highly modular ultra-high-flux heliostat fields.</td>
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- AFW matrix definition and pretreatment/hydrolysis
- Strain improvement and enzyme production
- Engine tests and ecotoxicology
- Fermentation reactor & butanol recovery systems
- Catalytic conversion
This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 654623

Project Acronym: WASTE2FUELS    Project Number: 654623    Call: LCE-2015-1

Topic: Developing next generation technologies for biofuels and sustainable alternative fuels

Project title: Sustainable production of next generation biofuels from waste streams

Main Category of the Project: Biofuel

TRL: 5 (Pretreatment methods. Biofilm reactor and Recovery Systems. Test engines and burners)

Keywords: biofuels, renewable energies, chemical engineering, biotechnology, bioprocess, sustainable waste management, butanol, agro-food wastes (AFWs), pretreatment, fermentation, alcohol recovery, simulation, engine, LCA, ecotoxicology


Expected Impact of the Project: Permit the use of new feedstock sources that do not compete directly or indirectly with food or feed production. Breakthrough in fermentation conversion efficiencies.

Highlights (technological/non-technological): Pretreatment/hydrolysis to be optimized. Logistic and time schedule to be detailed.

What is needed in future: Extend/test process development at higher TRL. Strategies for feedstock providing