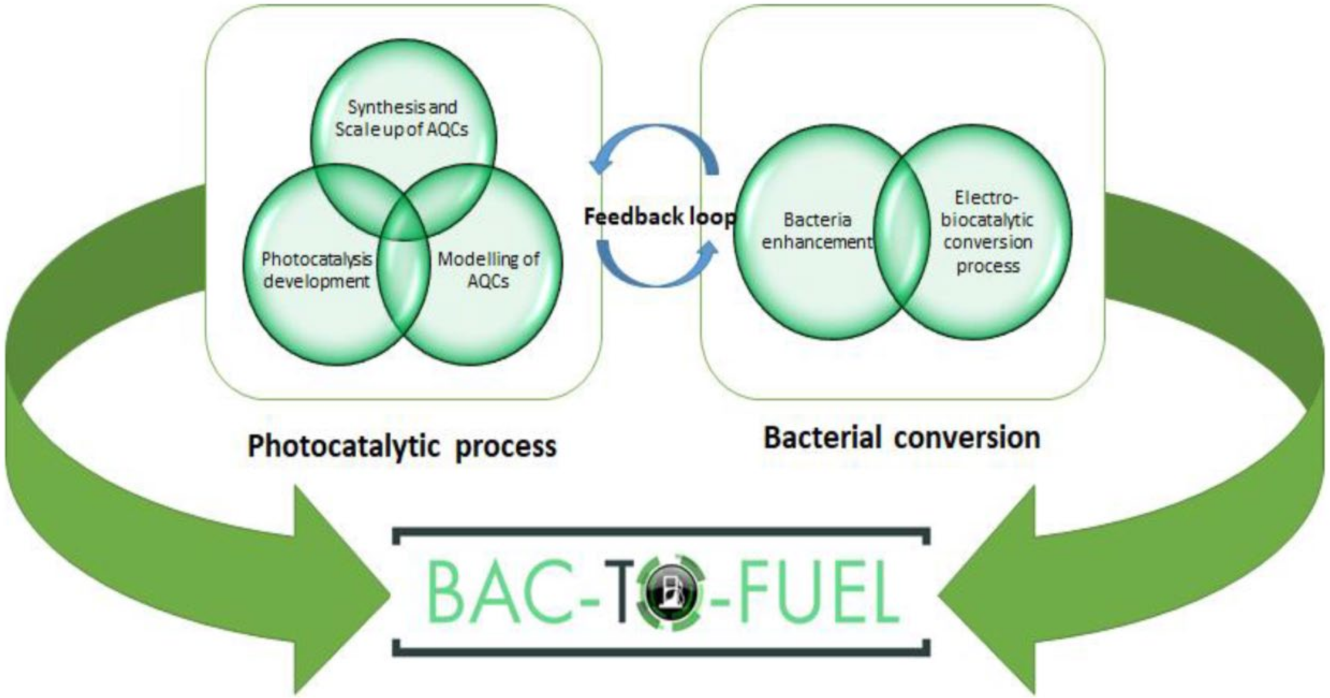
Bacterial conversion of CO_2 and renewable H_2 into biofuels



CONSORTIUM

Universidad de Santiago de Compostela

Nanogap Sub-nm-Powder SA

Lancaster University

Vlaamse Instelling Voor Technologisch Onderzoek N.V.

Wageningen University

Technische Universitat Berlin

Development of novel visible light photocatalysts based on Atomic Quantum Clusters

Photocatalytic production of H_2 from sunlight and water

Microbial production of biofuels from CO_2 and renewable H_2

Project title: **BACterial conversion of CO_2 and renewable H_2 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 H_2 from sunlight and water. Microbial production of biofuels from CO_2 and H_2

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

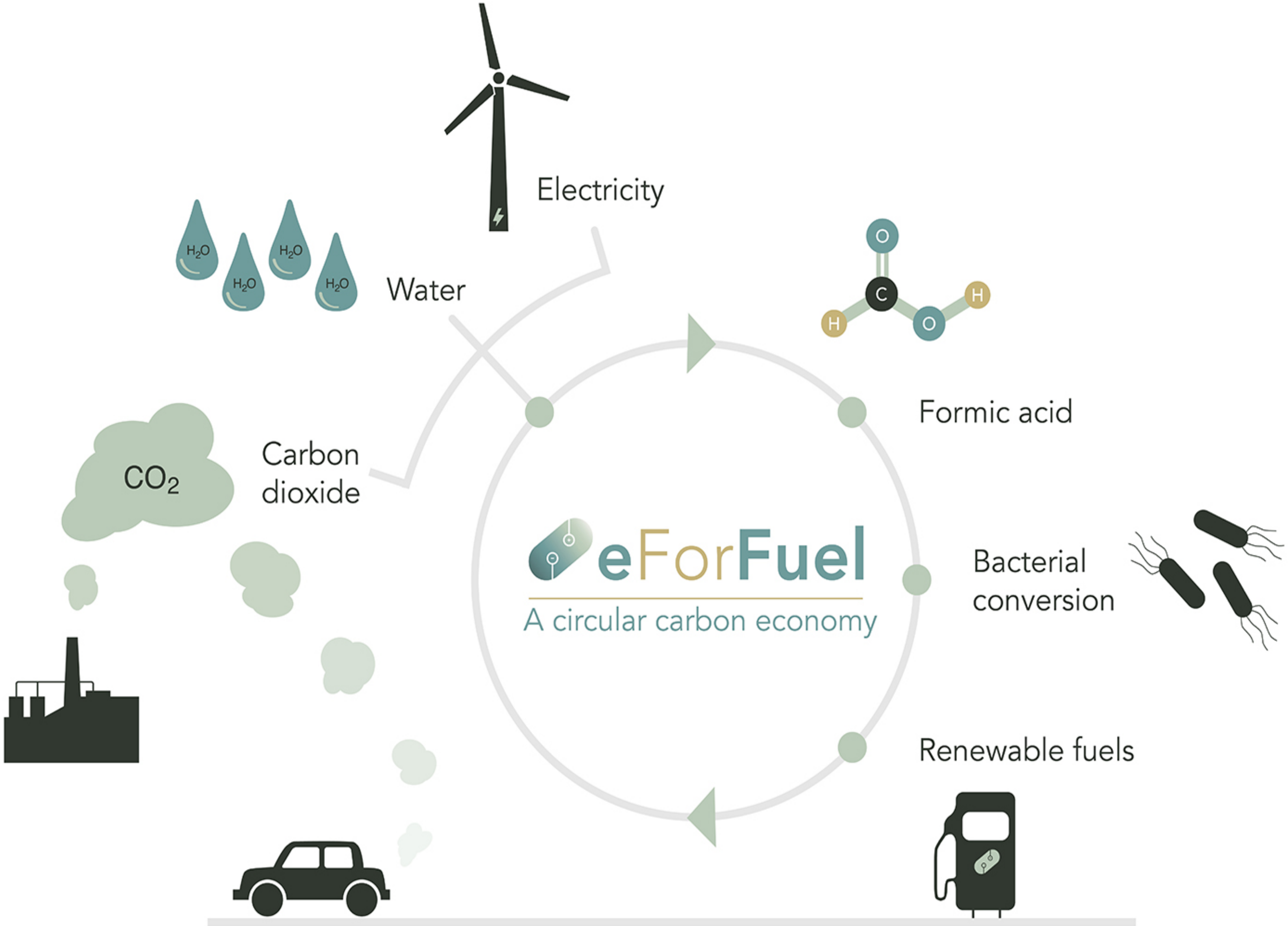
Highlights (technological/non-technological): Mimics the photosynthesis process of plants. Uses enhanced bacterial media to convert CO_2 and renewable H_2 into bio ethanol. No impact on land for food crops. Can utilize waste water and waste CO_2 streams

What is needed in future: Engaging with end-users: Fuel Producers, Fuel Users, CO_2 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 torwards clean energy and fuels in Europe

Talks with research, industry and EU Member States on bioenergy, advanced biofuels and renewable fuels



Project Acronym: **eForFuel** Project Number: **763911** Call: **H2020-LCE-2016-2017** Topic: **LCE-06-2017**

Project title: **Fuels from CO2 and Electricity:de novo metabolic conversion of electrochemically produced formate into hydrocarbons**

Main Category of the Project: Biofuel, Bioenergy, renewable Fuel

TRL: 4 – paving the way to TRL 5

Keywords: metabolic conversion, formate, carbon capture, advanced biofuels

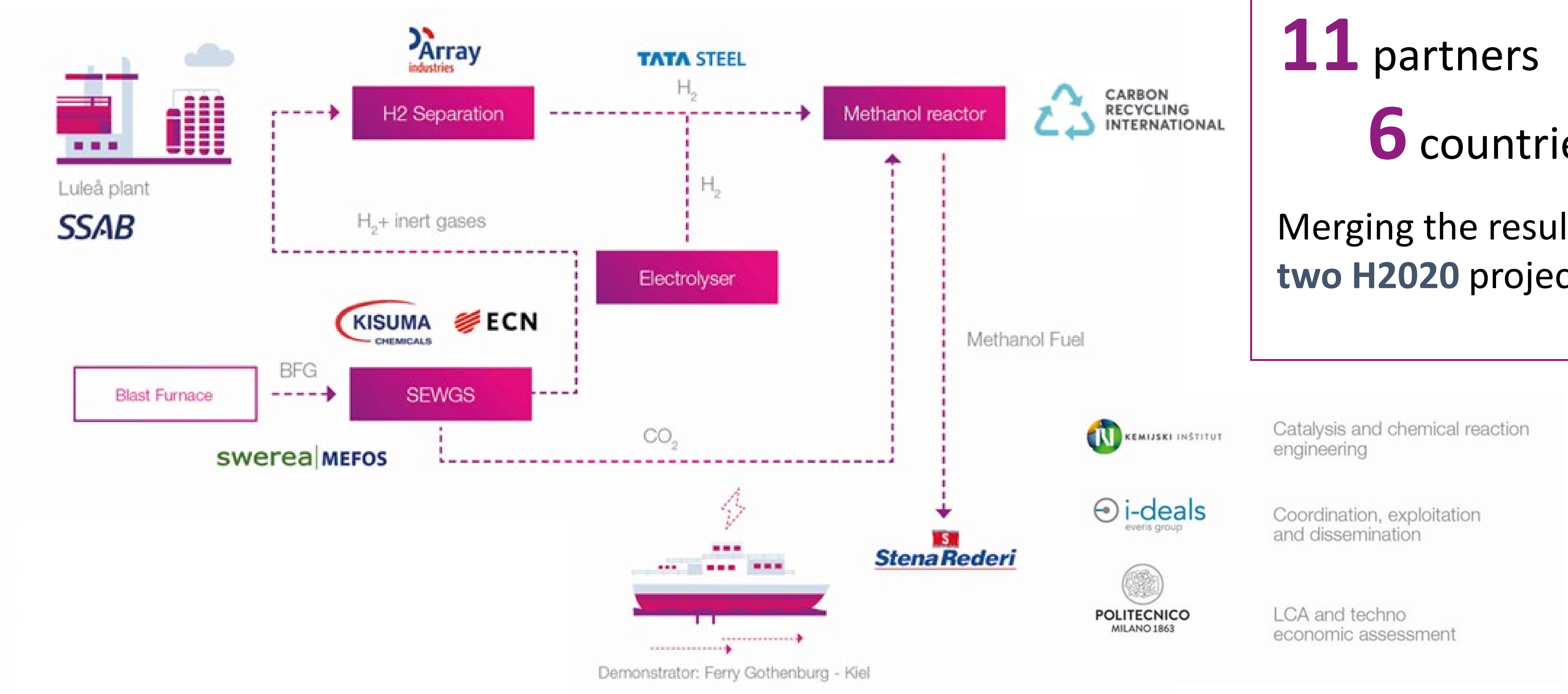
Technological approach of the Project: Our technology relies on widely available resources, such as water, renewable electricity, and waste CO_2 . Within an integrated, modular **electrobioreactor**, CO_2 will be reduced to **formic acid** at a very **high rate**, where **formate** will be then consumed by an **engineered E. coli** to produce **hydrocarbons.**

Expected Impact of the Project: Our products, gaseous propane and isobutene, can be easily separated from the microbial culture and integrated into existing fuel facilities

Highlights (technological/non-technological): **vision:** in the first stage, CO2 and electricity will be provided by steel maker AM and used in the constructed electrobioreactor for propane, commercialized by C3BT, and isobutene, to be converted to isooctane and commercialized by GBE. In the second stage, we will use emitted CO2 that from other carbon emitting industries, i.e., cement production, aluminum and non-ferrous metals production. Electricity will be provided from dedicated renewable sources, such as wind turbines and solar panels. In the mature stage, CO2 will be captured from air (using state-of-the-art technologies, but still considering the increased price for concentrating CO2), and renewable electricity will originate from multiple parallel sources. Downstream products, beyond just propane and isobutene, will be pursued.

What is needed in future: clarify in REDII how sources such as steel plants for CO2 will be considered within the directive. Relationships and comparison with other advanced biofuels (ReFunoBio); future funding for both low TRLs and higher TRLs, potential R&D challenges: metabolic engineering, downstream value chain (other added value biocompounds to complete the value chain), standardisatiotn in synbio

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No *763911*



11 partners

6 countries

Merging the results of **two H2020 projects**

STEP WISE a H2020 Project

The FReSMe concept demonstrates **SEWGS** technology which captures CO_2 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**.

Project Acronym: FReSMe Project Number: 727504 Call: H2020-LCE-2016-RES-CCS-RIA Topic: LCE-25-2016
Project title: From residual steel gasses to methanol

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 CO_2 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 CO_2 abatement costs. The FReSMe concept can contribute to the decarbonisatation 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 MefCO_2 project. The overall concept maximizes the value of steel production off-gases through methanol production and enables large scale CO_2 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.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 727504

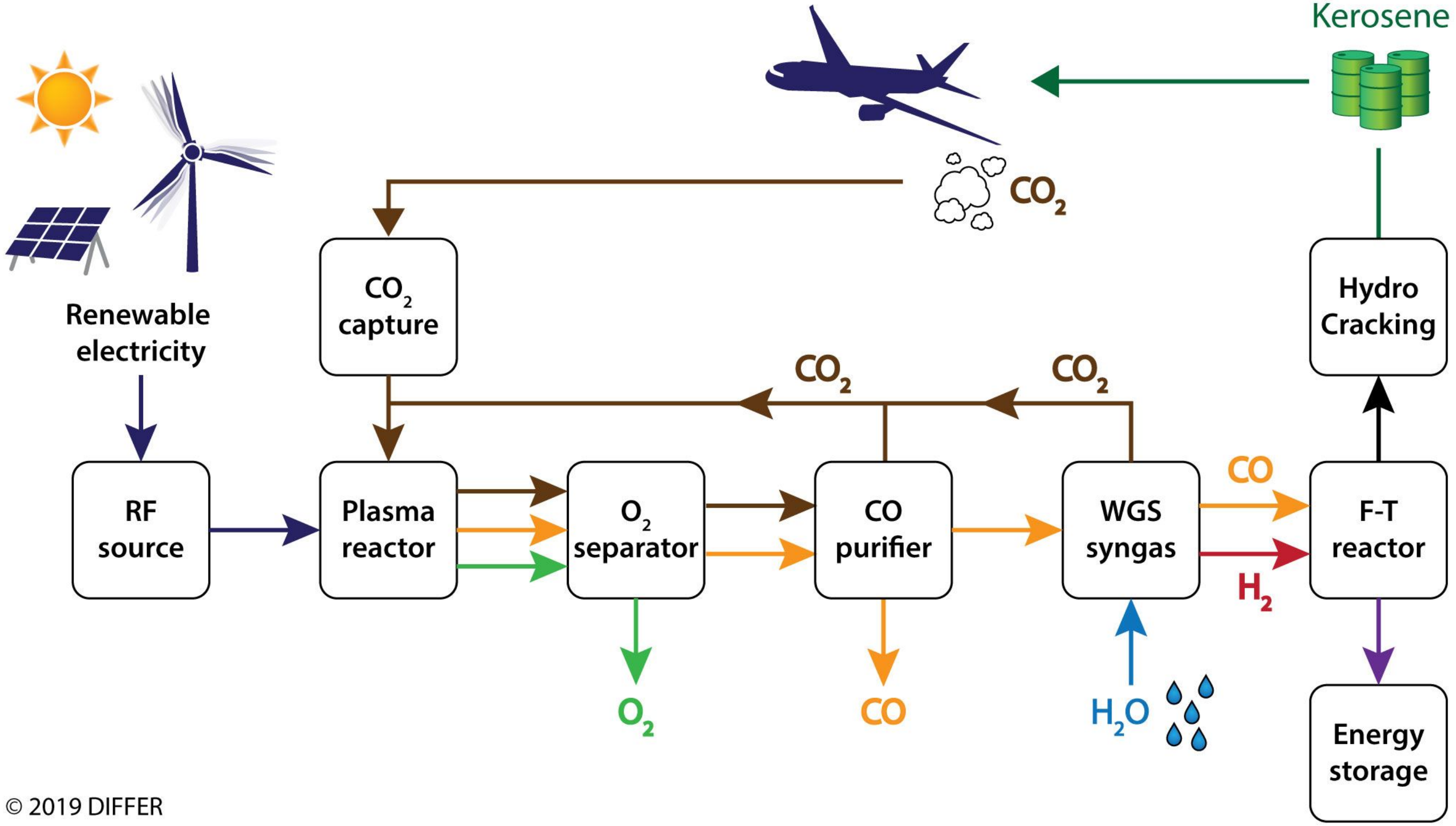
Paving the way towards clean energy and fuels in Europe, EUBCE Conference, 29 May 2019, Lisbon

Talks with research, industry and EU Member States on bioenergy, advanced biofuels and renewable fuels

KEROGREEN

DIFFER
Dutch Institute for
Fundamental Energy Research

This project has received funding from the European Union's Horizon 2020 Research and Innovation program under agreement No. 763909



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

Karlsruher Institut für Technologie | vito vision on technology | CerPoTech Ceramic Powder Technology | HYGEAR ENGINEERING FOR SUSTAINABLE GROWTH | INERATEC

Project Acronym: **KEROGREEN** Project Number: **763909** Call: H2020 LCE-06-2017 Topic: Sustainable Fuels Diversification of renewable fuel production through novel conversion routes

Project title: Production of sustainable aircraft grade Kerosene from air and water powered by renewable electricity

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

Keywords: Sustainable Aircraft grade fuel, plasma chemistry, CO_2 splitting, renewable electricity, Fischer-Tropsch synthesis, container sized module, P2X, sector coupling, energy storage.

Technological approach of the Project: Plasma driven CO_2 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 CO_2 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: CO_2 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.

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No 763909

Solar-thermochemical synthesis of hydrocarbon fuels

SUN to LIQUID
Fuels from concentrated sunlight

Solar Redox Cycles

$2H_2O + CO_2$ → $2H_2 + CO$

Gas-to-Liquid Synthesis

„CH_2“

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

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**

Main Category of the Project: Renewable hydrocarbon fuels; **TRL:** 5
Key words: Solar-thermochemical conversion, renewable hydrocarbon fuel, non-biomass non-fossil sources
Technological approach of the Project: SUN-to-LIQUID establishes a radically different non-biomass non-fossil path to synthesize renewable liquid hydrocarbon fuels from abundant feedstock of H_2O, CO_2 and solar energy. Concentrated solar radiation drives a thermochemical redox cycle, which inherently operates at high temperatures and utilizes the full solar spectrum.

Expected Impact: 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.

Highlights (technological/non-technological): 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 H_2O and CO_2. 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 >80% GHG emission reduction.

What is needed in the future: 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.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654408 – SUN-to-LIQUID // This work was supported by the Swiss State Secretariat for Education, Research and Innovation (SERI) under contract number 15.0330

Paving the way towards clean energy and fuels in Europe

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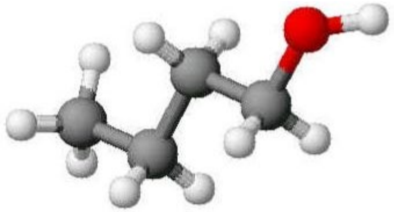
✓AFW matrix definition and pretreatment/hydrolysis

Apple juice waste

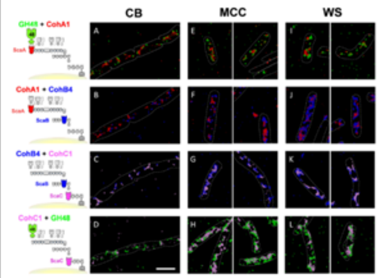
Brewers' Spent Grains

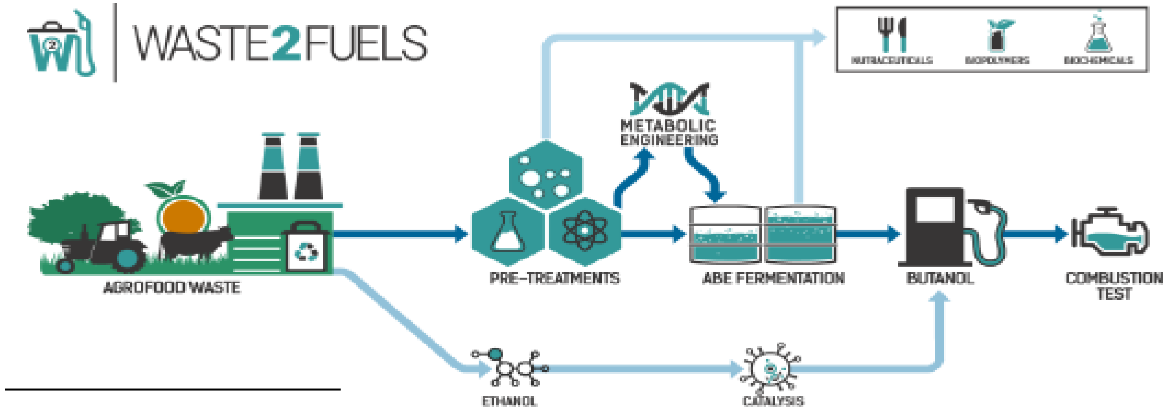
Coffee Silver Skin

Potato peels

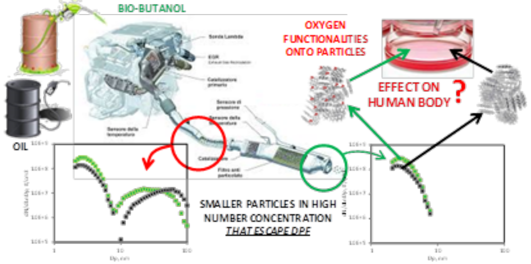


✓Strain improvement and enzyme production

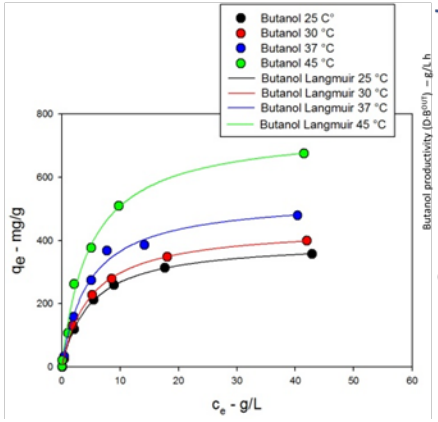


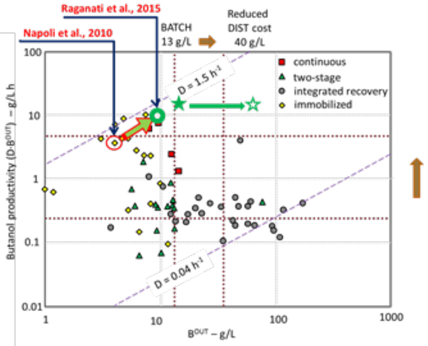


✓Engine tests and ecotoxicology

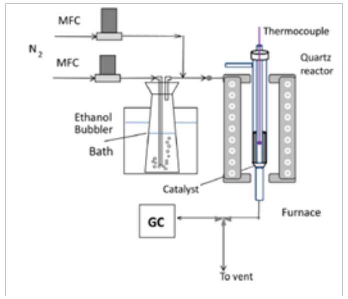


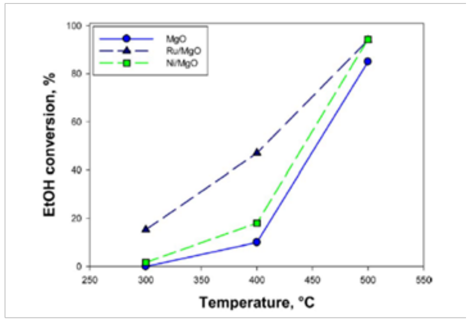
✓Fermentation reactor & butanol recovery systems





✓Catalytic conversion





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

Technological approach of the Project: Pretreatment methods for converting AFW to feedstock for biobutanol production. Genetically modified microorganisms. Coupled recovery and biofilm reactor systems. Biobutanol production via ethanol catalytic conversion. Engine tests. Ecotoxicological assessment.

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

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No *654623*