Introduction to the Projects

International Workshop on CO_2 Capture and Utilization,
16-17 February 2021, TU/E, Eindhoven, The Netherlands

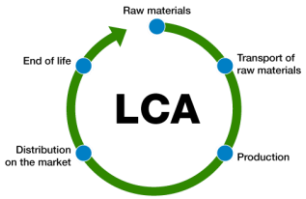
Outline

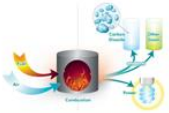
1. MEMBER
2. CARMOF
3. BIOCOMEM
4. C2FUEL
5. COZMOS
6. eCOCO2
7. CO2Fokus
8. C4U
9. REALISE
10. CONVERGE
11. KEROGREEN

Nº	Topic	Acronym	Project Tytle	website	Coordinator or speaker
1	NMBP-20-2017: High-performance materials for optimizing carbon dioxide capture	MEMBER	Advanced MEMBranes and membrane assisted procEsses for pre- and post- combustion CO2 captuRe	https://member-co2.com/	José Luis Viviente
2	NMBP-20-2017: High-performance materials for optimizing carbon dioxide capture	CARMOF	TAILOR-MADE 3D PRINTED STRUCTURES BASED ON CNTS AND MOFS MATERIALS FOR EFFICIENT CO2 CAPTURE	https://carmof.eu/	Adolfo Benedito
3	BBI-2019-SO3-R10 - Develop bio-based high-performance materials for various and demanding applications	BIOCOMEM	Bio-based copolymers for membrane end products for gas separations	https://www.biocomem.eu/	Oana David
4	CE-SC3-NZE-2-2018: Conversion of captured CO2	C2FUEL	Carbon Captured Fuel and Energy Carriers for an Intensified Steel Off-Gases based Electricity Generation in a Smarter Industrial Ecosystem	https://c2fuel-project.eu/	Camel Makhloufi
5	CE-SC3-NZE-2-2018: Conversion of captured CO2	COZMOS	Efficient CO2 conversion over multisite Zeolite-Metal nanocatalysts to fuels and OlefinS	https://www.spire2030.eu/cozmos	Richard H. Heyn
6	CE-SC3-NZE-2-2018: Conversion of captured CO2	eCOCO2	Direct electrocatalytic conversion of CO2 into chemical energy carriers in a co-ionic membrane reactor	https://ecocoo.eu/	José M. Serra
7	CE-SC3-NZE-2-2018: Conversion of captured CO2	CO2Fokus	CO2 utilisation focused on market relevant dimethyl ether production, via 3D printed reactor- and solid oxide cell-based technologies	https://www.co2fokus.eu/	Vesna Middelkoop
8	LC-SC3-NZE-5-2019-2020 - Low carbon industrial production using CCUS	C4U	Advanced Carbon Capture for steel industries integrated in CCUS Clusters	https://c4u-project.eu/	Haroun Mahgerefteh
9	LC-SC3-NZE-5-2019-2020 - Low carbon industrial production using CCUS	REALISE	Demonstrating a Refinery-Adapted Cluster-Integrated Strategy to Enable Full-Chain CCUS Implementation	https://realiseccus.eu/	Inna Kim
10	LC-SC3-RES-21-2018 - Development of next generation biofuels and alternative renewable fuel technologies for road transport	CONVERGE	CarbON Valorisation in Energy-efficient Green fuels	https://www.converge-h2020.eu/	Giampaolo Manzolini
11	LCE-06-2017 - New knowledge and technologies	KEROGREEN	Production of Sustainable aircraft grade Kerosene from water and air powered by Renewable Electricity, through the splitting of CO2, syngas formation and Fischer-Tropsch synthesi	http://www.kerogreen.eu/	Michael Tsampas

Advanced MEMBranes and membrane assisted procEsses for pre- and post- combustion CO_2 captuRe

MEMBER project aims to reduce the cost of the Carbon Dioxide capture technologies by scaling-up and manufacturing advance materials (membranes, catalysts and sorbents) to develop membrane-based technologies that outperform current technology for pre- and post-combustion CO_2 capture in power plants as well as H_2 generation with integrated CO_2 capture.



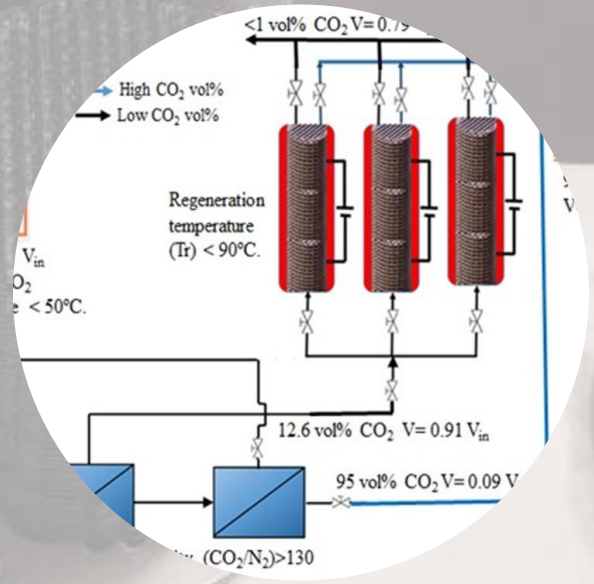
Material Production and Scale up		Prototype Manufacturing		Demonstration TRL 6	Performance Targets
Raw Material	Processing & Scale Up	Module / Reactor	CO_2 Capture System	Application	
MOFs  Polymers	 Mixed Matrix Hollow Fibers			Pre- & Post- combustion CO_2 capture in power plants  	CO_2 capture > 90% CO_2 capture cost: < 30 €/ton pre- < 40 €/ton post-
Sorbents   Catalyst	 Membranes			Membrane Assisted Sorption Enhanced Reforming (MA-SER): H_2 production with integrated CO_2 capture	CO_2 capture > 90% CO_2 capture cost: < 30 €/ton pre-

https://member-co2.com/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 760944.

CARMOF Project

TAILOR-MADE 3D PRINTED STRUCTURES BASED ON CNT AND MOF MATERIALS FOR EFFICIENT CO2 CAPTURE



CARMOF is developing a hybrid CO_2 process combining **VTSA modules** based on 3D printed monoliths with thermoelectric regeneration and "in cascade" **membranes system**. The goal is to achieve high purity CO_2 streams from synergetic effects from both technologies

Bio-based copolymers for membrane end products for gas separations

BioCoMem

BBI JU

Bio-based Industries Consortium

This project has received funding from the Bio Based Industries Joint Undertaking (JU) under the European Union's Horizon 2020 research and innovation programme, under grant agreement No 887075.

The JU receives support from the European Union's Horizon 2020 research and innovation program and the Bio Based Industries Consortium

Material production and scale up WP3 +WP4

Core material	Processing & scale up	Process quality control
Bio based Monomers	3 new bio-HF Membranes	**Process control** Homogeneity Morphology Permeation **Product Control and**
Polymers		
ARKEMA, UM, B4PLASTICS	polymem, tecnalia	UM, ARKEMA, B4PLASTICS, polymem, tecnalia

Prototype membrane module Integration & Validation WP5

Modules construction	Modules testing (TRL 4)	Modules testing (TRL 5)
polymem	Aging Bio gas upgrading Natural gas upgrading CO_2 separation from post combustion processes flue gases TU/e	Bio gas upgrading dmt Environmental Technology

LCA (Raw materials, Transport of raw materials, Production, Distribution on the market, End of life)

Quantis

Industrial Specifications, Process design, Technical and Economical Assessment. WP2

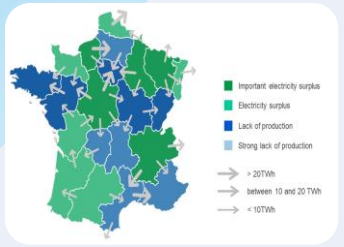
Dissemination and exploitation WP7

Recyclability and plastic footprint WP6

C2FUEL Approach: Aligning local supply and demand

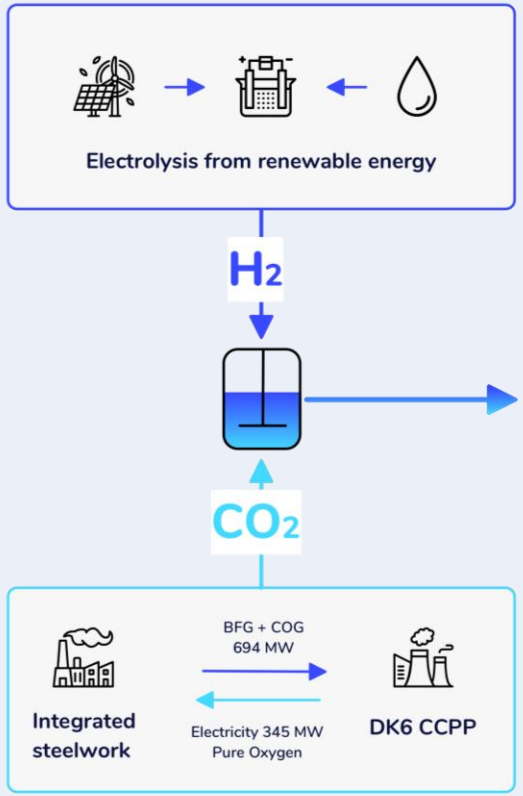
Dr Camel Makhloufi – ENGIE Lab CRIGEN - France

Dunkirk Integrated steel making factory



Large renewable penetration

Dunkirk Harbor



Formic acid as Hydrogen carrier

Decreasing the electricity footprint during boat charging on docks

C2FUEL Output

2,4 million ton of FA

100 000 ton of green hydrogen

1,8 TWh of green electricity

Seasonal storage using 3.6 TWh of renewable electricity

Dimethylether as Maritime and truck fuel

Displacing fossil fuel emission from power plant and decreasing harbor mobility footprint

C2FUEL Output

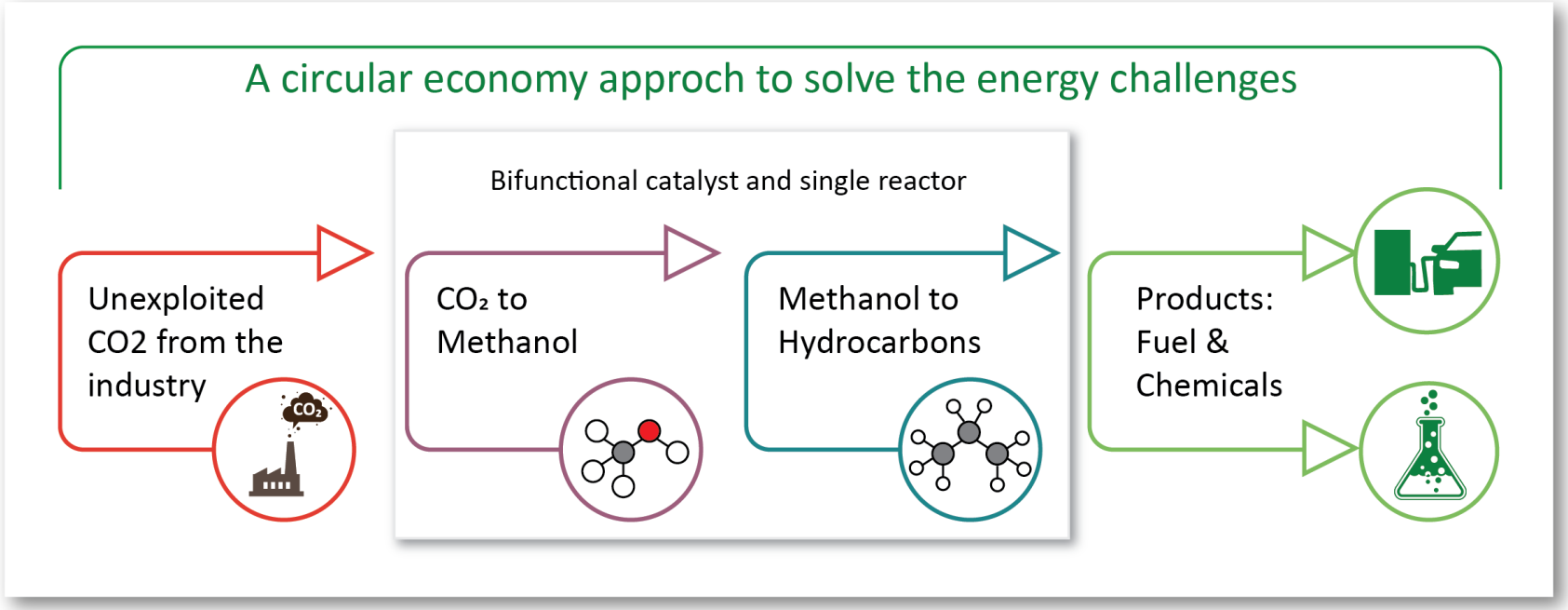
1,2 million ton of DME

320 000 ton of green H_2 produced using 11 TWh of renewable electricity

"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 838014".

CO2MOS

Efficient CO_2 conversion over multisite Zeolite-Metal nanocatalysts to fuels and OlefinS



Unni Olsbye, University of Oslo, Coordinator

Other partners

COZMOS: Efficient CO2 conversion over multisite Zeolite-Metal nanocatalysts to fuels and OlefinS.
This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 837733.

Direct electrocatalytic conversion of CO_2 into chemical energy carriers in a co-ionic membrane reactor

AIM: Set-up a technology for direct synthesis of carbon-neutral jet fuels from CO_2 using renewable energy and electrochemical catalytic membrane reactors. Bench-testing targets a 500 W multi-tubular system.

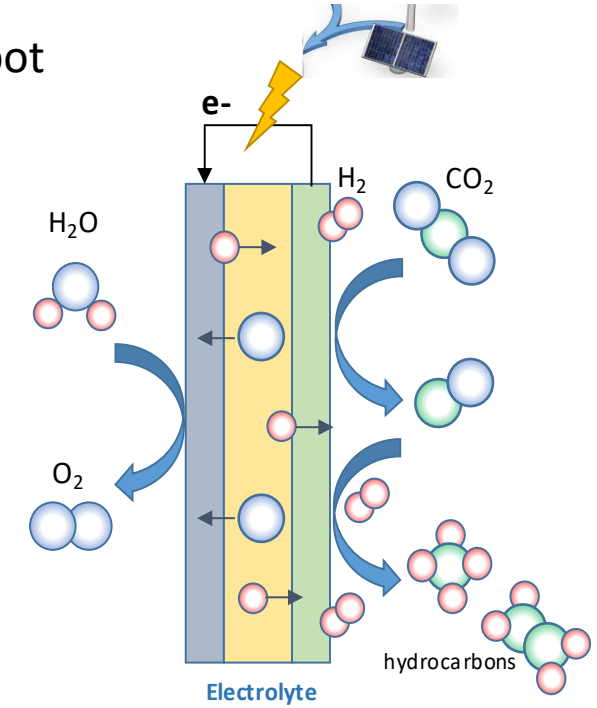
- Single-step electrolysis and one-pot catalytic conversion.
- Operating conditions:
  T = 350-450 °C and > 25 bar.

Product:
Jet fuel

Efficiency:
> 85%

Full integration:
compact sized reactor

Final TRL:
5



Co-Electrolysis Reactor

PARTNERS

CSIC Consejo Superior de Investigaciones Científicas
CoorsTek Membrane Sciences
ITQ Instituto de Tecnología Química
Universitas Oslo
Universitat Politècnica de València
RWTH Aachen University
HERA
Shell
ArcelorMittal
SINTEF
CEMEX
九州大学 Kyushu University
Universitas Amoiensis

https://ecocoo.eu

H2020-LC-SC3-2018-NZE-CC | Duration: May 2019 – May 2023 | **EC funding**: 3.9 M€

This project has received European Union's Horizon 2020 research and innovation funding under grant agreement Nº 838077.

SPIRE Sustainable Process Industry through Resource and Energy Efficiency

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CO_2 utilisation focused on market relevant dimethyl ether production, via 3D printed reactor and solid oxide cell based technologies

Vesna Middelkoop, VITO

1500 N L/h CO_2/H_2 feed, > 30 % CO_2 conversion, 3.5 kW SOE 50 % conversion demo in industrial environment in 2022

www.co2fokus.eu

The project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement n. 838061

info@co2fokus.eu

C⁴U Advanced Carbon Capture for Steel Industries Integrated in CCUS Clusters

• C⁴U addresses the essential elements for the optimal integration of CO_2 capture in the iron and steel industry as part of the CCUS chain. This spans demonstration of two highly efficient solid based CO_2 capture technologies for optimal integration into an iron and steel plant and detailed consideration of the safety, environmental, societal, policy and business aspects for successful incorporation into the North Sea Port CCUS industrial cluster.

https://c4u-project.eu/

Testing and demonstration of capture technologies at TRL7

WP1: DISPLACE process for reheating ovens

1. Design, construction and commissioning
2. TRL7 N_2-H_2 benchmark demonstration
3. TRL7 DISPLACE technology demonstration
4. Detailed DISPLACE reactor modelling
5. CO_2 purity analysis for pipeline and storage

WP2: CASOH process for blast furnace gas

1. Reactor design modelling
2. Pilot commissioning
3. Screening operating conditions at TRL7
4. Long term experimental testing at TRL7
5. CO_2 purity analysis for pipeline and storage

Integrating CO_2 capture in industrial installations and clusters

WP3: Integration of CO_2 capture technologies in steel plant

1. Detailed CO_2 capture process modelling
2. Techno-economic assessment and optimization of steel mill with CO_2 capture
3. Industrial design and costing of capture systems

WP4: Integration of CO_2 capture in industrial clusters

1. Transport and storage safety impact assessment
2. CCUS cluster whole system modelling and operational logistics
3. Life Cycle Assessment of the North Sea Port CCS cluster

Societal readiness, public policy and the business case

WP5: Societal readiness and public policy

1. System dynamics of socio-economic and political aspects
2. Assessment of concerns and needs of societal stakeholders
3. Policy instruments assessment for CCUS in industrial clusters

WP6: Long term business models

1. Market and stakeholder analysis
2. Scenario development, investment and risk analysis
3. Customer value proposition development
4. Business model descriptions

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 884418.

Project Coordinator
Haroun Mahgerefteh
University College London
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Project Period
April 2020 - March 2024
Overall budget
€ 13,845,496

Demonstrating a refinery-adapted cluster-integrated strategy to enable full-chain CCUS implementation – REALISE (May 2020 – April 2023)

CO_2 capture with 2nd gen. solvents

- Mobile pilot on-site refinery
- Stationary pilot

Solvent management technologies

- Avoid solvent loss
- Emissions control

CO_2 transport, conversion and storage

- CO_2 liquefaction
- CO_2 conversion
- CO_2 storage

Societal study

- EPE program
- CCUS readiness

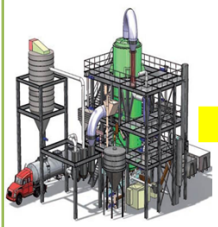
CCUS business cases: Irland, China, S. Korea

biobe Expertise in plastics · Bord Gáis Energy · CYBERNETICA · equinor · 敦华石油 DUNHUA OIL · IRVING · NTNU · PENTAIR UNION ENGINEERING · POLITECNICO MILANO 1863 · SCCS · ervia ervia · ESB Energy for generations · UCC University College Cork, Ireland · SINTEF · TNO innovation for life · SK innovation

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 884266

The **CONVERGE project will validate an innovative process** which will **increase the biodiesel production by 12%** per secondary biomass unit used and **reduce the CAPEX by 10%.** The **CONVERGE technologies will be validated** for more than **2000 cumulated hours** taking these from the discovery stage (TRL3) to development stage (TRL5).

In addition, **the CONVERGE process will valorise the** remaining biogenic and **purified CO_2** for production of negative emissions via BECCS.



Biomass gasification

Syngas pre-treatment
+5% efficiency

Syngas

Sorption Enhanced Reforming: H_2/CO_2 separation
+15% efficiency

CO_2

CO_2 to storage

LP H_2

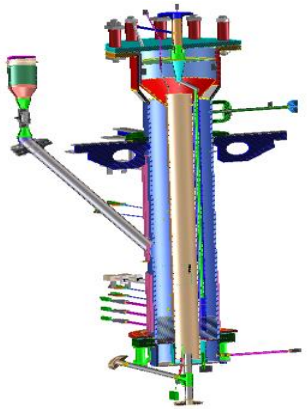
Electrochemical Hydrogen compression
+15% efficiency

HP H_2

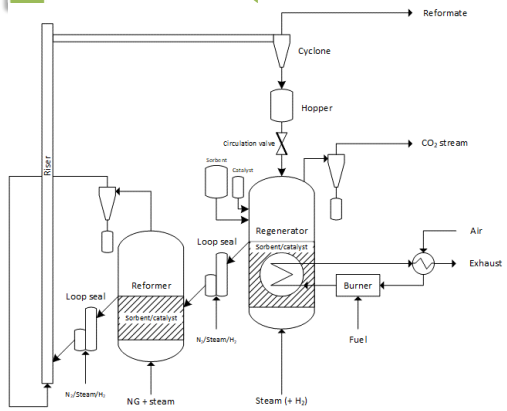
Enhanced Methanol Membrane synthesis
+10% efficiency

+12% Green Biodiesel Production

CONVERGE
CarbON Valorisation in Energy-efficient Green fuels

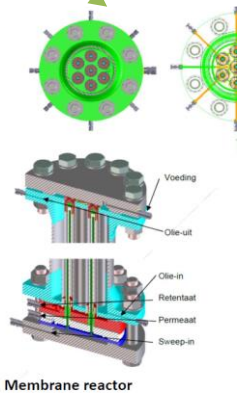


Catalytic cracking reactor



Sorption Enhanced Reformer

Electrochemical Hydrogen compressor

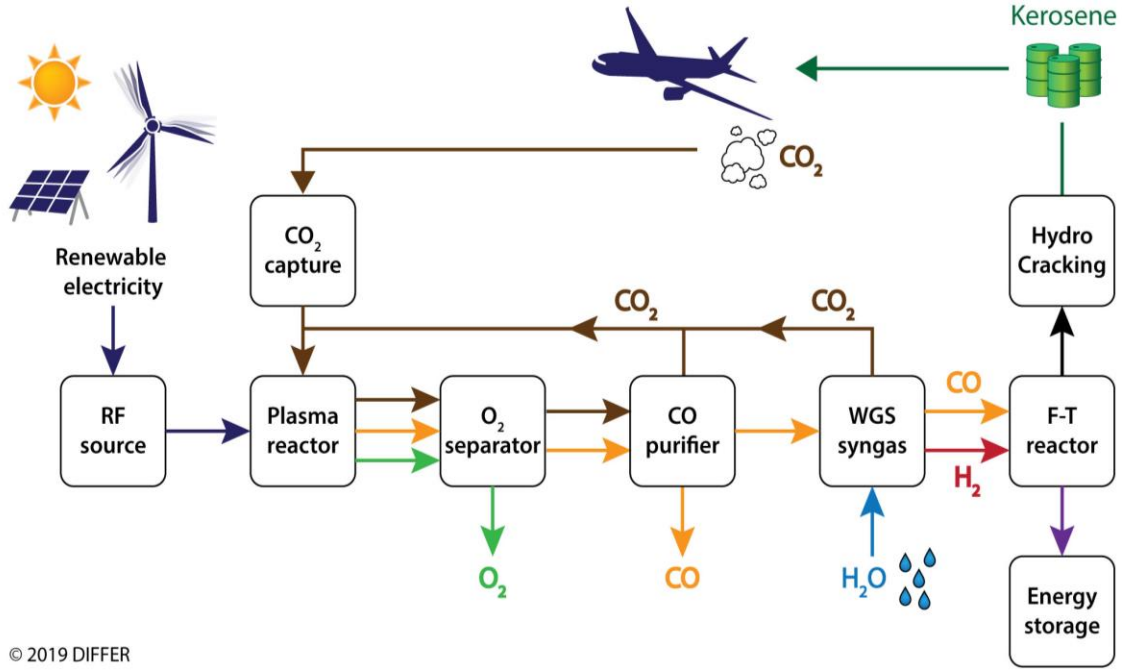


Membrane reactor

Methanol membrane reactor

The CONVERGE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 818135

www.converge-h2020.eu



The KEROGREEN CO_2 plasma route to CO and alternative fuels

M.N. Tsampas, DIFFER, THE NETHERLANDS

Kerogreen aim: Demonstation of the full chain process from renewable, electricity, CO_2 (captured) and H_2O to kerosene.

- Research and optimization of individual process steps TRL (1-3) → 4
- Integration phase at Karlsruhe Institute of Technology → 3 L per day
- Duration 2018-2022