FLExible Dimethyl ether production from biomass Gasification with sorption enhancED processes

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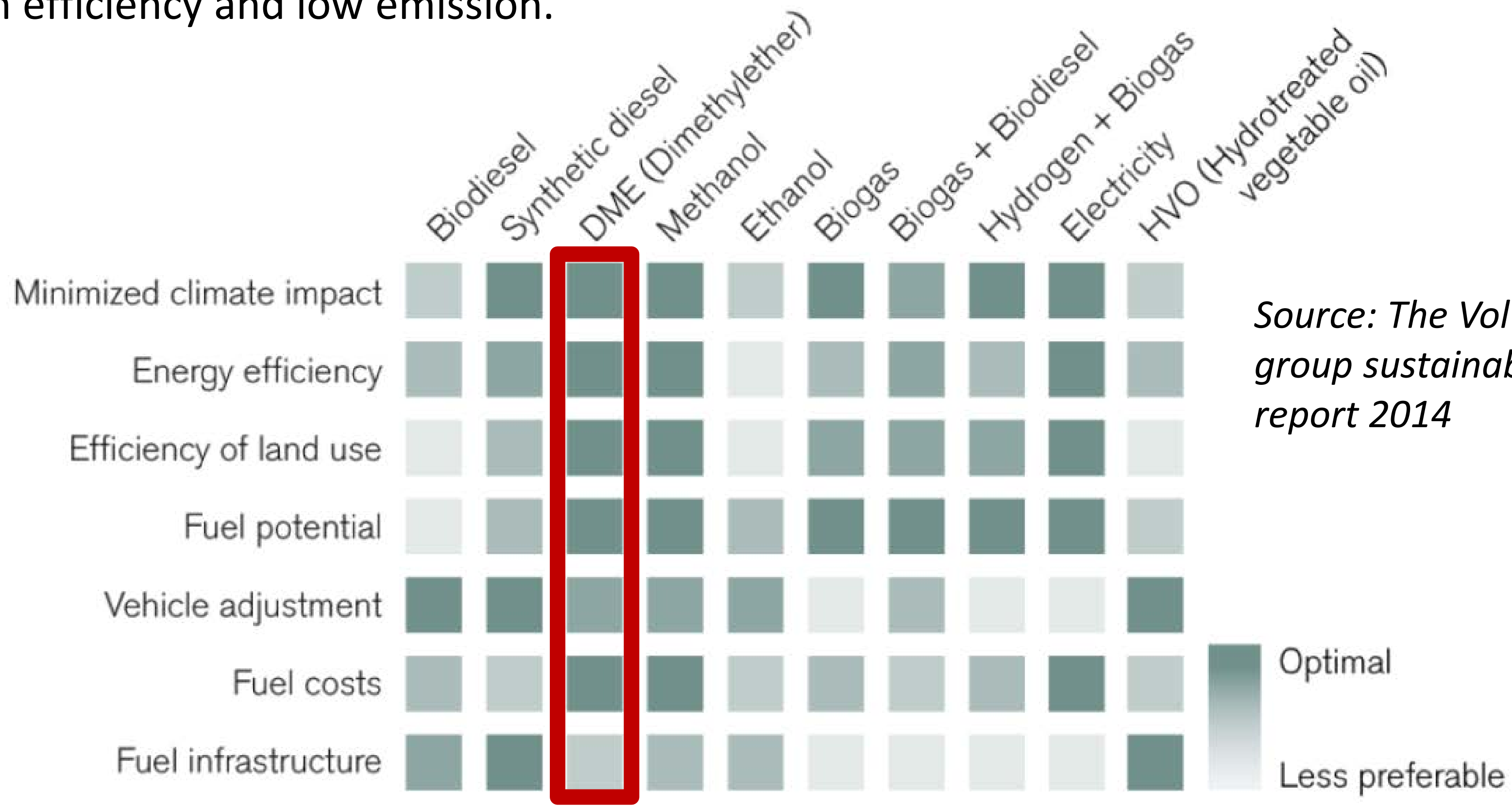
DME and other renewable fuels for automotive

Among the different solutions for "greening" the automotive sector, DME has several advantages: it requires only moderate adjustments of vehicle and diesel motor and yields high efficiency and low emission.



Source: The Volvo group sustainability report 2014

Production processes and supply chain still require improvements to be competitive.

Recent facts on DME as vehicle fuel

- USA, 2017: Demonstration of DME as fuel in Mack Trucks vehicles owned by New York City Department of Sanitation (DSNY), as alternative to Diesel. The evaluation is taking place at the Fresh Kills Landfill on Staten Island, New York, with fuel-grade DME produced by Oberon Fuels.
- China, 2015: A consortium collaborating on a DME vehicle demonstration project has received certification from the provincial government of Shanghai for a DME fueled heavy-duty diesel engine satisfying Euro 6 emission standards. The engine, a modified 6 liter 135 kW WP6 common rail injection diesel engine from Weichai Power, is being demonstrated on short-haul heavy-duty street sweeper and refuse trucks.
- Germany, 2015: Ford Motor Company is leading a 3-year project co-funded by the German government to develop and test the world's first production Mondeo passenger car to run on DME.
- California, 2015: The State of California approves DME's use as a vehicle fuel, allowing the retail sale of DME throughout the state.
- Geneva, 2015: The International Organization for Standardization (ISO) published a specification for DME fuel, marking another important milestone in the introduction of DME as an ultra-low emission fuel for a range of automotive, power, and heating applications.
- Sweden, 2010-13: BioDME EU FP7 project (www.biodme.eu/) demonstrated DME production from black liquor gasifiaction, its distribution and field test of 10 Volvo trucks fuelled by DME, which covered a total milage of more than 800 000 km. http://www.biodme.eu/

https://www.aboutdme.org/index.asp?sid=97

The FLEDGED project

The ***FLEDGED*** project will deliver a process for ***Bio-based dimethyl Ether (DME)*** production from **biomass** gasification, validated in ***industrially relevant*** environment (TRL5).

NOVEL FLEDGED PROCESS

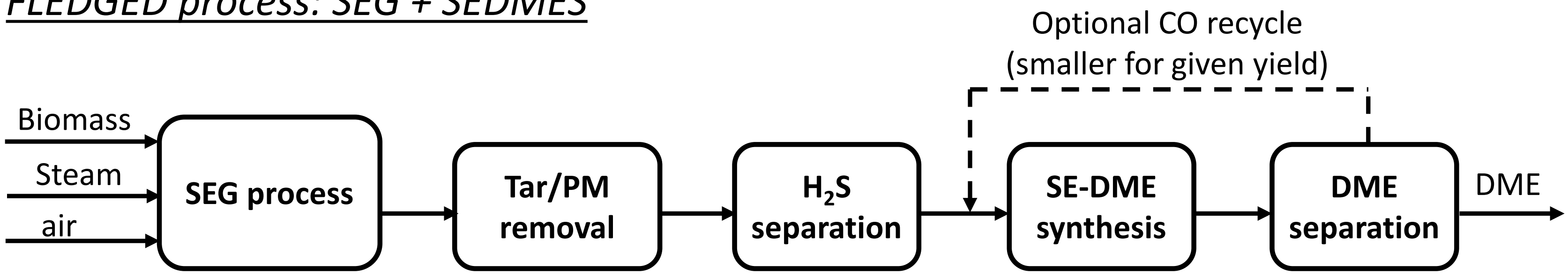
Flexible sorption enhanced gasification (SEG) process

+

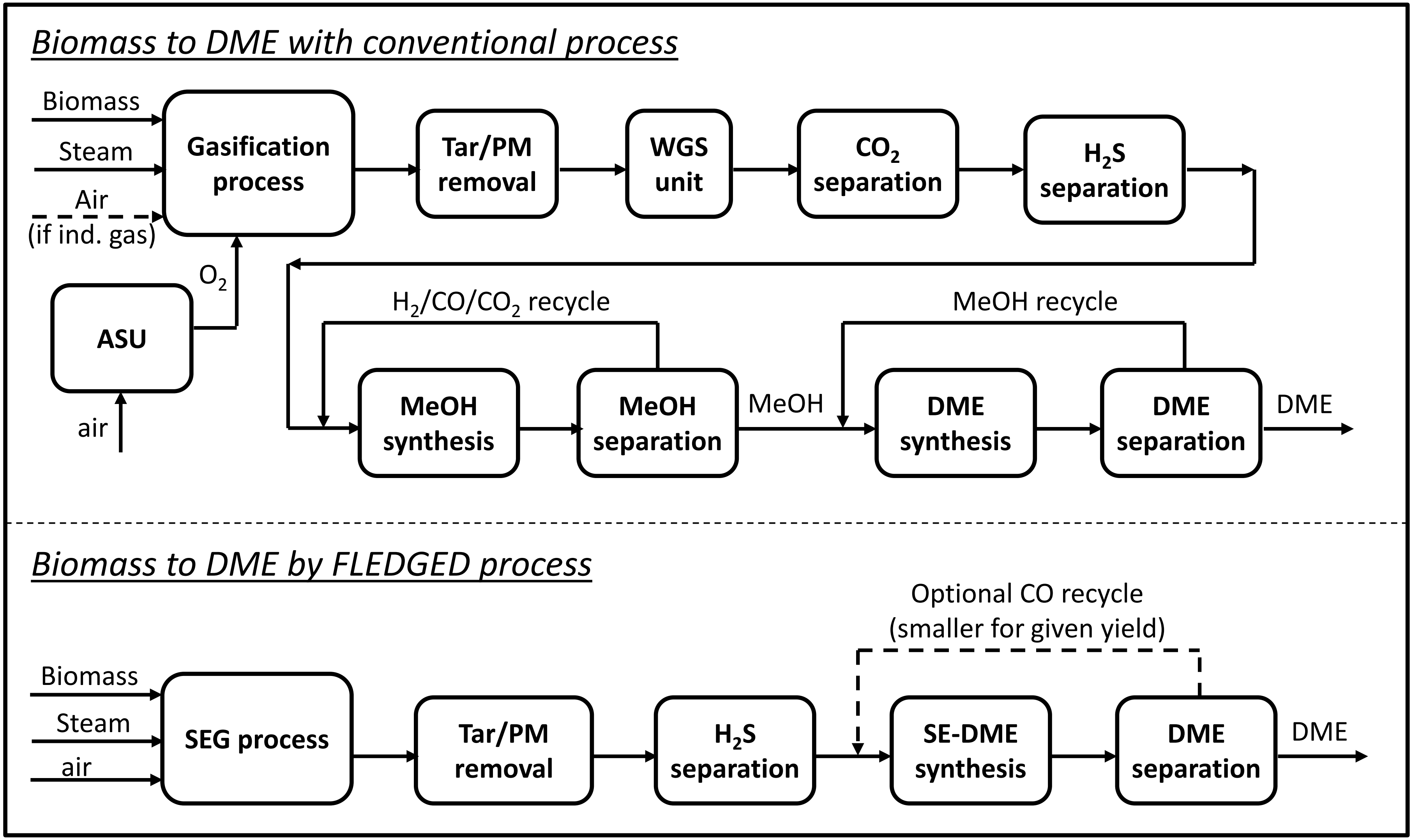
Sorption enhanced DME synthesis (SEDMES) process

- Process intensification
- Efficiency improvements
- Environmental impact reduction
- Cost reductions
- Process flexibility

FLEDGED process: SEG + SEDMES



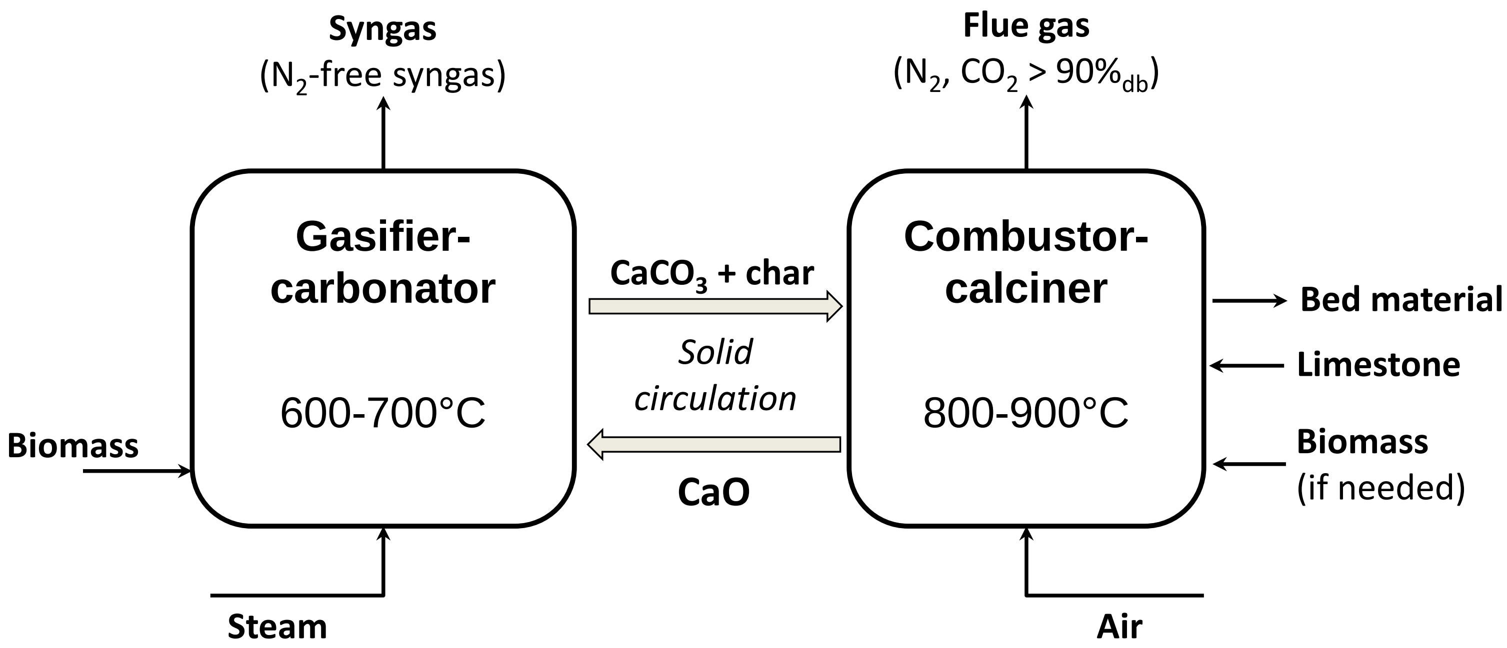
Process intensification



Sorption Enhanced Gasification

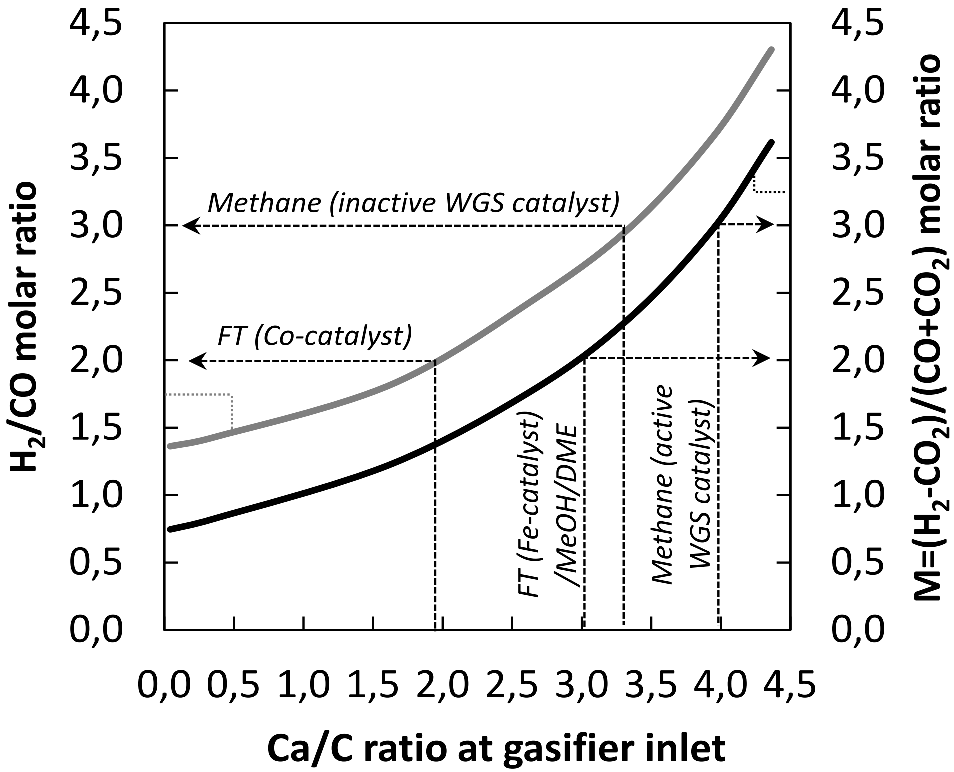
Solid material with Ca-based sorbent is circulated between the gasifier-carbonator and the combustor-calciner to:

- produce a N_2-free syngas with no need of pure oxygen production and external heating of the reactor;
- absorb CO_2 in the gasifier and adjust C/H content in the syngas.



SEG process flexibility: tailored syngas module

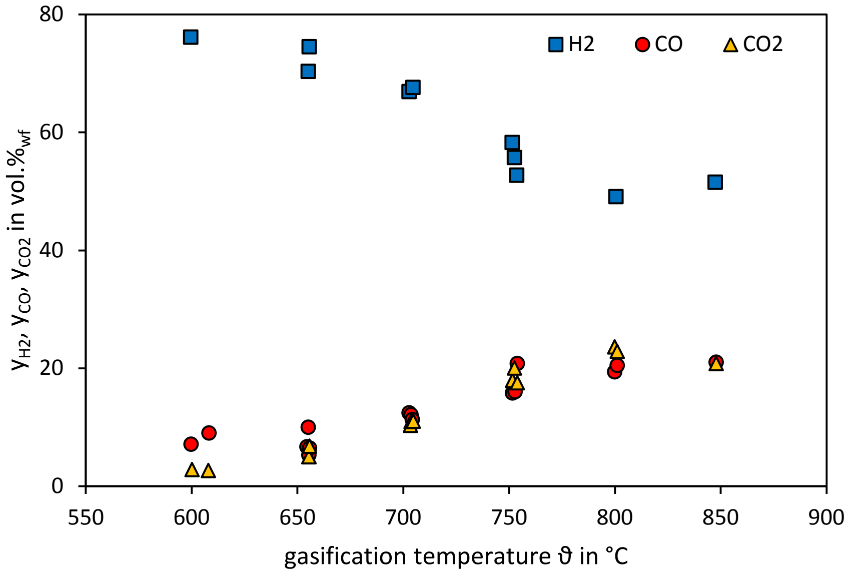
By controlling the SEG process parameters (solid circulation, Ca/C ratio in the gasifier, gasifier temperature, S/C ratio), syngas composition can be adjusted to match with the downstream synthesis process.

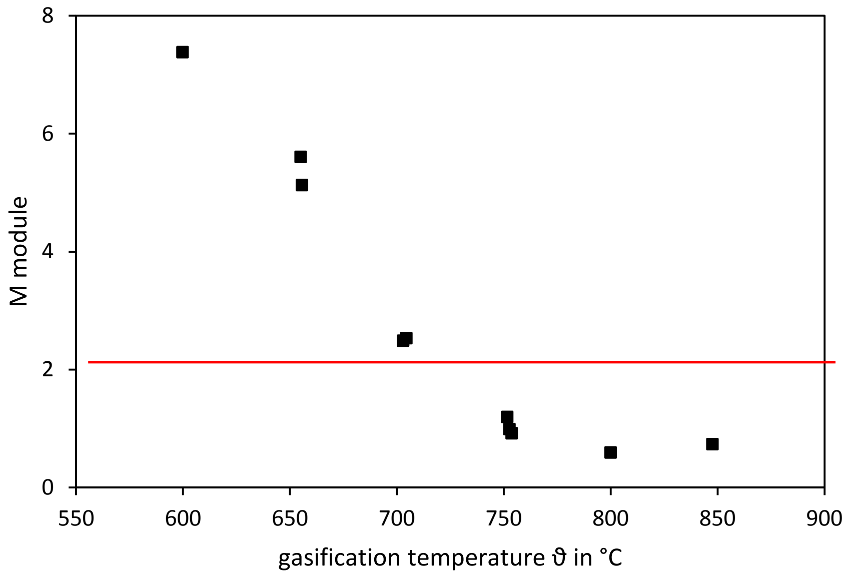


Source: Martínez, Romano, 2016. Energy 113, 615-630.

SEG process flexibility: tailored syngas module

Influence of the gasification temperature on the syngas module 'M'





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Results shown on this slide were obtained in the project 30KB011C which has received funding within the program „Forschung und Entwicklung zur Optimierung der energetischen Biomassenutzung" from the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety of Germany.

FLEDGED

Sorption enhanced DME synthesis

Methanol synthesis:

$$CO + 2H_2 \rightleftharpoons CH_3OH$$

$$CO_2 + 3H_2 \rightleftharpoons CH_3OH + \mathbf{H_2O}$$

Reverse water-gas shift (WGS)

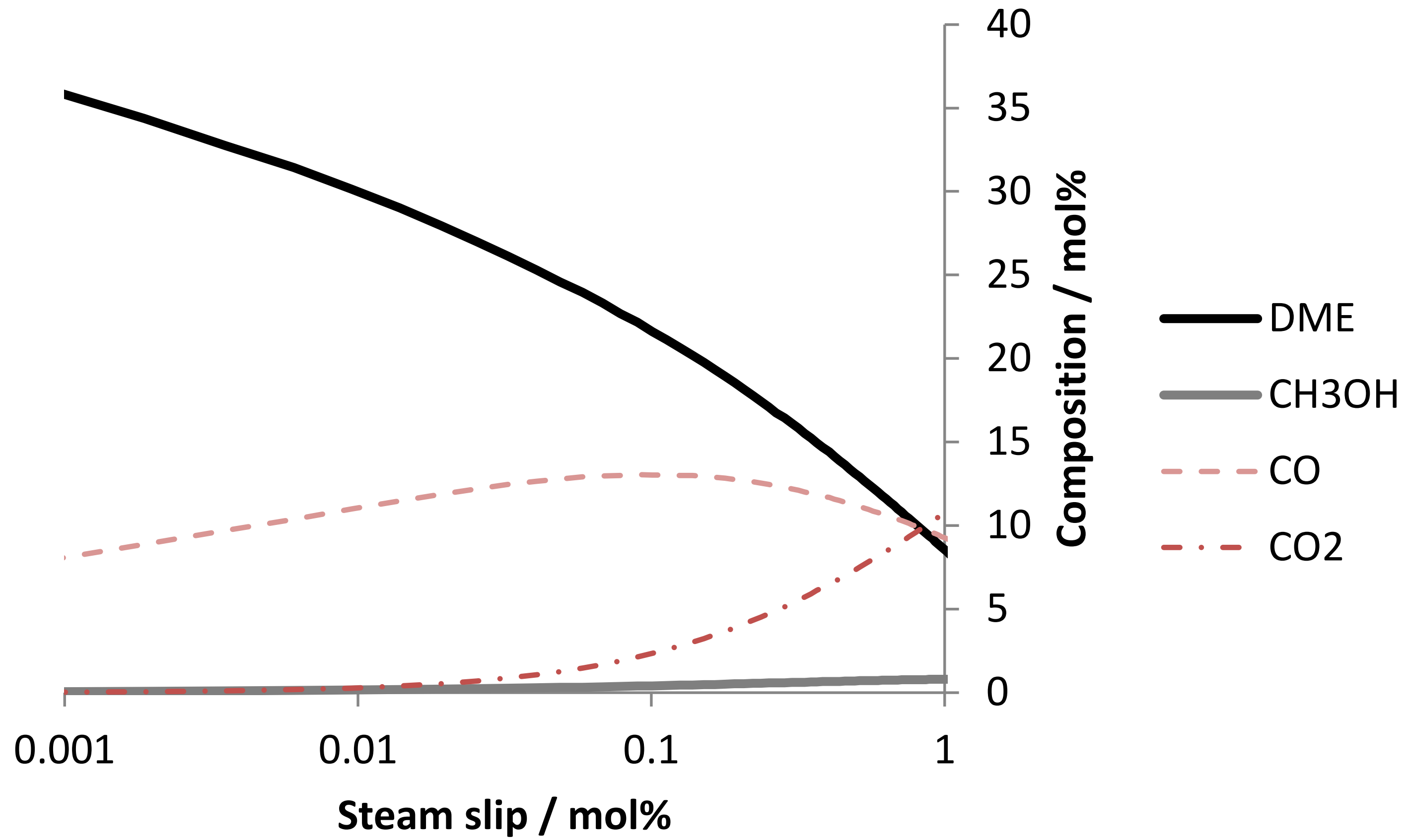
$$H_2 + CO_2 \rightleftharpoons CO + \mathbf{H_2O}$$

Methanol dehydration

$$2CH_3OH \rightleftharpoons CH_3OCH_3 + \mathbf{H_2O}$$

Sorption enhanced DME synthesis

Equilibrium with in-situ water removal:



275 °C
25 bar(a)

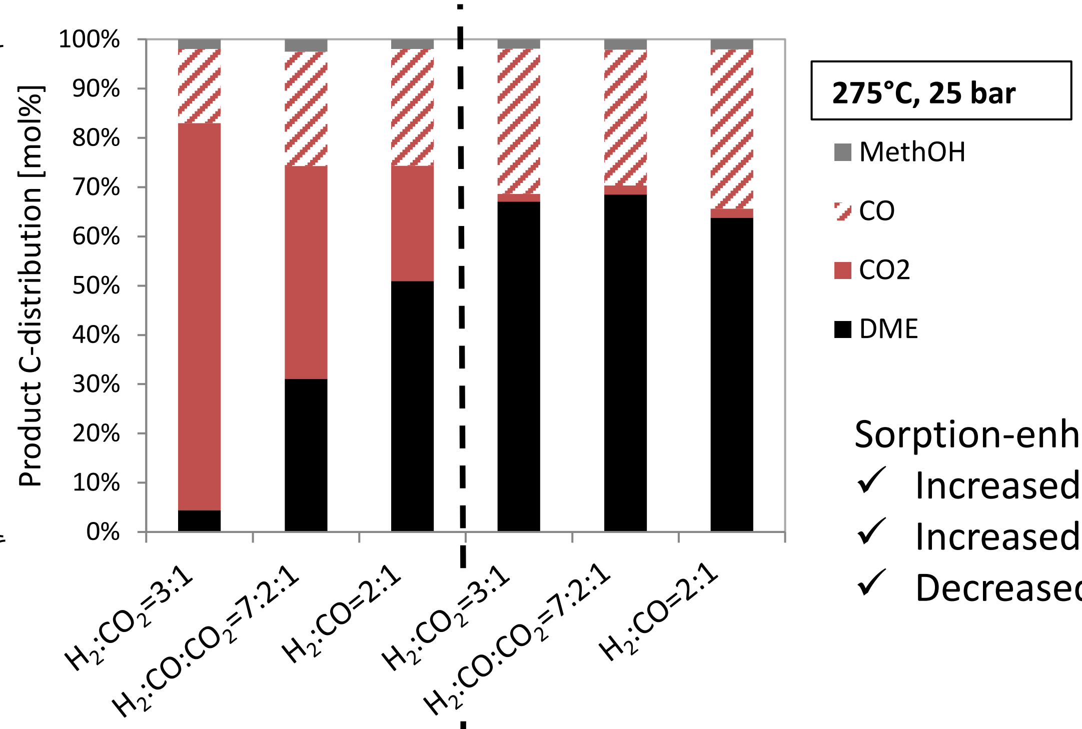
54 mol% H_2
15 mol% CO
7.7 mol% CO_2

Sorption enhanced DME synthesis

In presence of a H_2O sorbent, the thermodynamic limitation of DME yield from methanol dehydration can be significantly reduced.
DME yield in SEDMES process is insensitive to $CO:CO_2$ ratio in the syngas.

Product

$M = 2$ **Feed**



Conventional direct DME
(thermodynamic calculation)

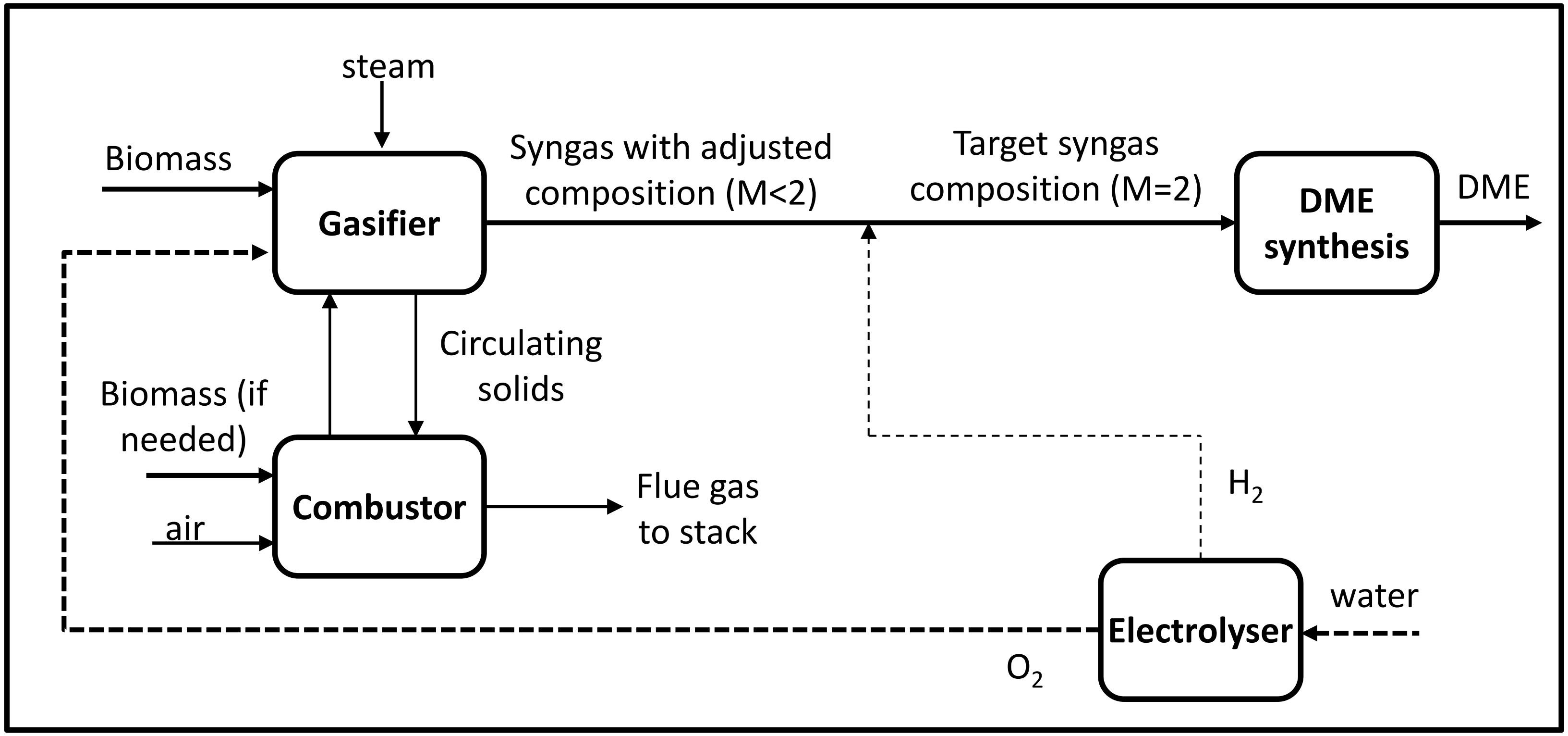
Sorption enhanced DME
(experimental observation)

Sorption-enhanced DME synthesis
- ✓ Increased CO/CO_2 flexibility
- ✓ Increased DME yield
- ✓ Decreased CO_2 content

Process flexibility: integration with intermittent RES

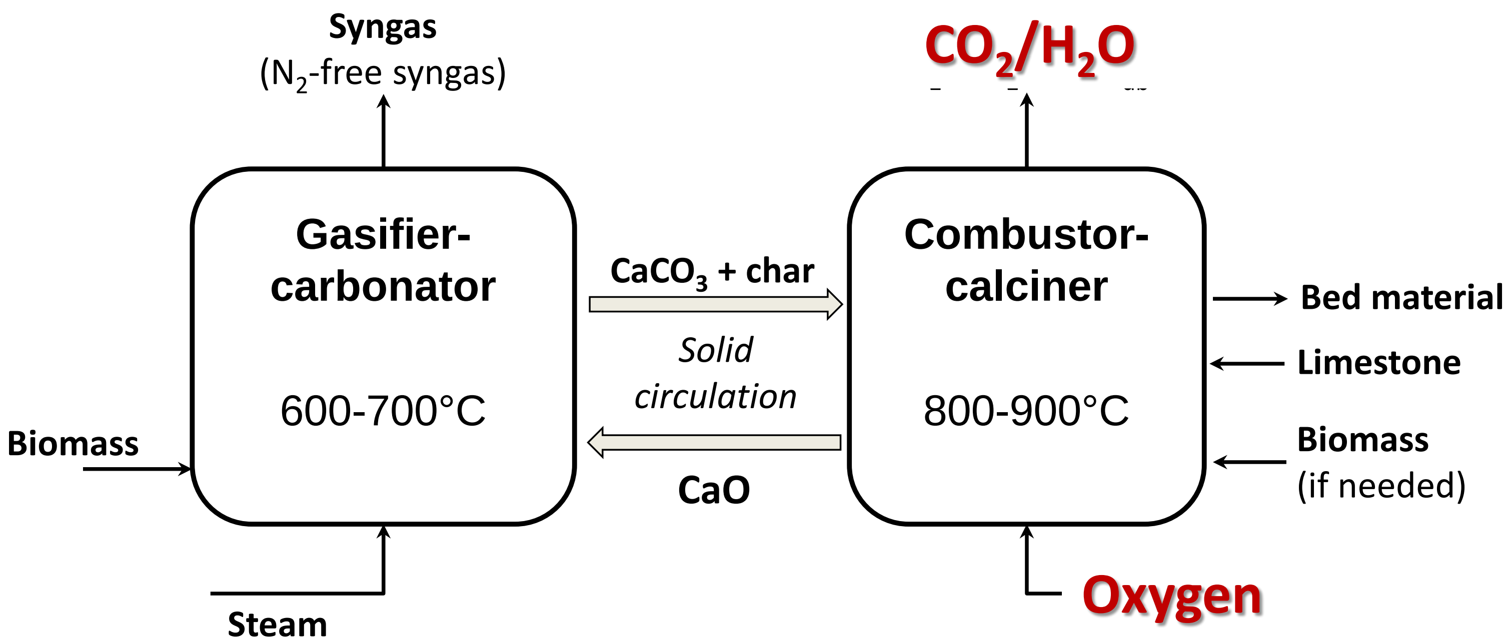
If integrated with an electrolysis unit providing renewable hydrogen, SEG process parameters can be adjusted to produce syngas suitable for SEDMES process.

Contribution to electric grid stability by power-to-liquid



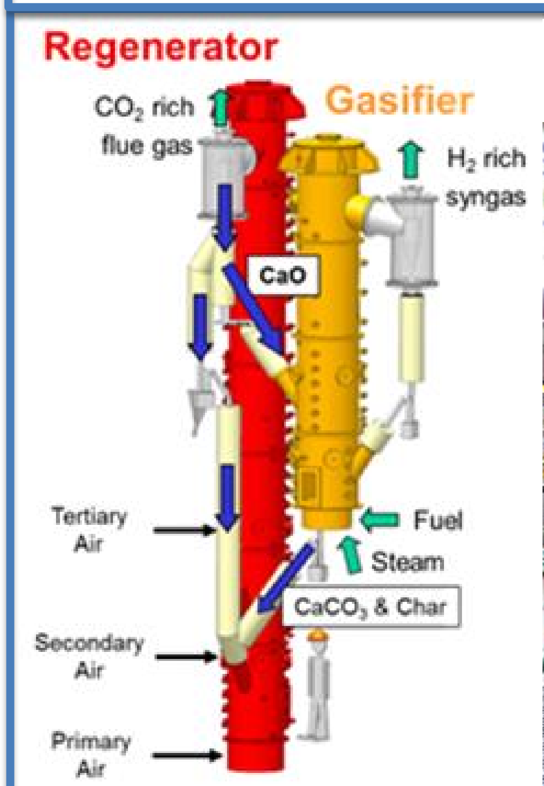
Process flexibility: CO_2 capture and storage

Possibility of CO_2 capture and storage by oxyfuel combustion in the SEG combustor.



Facilities for TRL5 demonstration

Flexible SEG process will be demonstrated in the 200 kW dual fluidized bed facility at IFK, University of Stuttgart.

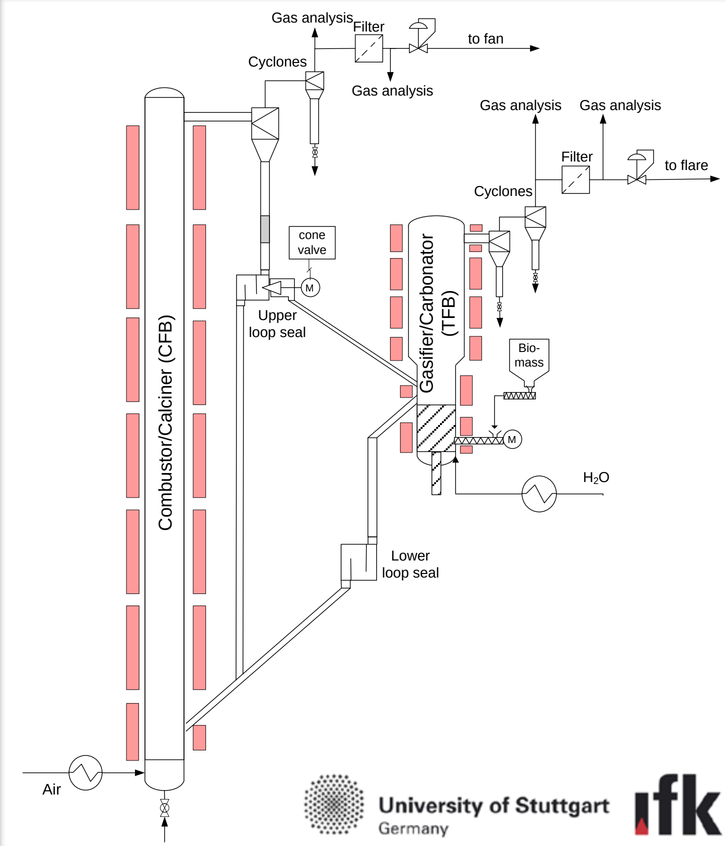


SEDMES process will be demonstrated in multi column PSA rig at ECN

Other experimental facilities for SEG development

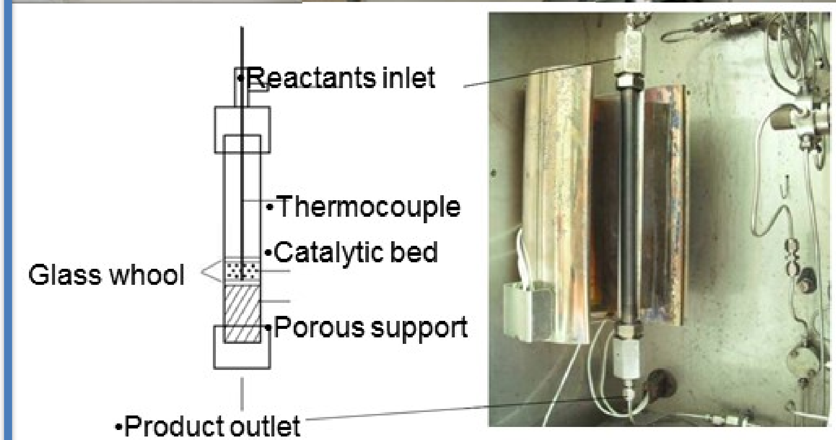
75 kW CSIC-ICB bubbling fluidized bed gasifier

20 kW USTUTT dual fluidized bed facility



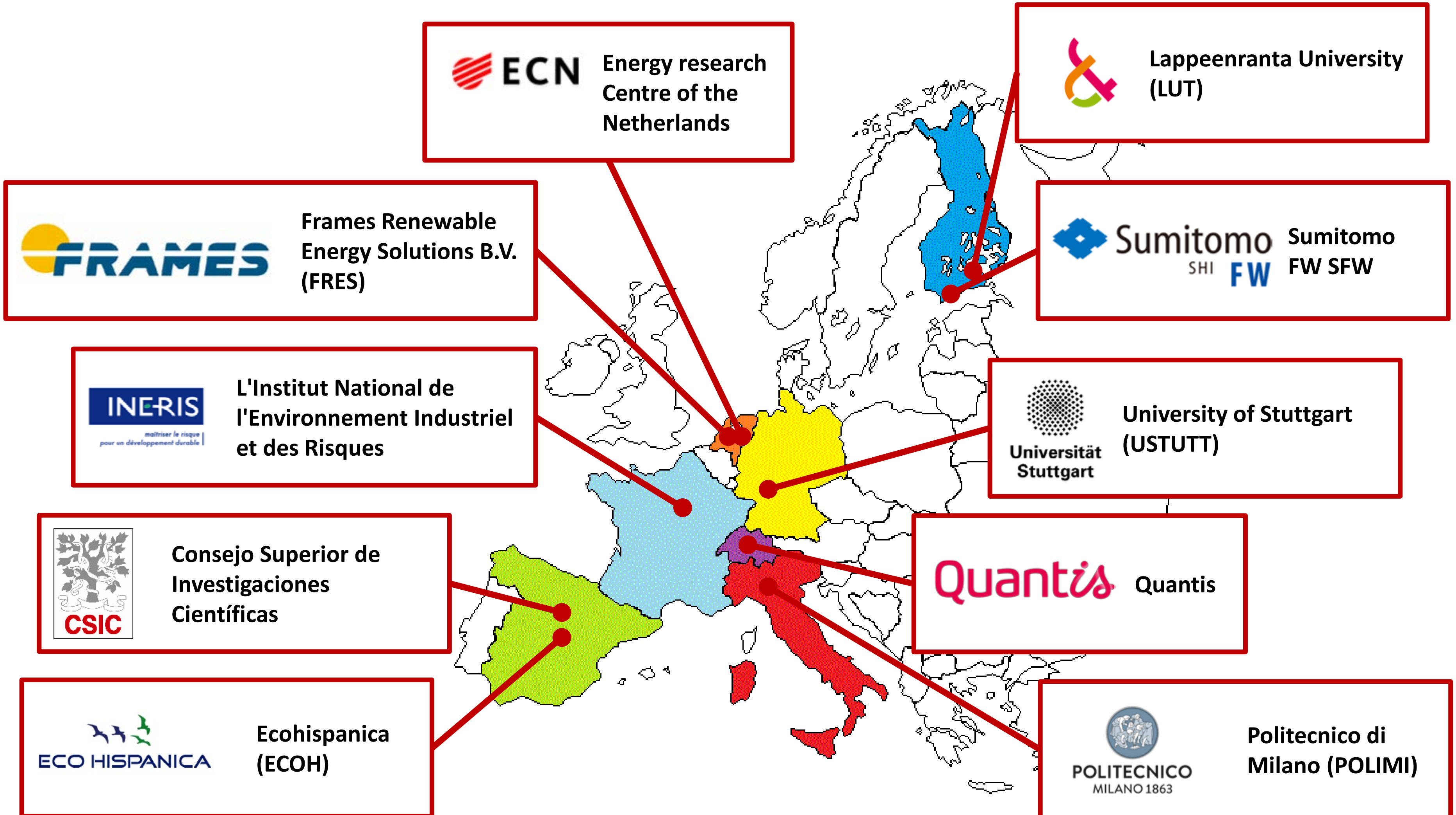
Other experimental facilities for SEDMES development

Facilities for testing and synthesis of SEDMES catalysts at CSIC-ICP



High throughput test-rig (Spider setup) and Single column PSA test-rig (SEWGS-1 setup) at ECN

The consortium



FLEDGED

Work Packages

WP1	Project coordination	
WP2	Component development • Fundamental research on gasification of different biomass types and different natural sorbents (CSIC, USTUTT) • Fundamental research on sorption enhanced DME production (CSIC, ECN)	
WP3	Process validation at TRL5 • Identification of experimental parameters/matrices (POLIMI, USTUTT, ECN, CSIC) • Sorption Enhanced Gasification validation under industrially relevant conditions (USTUTT, CSIC) • Validation DME production under industrially relevant conditions (ECN, CSIC)	

Work Packages

WP4	Modelling and process integration • Process simulation and optimization of full-scale FLEDGED plants (POLIMI, FRES) • Modelling of SEG dual fluidized bed reactors (LUT, CSIC) • Modelling of DME reactor and synthesis process (ECN, POLIMI)	LUT Lappeenranta University of Technology POLITECNICO MILANO 1863 ECN CSIC Consejo Superior de Investigaciones Científicas FRAMES
WP5	Technology scale-up and economic analysis • Economic analysis of full scale SEG+SEDMES plants (FRES, ECOH, SFW, POLIMI) • Scale up study of SEG process (SFW, LUT, USTUTT) • Scale up study of SEDMES unit (FRES, ECN, POLIMI)	FRAMES Sumitomo SHI FW ECOHISPÁNICA

Work Packages

WP6	Risk and Sustainability Analysis • Environmental Life Cycle Assessment (QUANTIS) • Process safety Analysis (INERIS) • Socio-Economic Analysis (INERIS)	INERIS maîtriser le risque pour un développement durable Quantis
WP7	Exploitation • Short-term technical exploitation: design of a demo FLEDGED plant at ECOH site, for technology demonstration at TRL 6-7 (ECOH, FRES, SFW) • Short-medium term commercial exploitation at small scale (ECOH, FRES, SFW) • Medium-long term commercial exploitation at large scale (FRES, SFW) • Commercial exploitation of the SEG and SEDMES sub-processes (SFW, FRES)	ECOHISPÁNICA FRAMES Sumitomo SHI FW
WP8	Dissemination and communication	POLITECNICO MILANO 1863

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Find out more: www.fledged.eu

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Fledged H2020 Project

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