FLEDGED project: power and biomass-to-X

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Mobilità Sostenibile: Bio-combustibili e infrastrutture
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FLEDGED PROJECT

FLExible **D**imethyl ether production from biomass **G**asification with sorption enhanc**ED** processes

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

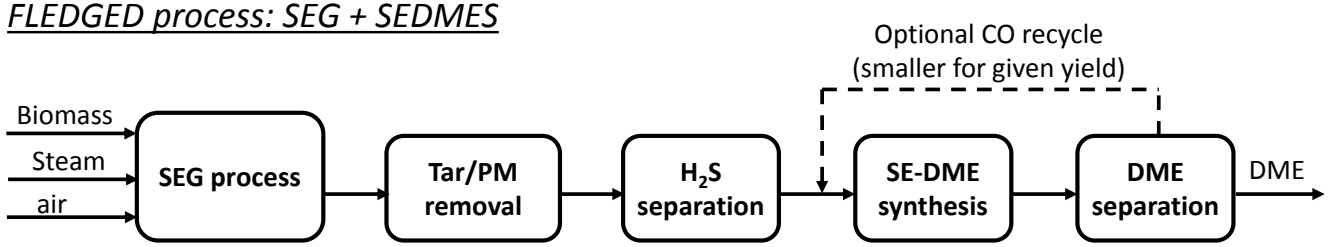
Flexible sorption enhanced gasification (SEG) process

+

Sorption enhanced DME synthesis (SEDMES) process

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

FLEDGED process: SEG + SEDMES

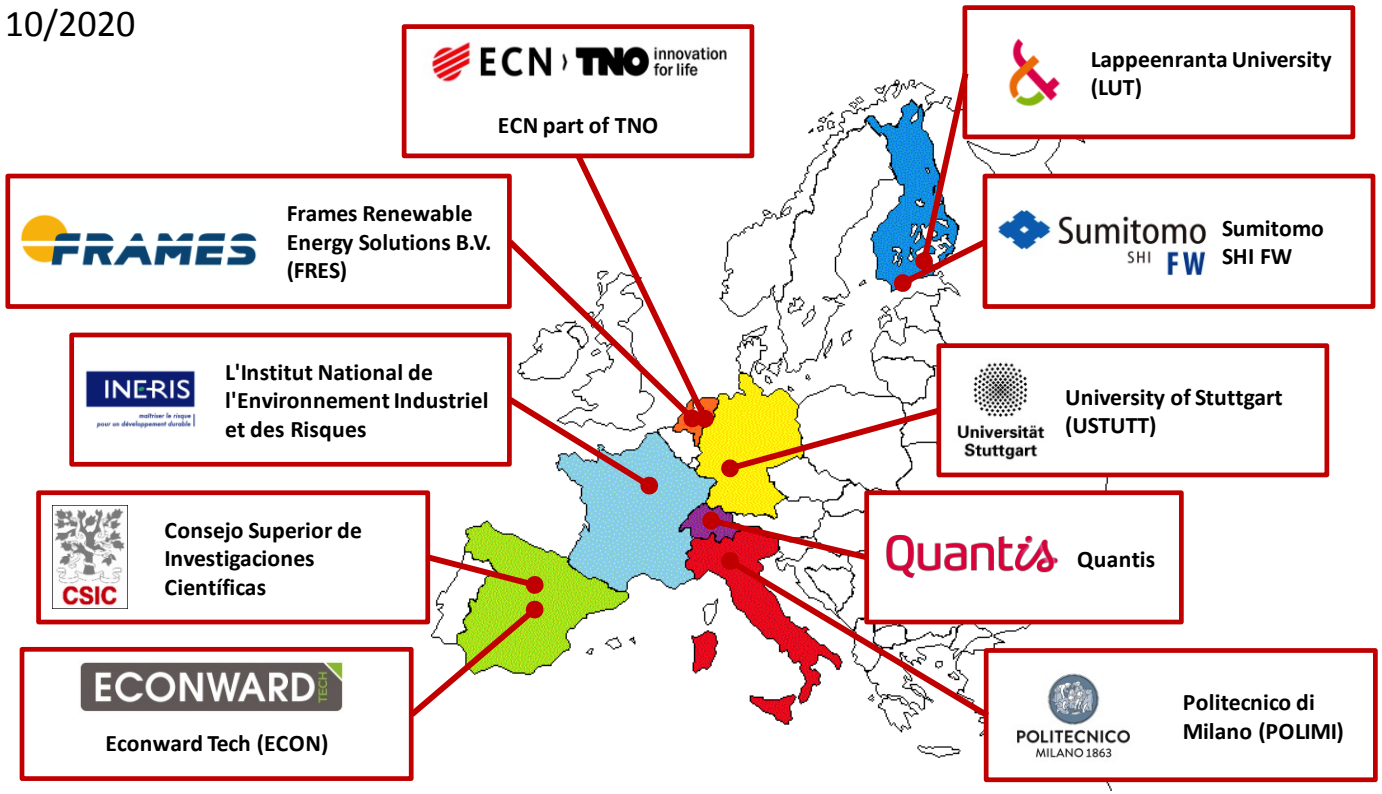


FLEDGED PROJECT

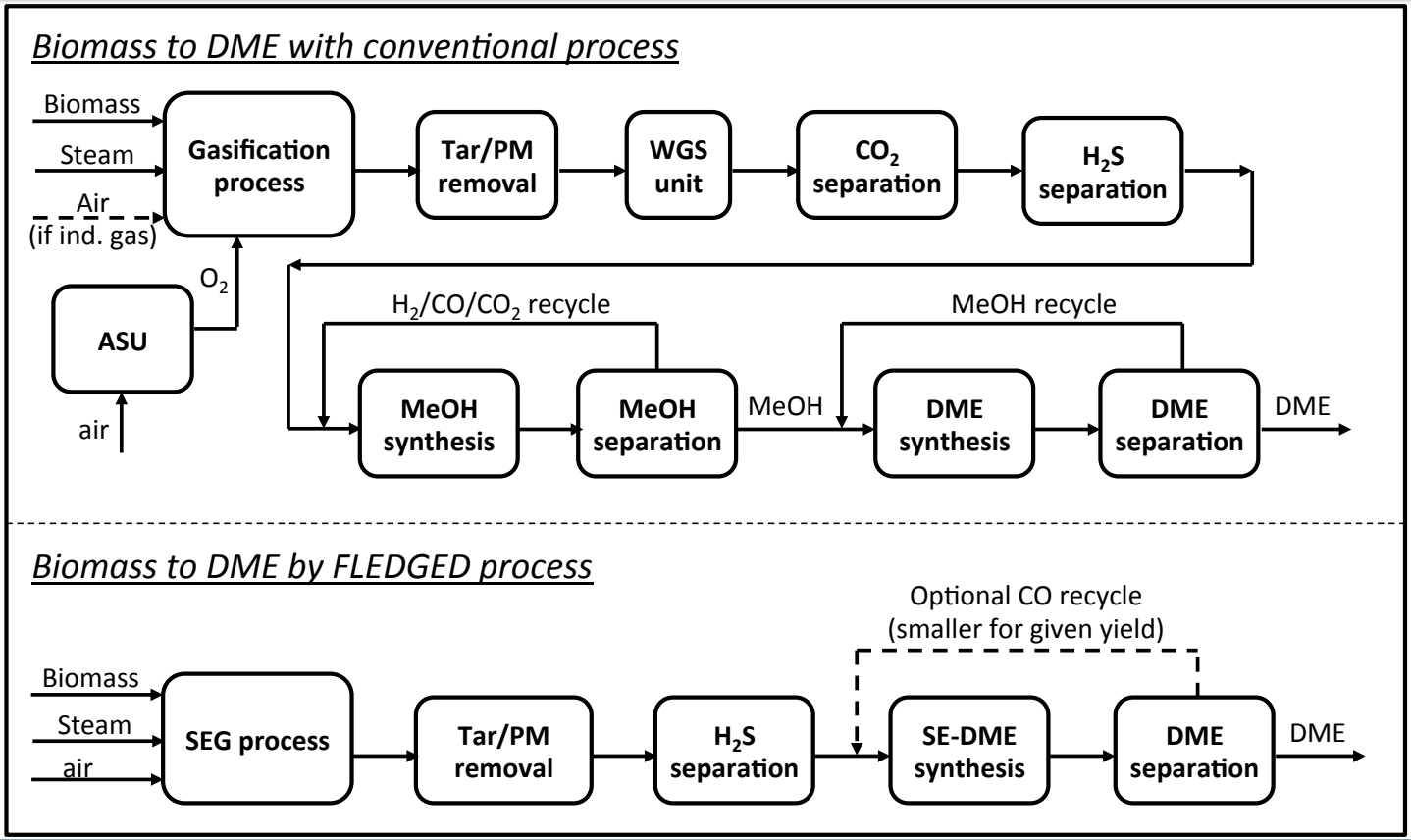
Project time span: from 11/2016 to 10/2020
Project budget: 5.3 M€
Project consortium:

- 6 academic/research partners
- 4 industrial partners

Web: *www.fledged.eu*
Twitter: @FledgedProject



FLEDGED PROJECT: PROCESS INTENSIFICATION

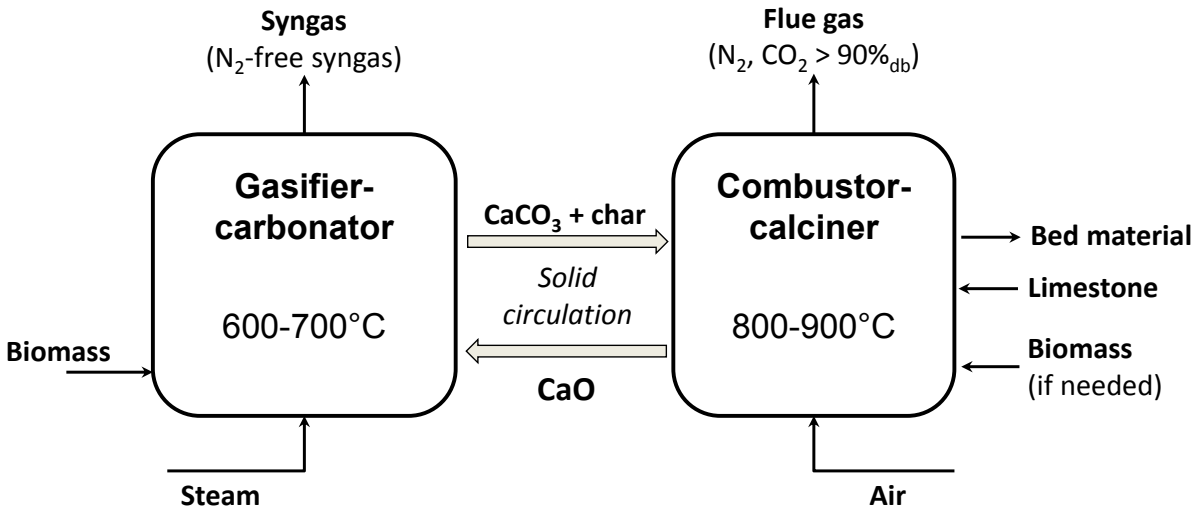


FLEDGED PROJECT: SORPTION-ENHANCED GASIFICATION

Sorption-enhanced gasification (SEG):

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

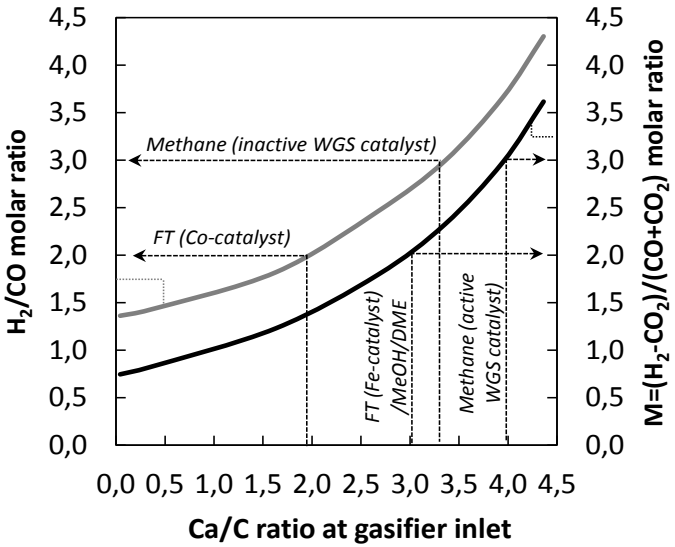
- produce a N_2-free syngas with no need of pure oxygen production and external heating of the reactor;
- absorb CO_2 in the gasifier and adjust C/H content in the syngas.



FLEDGED PROJECT: SORPTION-ENHANCED GASIFICATION

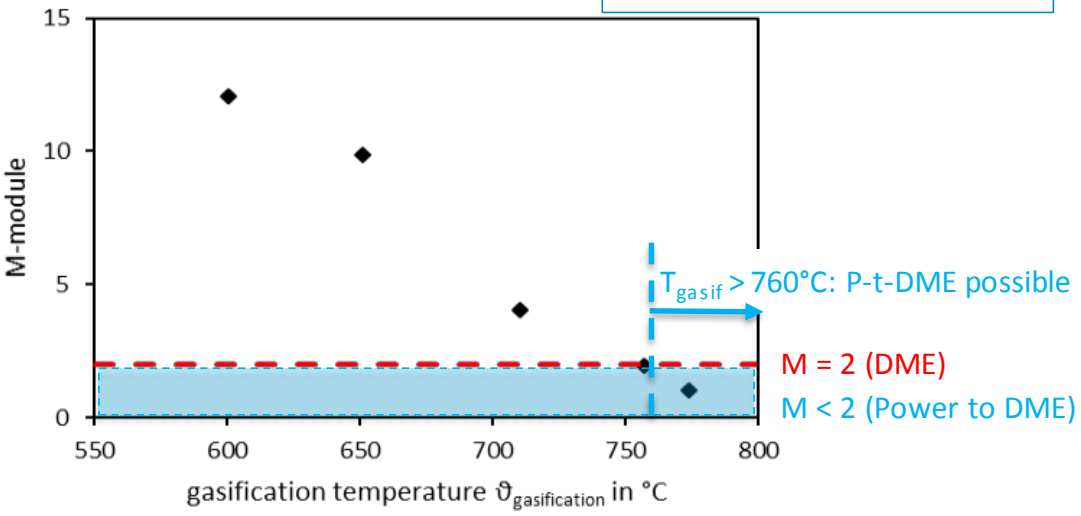
SEG flexibility:

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.



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

$M = (H_2\text{-}CO_2)/(CO+CO_2)$
Direct DME synthesis: M=2



From tests carried out at the University of Stuttgart, IFK

FLEDGED PROJECT: SORPTION-ENHANCED DME SYNTHESIS

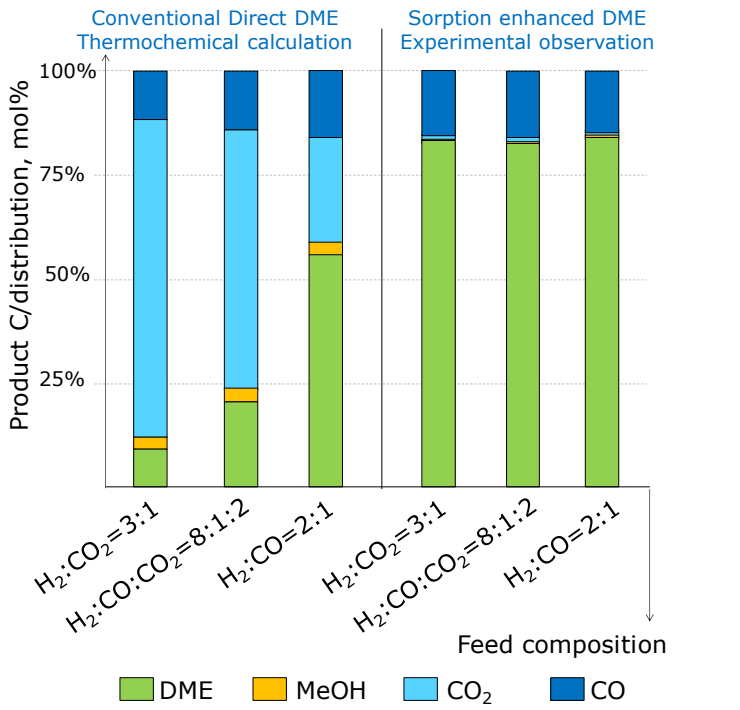
SEDMES flexibility:

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.

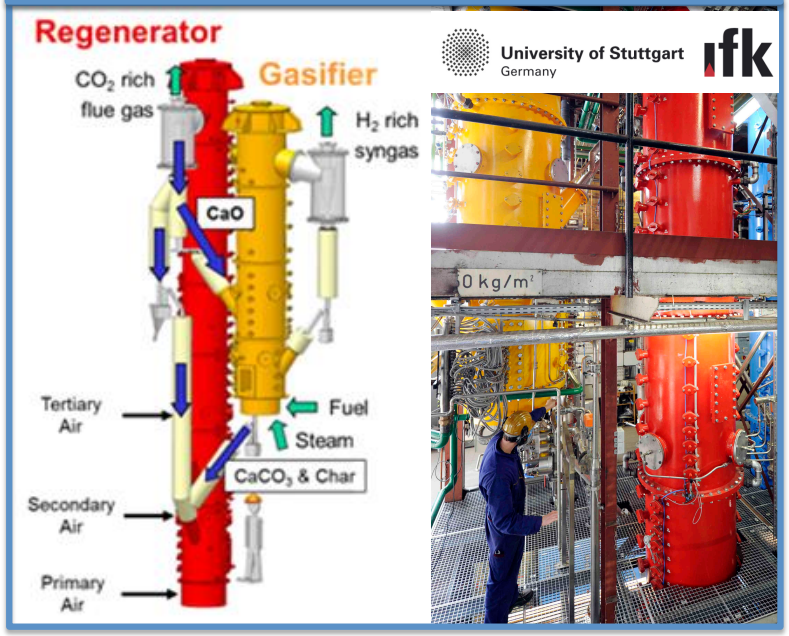
Conventional direct DME synthesis vs. SEDMES

Experimental tests at ECN at 40 bar, 275 °C



FLEDGED PROJECT: FACILITIES FOR DEMONSTRATION AT TRL5

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



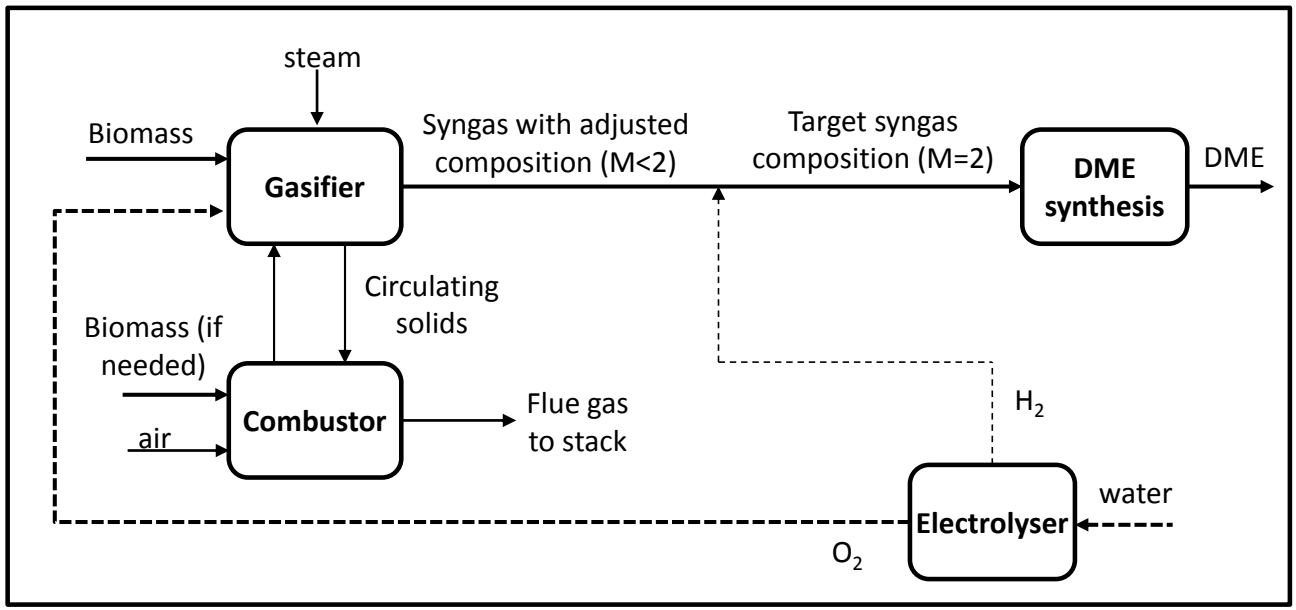
SEDMES process will be demonstrated in multi column PSA rig at ECN

FLEDGED PROJECT: SORPTION-ENHANCED DME SYNTHESIS

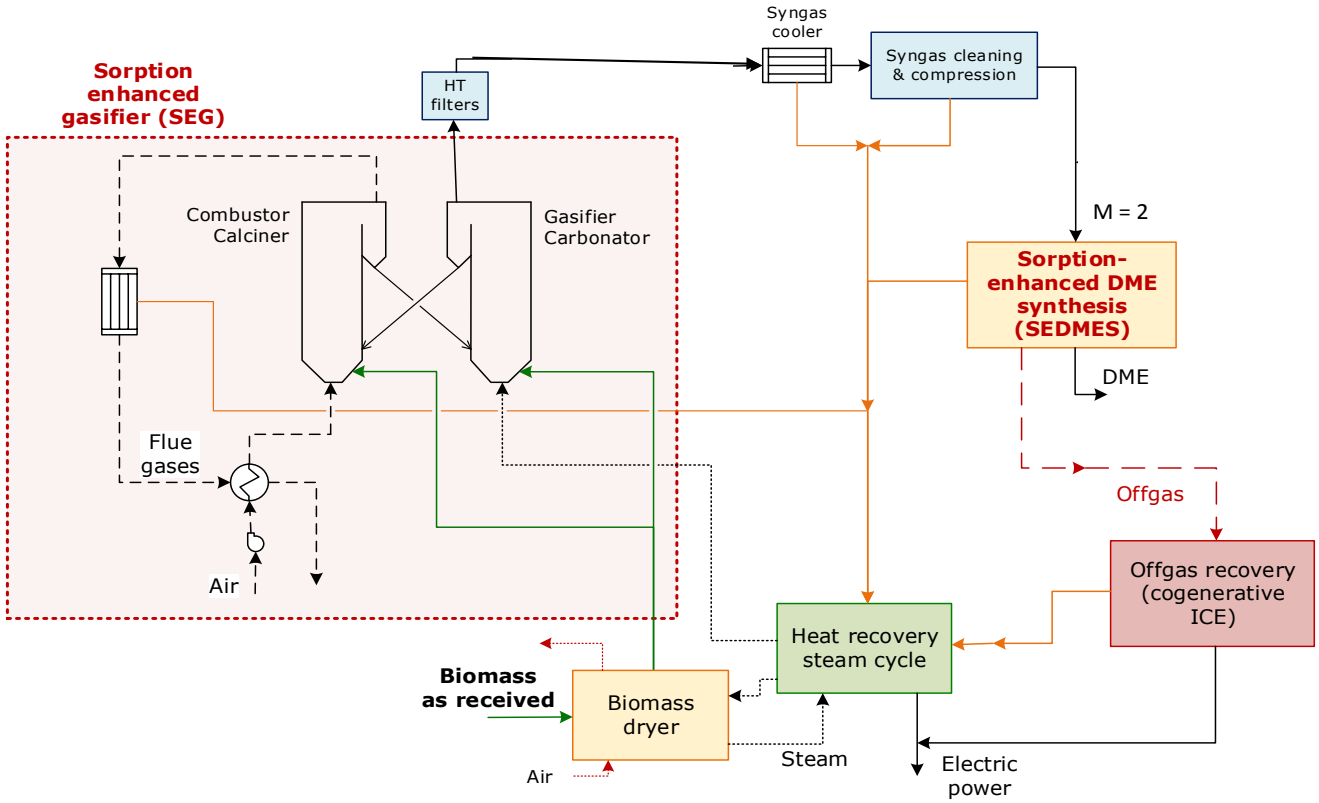
FLEDGED operational flexibility for power and biomass to DME

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



FLEDGED: PROCESS SIMULATIONS



FLEDGED: PROCESS SIMULATIONS

First process simulation results:

S/C in the gasifier	1.5	0.5	1.5	1.5
DME yield in the SEDMES process	90%	90%	95%	80%
SEG				
Biomass input to gasifier [%]	94.86	100	94.86	94.86
Biomass input to combustor [%]	5.14	-	5.14	5.14
SEDMES				
DME production [kg/s]	1.49	1.58	1.57	1.33
DME thermal output [MW]	42.92	45.42	45.28	38.23
Overall				
CGE_{SEG} [%]	67.58	71.76	67.58	67.58
CGE_{global} [%]	**42.92**	**45.42**	**45.28**	**38.23**
CGE_{eq} [%]	**58.28**	**64.20**	**58.80**	**56.58**
Electric efficiency [%]	8.96	9.95	7.82	11.03
Net electric output, P_{el} [MW]	8.96	**9.95**	**7.82**	**11.03**
Steam turbines output [MW_{el}]	6.34	6.96	6.27	6.50
ICE electric output [MW]	8.48	8.87	7.40	10.56
Auxiliaries consumption [MW_{el}]	5.86	5.88	5.86	6.03

Plant efficiencies:

$m \downarrow syn \cdot LHV \downarrow syn / m \downarrow bio$

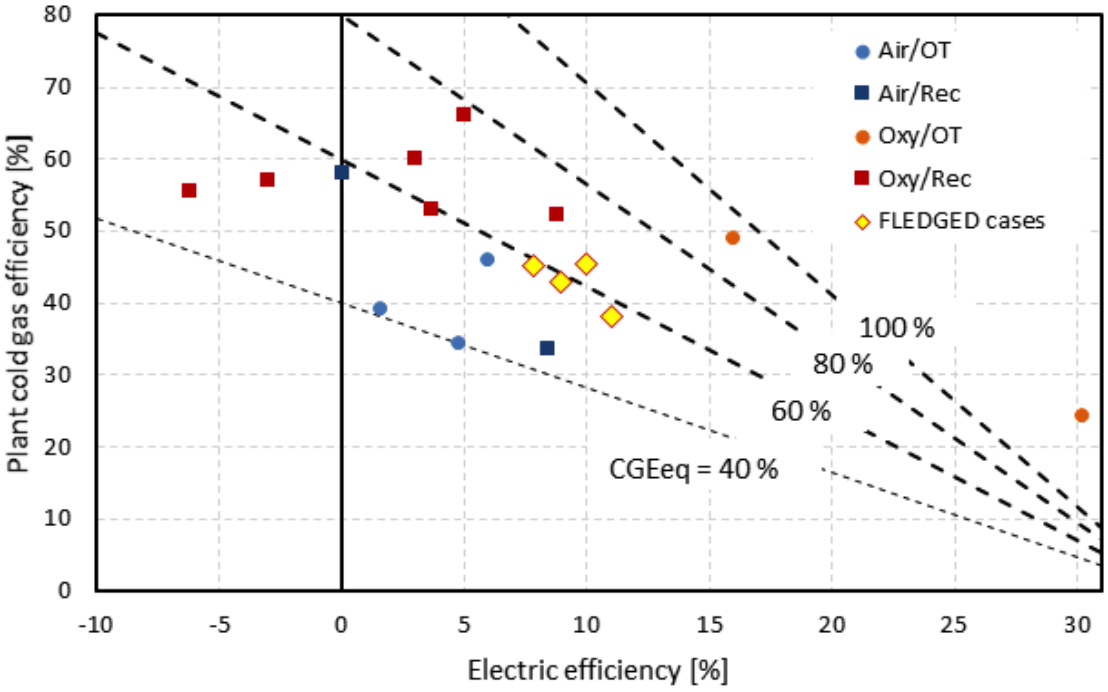
$m \downarrow DME \cdot LHV \downarrow DME / m \downarrow b$

$m \downarrow DME \cdot LHV \downarrow DME / m \downarrow bi$

$P \downarrow el,net / m \downarrow biom \cdot LHV \downarrow b$

FLEDGED: PROCESS SIMULATIONS

Comparison with alternative processes from literature



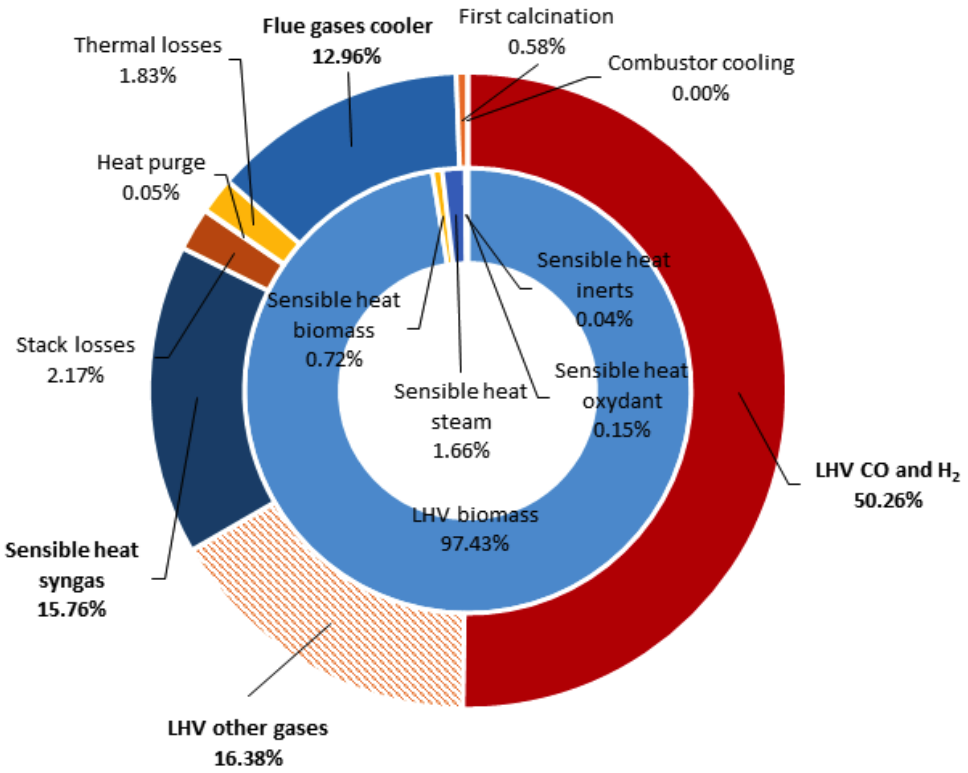
FLEDGED: PROCESS SIMULATIONS

The energy balance of the SEG process shows that:

- about 16% of the biomass heating value is available as heating value of CH_4 and C+ (inerts in the DME synthesis unit)

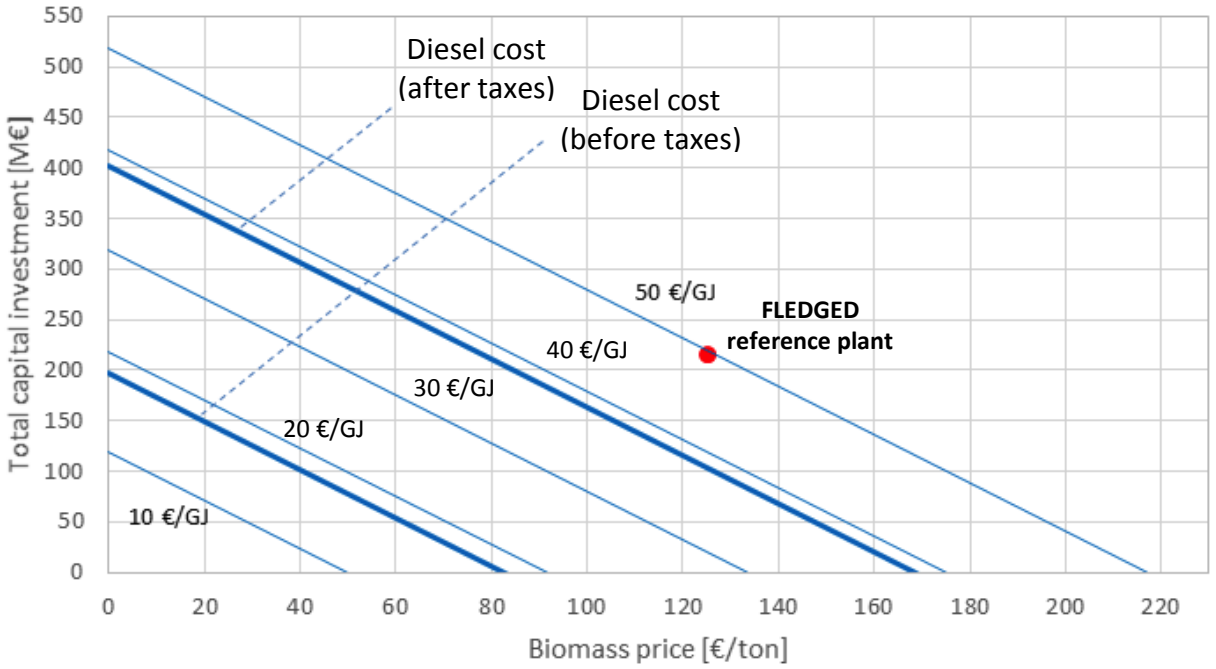
  → **reforming unit necessary to achieve high CGE**

- about 28% of the inlet energy is recovered as heat for electricity and steam generation
- about 5% is lost



FLEDGED: ECONOMIC ANALYSIS

First economic analysis: uncompetitive bio-DME production cost

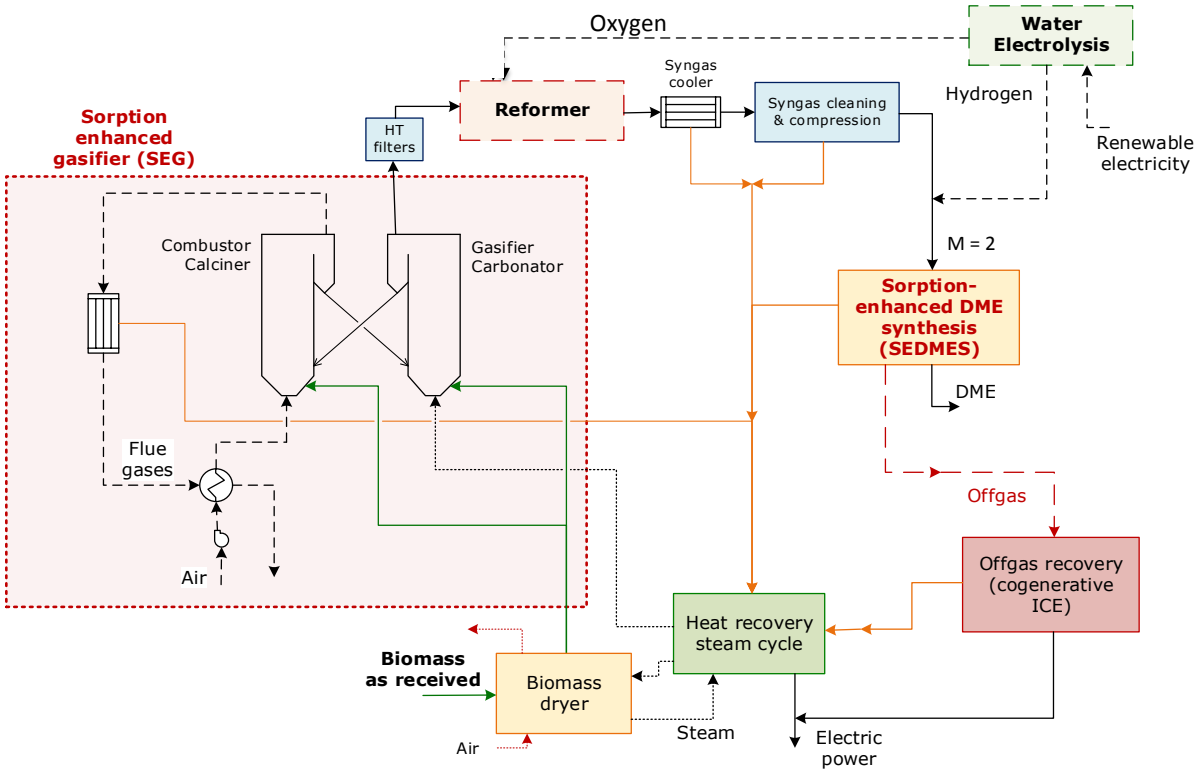


FLEDGED PROJECT: SORPTION-ENHANCED DME SYNTHESIS

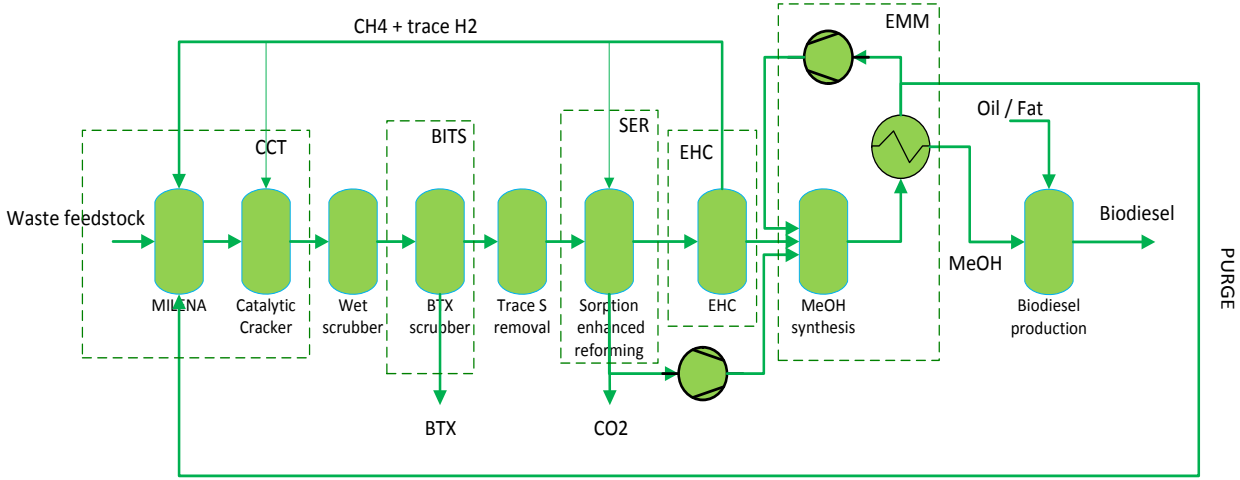
Opportunities of integration with electrolysis system:

- Increased DME production → improved economic indicators
- Availability of O_2 for methane reforming
- Potential revenues for grid services

→ Need of flexible technologies capable to operate with and without hydrogen addition



OTHER RELEVANT ONGOING PROJECTS: CONVERGE



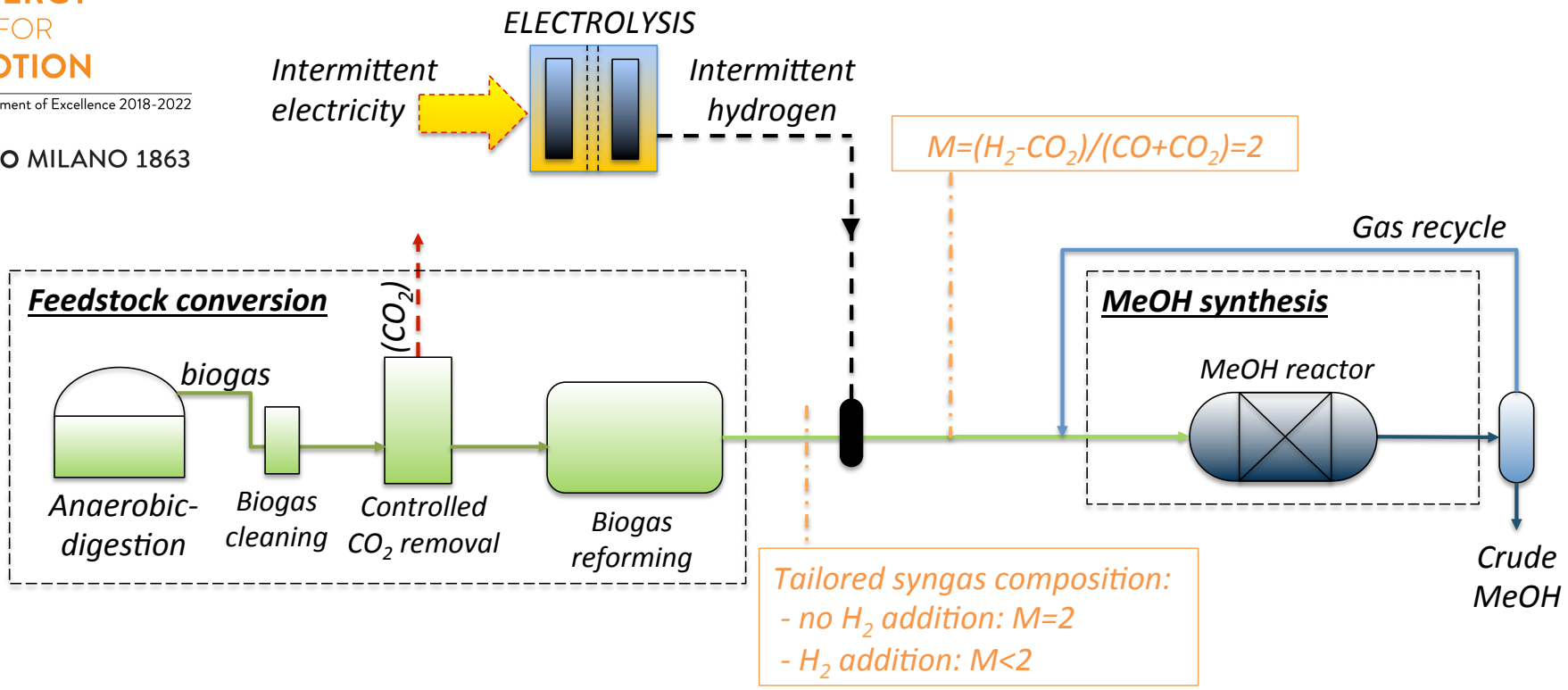
Project time span: 11/2018 - 10/2022
Project budget: 5.1 M€

CONVERGE
CarbON Valorisation in Energy-efficient Green fuels

- CCT: Catalytic cracking of tars from an indirectly heated gasifier to below green C_8
- BITS: Recovery of refinery products including aromatics for green C_6-C_8 fraction (BTX)
- SER: Sorption-Enhanced Reforming of C_1-C_6 for excess-carbon removal, and H_2 production
- EHC: Highly efficient electrochemical compression of green H_2 with by-product fuel
- EMM: Enhanced Methanol Membrane to ensure efficient green biodiesel production

OTHER RELEVANT ONGOING PROJECTS: POWER & BIOGAS TO X

ENERGY FOR MOTION
Department of Excellence 2018-2022
POLITECNICO MILANO 1863



CONSIDERAZIONI FINALI

- Il gruppo “Gecos” è sempre più attivo nell’analisi tecnico-economica di impianti di produzione di biocombustibili e di sistemi “power and biomass-to-X”
- Il focus della ricerca su processi P&B-to-X è su:
  - Analisi comparative di tecnologie flessibili
  - Ottimizzazione del dimensionamento e della logica di controllo di reattori chimici e dei cicli a recupero considerando l’intermittenza della disponibilità di idrogeno
- L’attività di ricerca è supportata da collaborazioni con istituti europei e con il gruppo POLIMI LCCP (Laboratory of Catalysis and Catalytic Processes)
- …felici di ampliare le collaborazioni sul tema, con altri gruppi di ricerca italiani!

Grazie

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www.polimi.it

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