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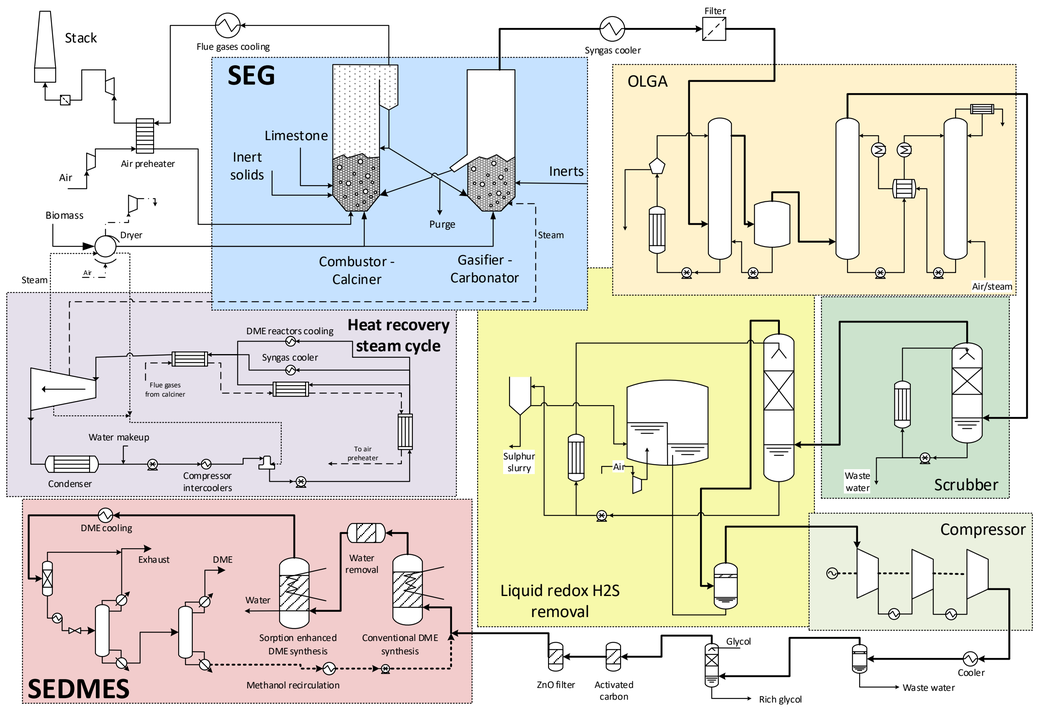
Research activity: Biomass gasification plants integrated with electrolyzers for Power-to-X conversion.
Professional interests:
- pyrolysis, gasification and combustion of solid fuels including biomass and wastes;
- integration of advanced technologies in power and industrial plants for low CO2 emission;
- modeling of chemical reactors.

Flexible Dimethyl ether production from biomass gasification with sorption enhanced processes

Plant concept



The process combines flexible **sorption enhanced gasification** (SEG) and **sorption enhanced DME synthesis** (SEDMES) technologies to produce DME from biomass.
SEG:
- gasification parameters adjusted to obtain a tailored syngas for the DME synthesis;
- the Ca-based sorbent provides heat to the gasifier and absorbes CO_2;
- no need of ASU, WGS reactor and CO_2 separation, resulting in a more compact plant.

SEDMES:
- in-situ water removal achieved by adding a steam adsorbent into the catalytic bed;
- overcome the thermodynamic limitation of the conventional direct DME synthesis;
- increase the single-pass DME yield;
- simpler downstream purification section and reduction or elimination of the recycle.

The research work is conducted as part of the European project FLEDGED[1].

[1] This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 727600.

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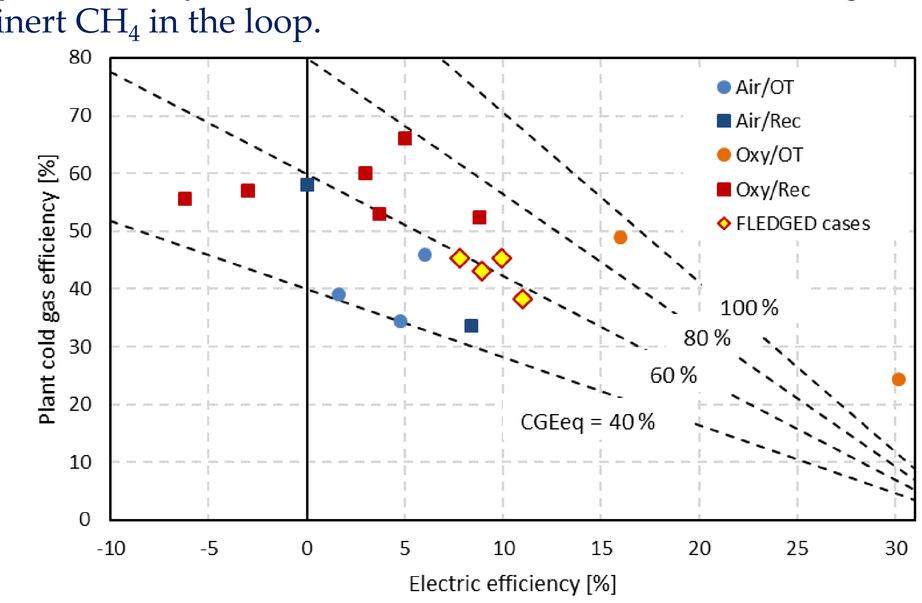
Techno-economic performance

An Aspen Plus model of the plant has been developed and used to calculate the mass and energy balance. Sensitivity analyses on the S/C in the gasifier and on the DME yield in the SEDMES process have been carried out.

Low S/C are preferable as low steam input reduces the need of heat in the gasifier. The effect of S/C on biomass conversion must be verified through experiments.

High DME yield is important to increase the overall plant efficiency and to reduce the DME cost. The achievable DME yield per pass with the SEDMES process must be determined through experiments. Gas recycle to improve overall DME yield is possible only in combination with methane reforming avoiding the build-up of inert CH_4 in the loop.

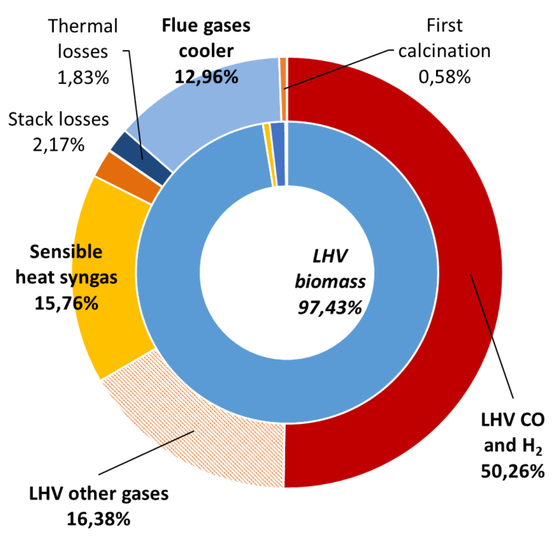


S/C in the gasifier	1.5	0.5	1.5	1.5
DME yield in the SEDMES process	**90%**	**90%**	**95%**	**80%**
SEG				
Biomass input to gasifier [%]	94.86	100	94.86	94.86
Biomass input to combustor [%]	5.14	-	5.14	5.14
SEDMES				
DME production [kg/s]	1.49	1.58	1.57	1.33
DME thermal output [MW]	42.92	45.42	45.28	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 electric output [MW]	6.34	6.96	6.27	6.50
ICE electric output [MW]	8.48	8.87	7.40	10.56
Electric consumption of auxiliaries [MW]	-5.86	-5.88	-5.86	-6.03
Economic indexes				
DME production cost [€/GJ]	49.6	46.1	47.5	54.8
Fixed cost [€/GJ]	21.7	20.3	20.6	24.2
Variable cost [€/GJ]	28.0	25.8	26.9	30.6

The obtained results are consistent with those reported in the literature for other biomass to DME processes based on air-blown gasification systems.

From the economic analysis of a 100 MW_{LHV} biomass input plant, a DME cost of 49.6 €/GJ_{LHV} has been calculated, largely associated to the cost of biomass and to the capital cost of the plant.

Process improvement



The analysis of the energy balance of the SEG section evidences that:
input energy:
- about 97% is the chemical energy of biomass;
- about 3% is the sensible heat of other streams fed to the SEG unit;

output energy:
- only 50% is useful chemical energy (LHV of CO and H_2), which can be converted in the synthesis process;
- about 16% is associated to the heating value of inerts for DME synthesis (CH_4 and higher hydrocarbons);
- about 28% is recovered as heat for electricity and steam generation;
- only 5% is lost to the environment.

A **methane reforming step** must be included in the plant to significantly improve the DME production.