Flexible Dimethyl ether production from biomass gasification with sorption enhanced processes

Newsletter #2 – March 2018

Project at glance

OBJECTIVE

FLEDGED project aims to develop a highly intensified and flexible process for DME production from biomass.

WHY DME

DME is recognized as one of the most promising future biofuels, due to the easy adaptability of car engines and reduced life-cycle environmental impact.

OUTCOME

The outcome of the *FLEDGED* project will be a highly competitive concept for both small-medium scale plants serving regional markets and for large scale plants.

Where to find us

www.fledged.eu

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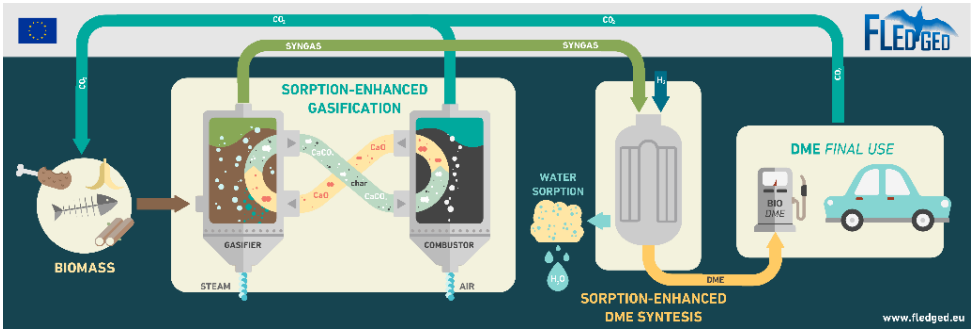
PROJECT NEWS

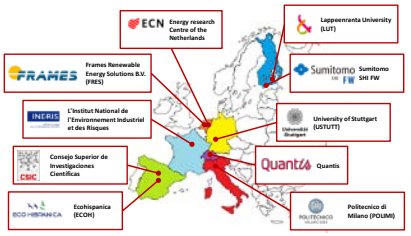
FLEDGED project – one year of results

FLEDGED consortium at the second project meeting hosted by Quantis (Lausanne).

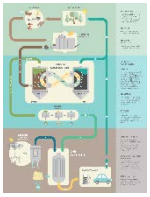
FLEDGED project is on his way and many activities are ongoing in the consortium.
Experiments are performed on both biomass gasification and DME synthesis sections at CSIC, University of Stuttgart and ECN facilities. LUT and POLIMI are active in the simulation of the key plant reactors and the complete FLEDGED process, while INERIS and QUANTIS have defined the framework for the LCA and the risk and sustainability analysis.
FRAMES, Ecohispanica and Sumitomo SHI-FW defined the economic framework for economic analysis and a first business case for Ecohispanica. In the first year of activities, a preliminary configuration of the plant has been defined and the focus is on first performance assessment and improvement. Sorption Enhanced Gasifier (SEG) and Sorption Enhanced DME Synthesis (SEDMES) require peculiar operating conditions for the indirect gasifier and the sorbent/catalyst mixture that are under investigation.



Partners involved in the consortium are leading institutes in their respective fields and cover all the key units of the biofuels production chain.
FLEDGED consortium combines 10 legal entities from 6 EU countries:



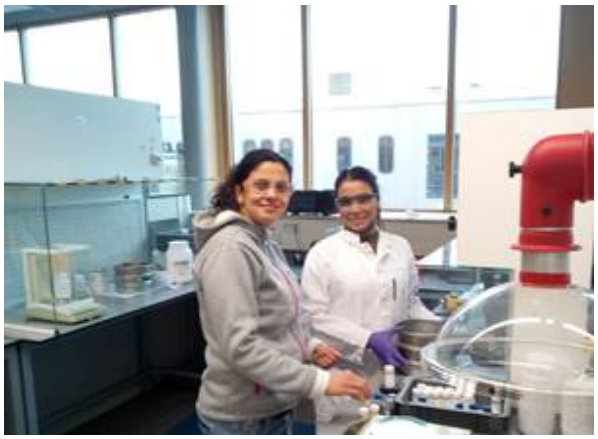
- Politecnico di Milano (Italy)
- Energy Research Centre of the Netherlands (ECN, Netherlands)
- Spanish National Research Council (CSIC, Spain)
- University of Stuttgart (Germany)
- Lappeenranta University of Technology (LUT, Finland)
- QUANTIS (Switzerland)
- INERIS (France)
- Sumitomo (SHI-FW, Finland)
- Ecohispanica (Spain)
- Frames Renewable Energy Solutions (FRES, Netherlands)



A more detailed descriptive infographic about the project is available on the project website www.fledged.eu, as well as free downloadable material on project concept and results, presentations and publications. Twitter and Facebook profiles keep you updated on the project.

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

Investigation on sorbent regeneration conditions (ECN)



Different regeneration conditions has been tested in sorption-enhanced DME synthesis (SEDMES), to assess the effect on the catalyst and the sorbent performance. It was shown that regeneration by temperature swing up to 400 °C improves the DME yield both pre- and post-water breakthrough. The adsorbent capacity clearly increases with temperature swing to 400 °C and indications are that the temperature swing also improves the catalyst activity or the adsorbent slip level.

Ongoing tests are helping finding better operating conditions for the SEDMES process, involving optimal functioning of both the catalyst and the adsorbent. More recently, cooperation between CISC-ICP and ECN has intensified with the starting of advanced SEDMES testing with CSIC synthesised catalyst materials at ECN laboratories. The picture shows CSIC-ICP researcher Dalia Liuzzi (right) and ECN researcher Özlem Pirgon in ECN's chemical lab, preparing samples for parallel testing of sorption-enhanced reactions.

Experiments at CSIC facility: bubbling fluidized bed gasifier (CSIC)

In the 10-30 kWth bubbling fluidized bed (BFB) facility at CSIC, the testing of the sorption enhanced gasification (SEG) has started. Experiments using a residual biomass from agricultural activities are being carried out, studying the influence of steam, amount of CO_2 sorbent and gasifier temperature.

Proper results in terms of syngas composition and char conversion have been obtained for the SEG process. Steady-state operation under the different conditions analyzed has been satisfactorily reached. In the coming tests, alternative residual biomasses will be tested.

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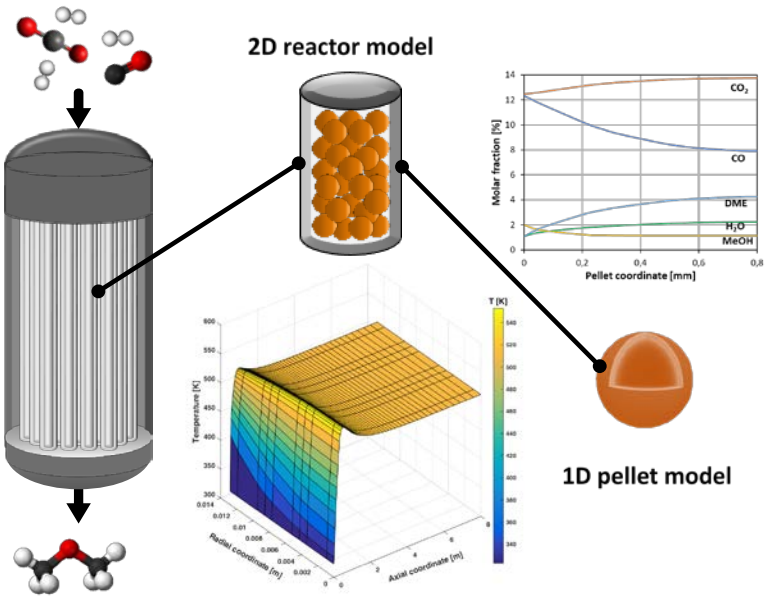
Detailed modelling of direct DME synthesis reactor



A steady state heterogeneous model of a single tube of a fixed bed multi tubular reactor for direct DME synthesis was developed. The model consists of i-species mass, energy and momentum balances written in 2D cylindrical coordinates, coupled with i-species mass and energy balances for the catalyst phase accounting for concentration gradients (1D) in an isothermal, isobaric pellet.

This model provides information about the complex interactions between the chemical kinetics and the transport phenomena occurring in the reacting environment. The results obtained can be used to size the reactor and settle the operating conditions in order to increase the DME productivity and control the temperature hot-spot. The main task of the second year project is the development of the dynamic model for the sorption-enhanced DME synthesis reactor, starting from the conventional reactor model.

Risk assessment and impact evaluation approach to DME value chain

Data collection for the sustainability and process safety analysis has started. A key driver behind this project is the need to reduce CO_2 emissions from road transport, which currently accounts for one-fifth of the EU's total fossil fuel-based CO_2 emissions to the atmosphere. Quantification of the improvement of FLEDGED process compared to reference scenarios is hence of the essence.

Evaluation of the environmental, safety, air quality and socio-economic impacts for the FLEDGED value chains are the next steps that will be undertaken.
Safety analysis on the plan will be also performed, considering hazard identification and recommendations for risk management.

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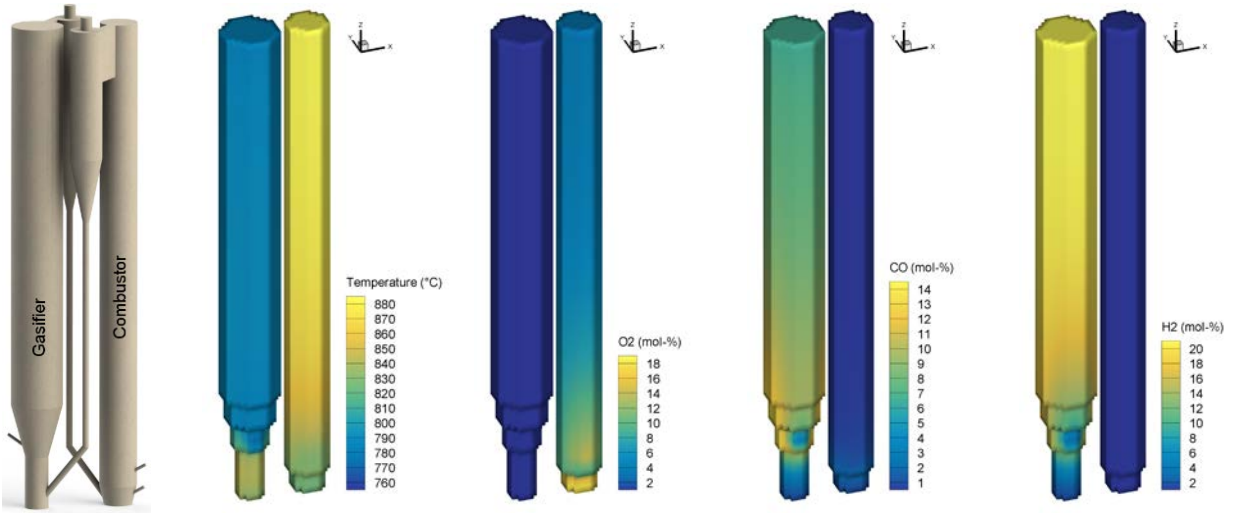
Scientific publication on Fuel Processing Technology Journal: Modelling of indirect steam gasification in circulating fluidized bed reactors



The paper presented a modelling method for interconnected gasifier-combustor system and an example study. The reactors were modelled three-dimensionally using a semi-empirical modelling concept developed at Lappeenranta University of Technology. The Fortran-written model combines modelling of all major heterogeneous and homogeneous combustion and gasification reactions, fluid dynamics of gas and solids, and heat transfer. Compared with fundamentals-oriented CFD models, the calculation time is very small, which enables practical engineering studies. The model was applied to study the effect of different gasification temperatures on the producer gas composition, heat value of gas, and cold gas efficiency. The object of study was a 12 MW_{th} gasifier-combustor, in which both reactors were operated in CFB mode. The temperature level was adjusted by changing the fuel feed to combustor while keeping the fuel feed to gasifier at a constant value. Based on comparison with the measurements in literature, the model could simulate many of the observed trends correctly, e.g. the effect of temperature on CO and CO_2 concentrations and the low conversion ratio of steam in indirect steam gasification. In future, the model concept can be applied to study sorption enhanced gasification.

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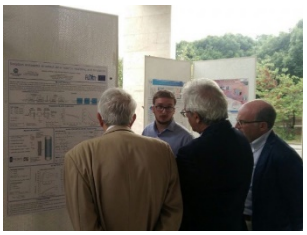
PROJECT NEWS

FLEDGED Project presentations at conferences and events

Results of the first year of investigation on FLEDGED system has been presented at national and international events and conferences in the last six months.
ECN presented FLEDGED project at *Dutch NL GUTS meeting on Affinity Separation* in September 2017 and Simone Guffanti (POLIMI) presented a poster on his research on DME synthesis reactor modelling at *GRICU PhD school* 2017.



Poster presentation at GRICU PhD school 2017.

Jasper van Kampen (ECN) presenting the SEDMES concept

Jasper van Kampen (ECN) presented SEDMES concept integrated in the FLEDGED process at CHAINS2017 (Dutch national chemistry conference, December 2017) in a plenary focus session "Making the molecules of the future: Sustainable Chemistry and Energy". The poster and the presentation are available in the download section of the website. SEDMES concept and experimental results on catalyst activity in the presence of water have been presented by ECN at The Netherlands Catalysis and Chemistry Conference (NCCC) in March. A poster related to the investigation into the impact of the regeneration conditions on the catalyst performance for the sorption-enhanced DME synthesis (SEDMES) is available for download on the website.

Where to find us – Next events

The project and its main outcomes will be presented at the following upcoming events:

- *DME Sustainable Mobility Workshop* in Aachen (Germany) on March, 15th 2018.
- *COMSYN project workshop* on 2nd generation biofuels in Stuttgart and Karlshrue (Germany), 18-19th April 2018.
- *23rd International conference on Fludized Bed Conversion (FBC 23)* in Seoul (Korea) on May, 13-17th 2018.
- *25th International Conference on Chemical Reaction Engineering (ISCRE 25)* in Florence (Italy) on May, 20-23rd 2018.
- *12th European Conference on Fuel and Energy Research and its Applications (ECCRIA 12)* in Cardiff (UK) on September, 5-7th 2018.
- *XXIII International Conference on Chemical Reactors (CHEMREACTOR 23)* in Ghent (Belgium) on November, 5-9th 2018.

Find more on the website

Scientific publications

Modelling of indirect steam gasification in circulating fluidized bed reactors (Kari Myöhänen, Juha Palonen, Timo Hyppänen, *Fuel Processing Technology, Volume 171, p. 10-19, 2018*)

Abstract
The indirect steam gasification in circulating fluidized bed reactors was studied by modelling. The object of study was a coupled 12 MWth gasifier-combustor system, which was fired by woody biomass. The heat for the steam-blown gasifier was produced in the air-blown combustor and transported by circulating solids between the interconnected reactors. The system was modelled by a semi-empirical three-dimensional model, which simulated the fluid dynamics, reactions, and heat transfer in the coupled process. The studied cases included different temperature levels, which were controlled by the amount of additional fuel feed to the combustor. The model concept can be later applied to study sorption enhanced gasification, which is a promising method for sustainable production of transport fuels to substitute fossil based fuels.

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