



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education



RESEARCH CENTRE FOR LOW-CARBON ENERGY TECHNOLOGIES: Towards CO₂ negative energy conversion

JAN HRDLIČKA
CZECH TECHNICAL UNIVERSITY IN PRAGUE



**Czech-Norwegian Cooperation on CCS –
launch event
5th March, 2021**

PROJECT SUMMARY

- one of the comprehensive research projects on CCS/U project in the Czech Republic
- OP RDE „Excellent research“ call funded project
- Major technical universities (Prague, Brno, Ostrava) and the Czech Academy of Sciences involved
- Associated partners across EU (Austria, Italy, Poland, Ireland, Germany, Netherlands...)
- duration 2018-2022 (*not far from finish!*), total budget approx. 12 mil. €, of which 5 % co-financing is required

PROJECT SUMMARY

We focus on direct CO₂ capture/utilization from BIOMASS energy conversion



we work towards future applicability of the biomass energy conversion chain to gain the CO₂ negative balance

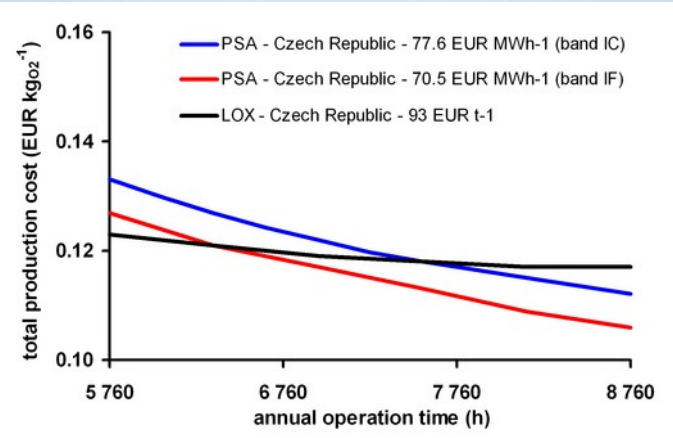
- we look on the specific technology chains, from the fuel input and treatment, to the CO₂-rich offgas cleaning or low-CO₂ syngas
- laboratory and pilot-scale facilities, publications, patents...

WP1: biomass oxyfuel combustion

- identification analysis of trace pollutants in CO_2
- bed materials, process control
- techniques for CO_2 purification (deSO_x, SCR, SNCR, dedusting,...)
- scale-up

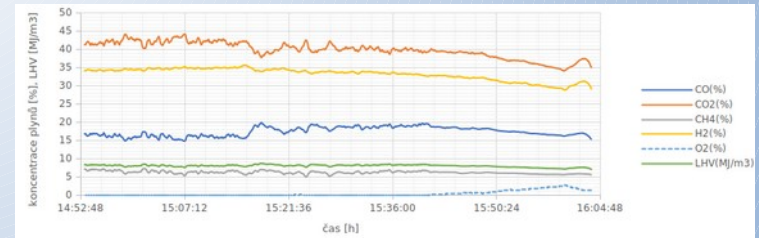
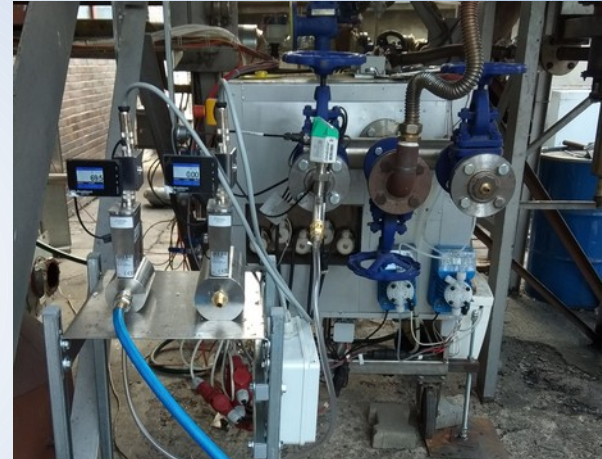


- lab-scale pretesting
- oxygen supply
- testing of materials for filter fabrication



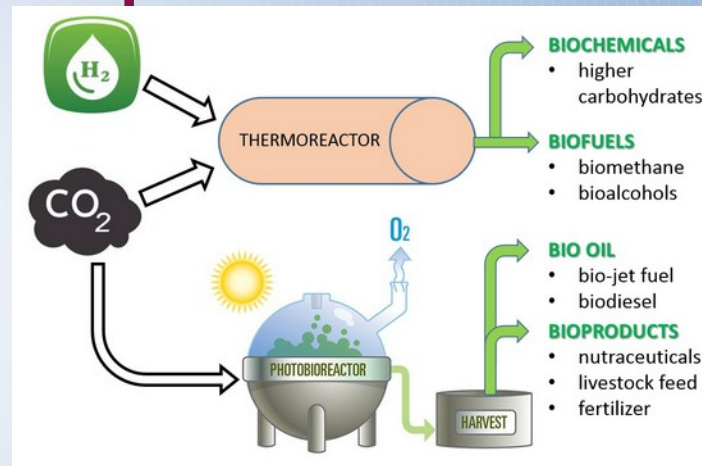
WP2: biomass gasification and pyrolysis with suppressed CO₂ formation

- novel biomass fuels
- modification and cleaning of syngas
- new approach in gasification agents
- combined methods of pyrolysis and gasification



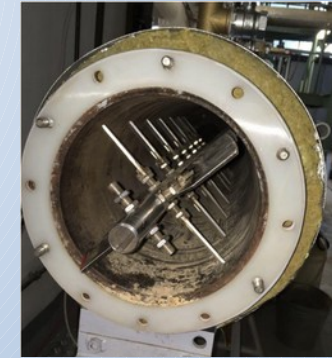
WP3: Usage of CO₂ and syngas as a feedstock for 3rd and 4th generation biofuels production

- CO₂+H₂ to methane, alcohols, higher hydrocarbons
- CO₂ + solar radiation to bio-oils and feedstocks
- membrane separation of CO₂
- biofuel treatment



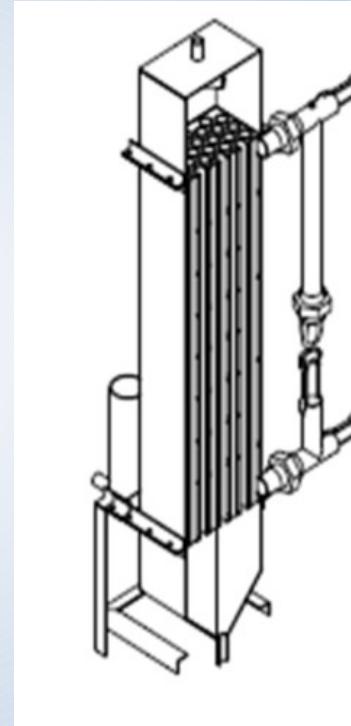
WP4: preparation of biomass for the oxyfuel combustion and gasification

- torrefaction
- drying
- separation and sorting
- crushing and grinding



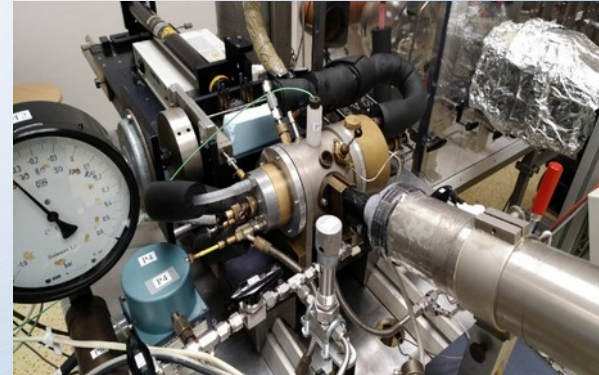
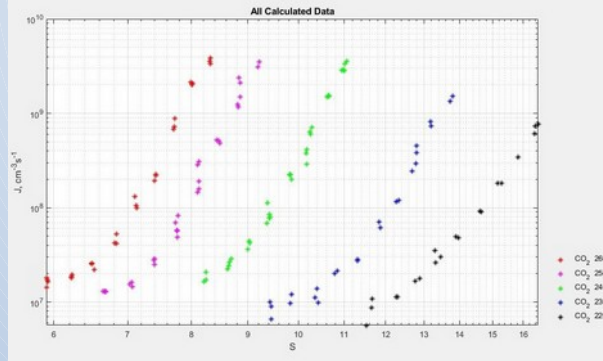
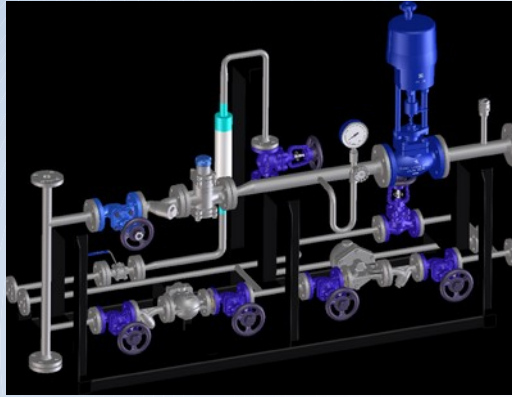
WP5: Effective cleaning of CO₂ by condensation

- direct spraying/
quenching
- indirect
condensation
- hollow fibres
heat
exchangers



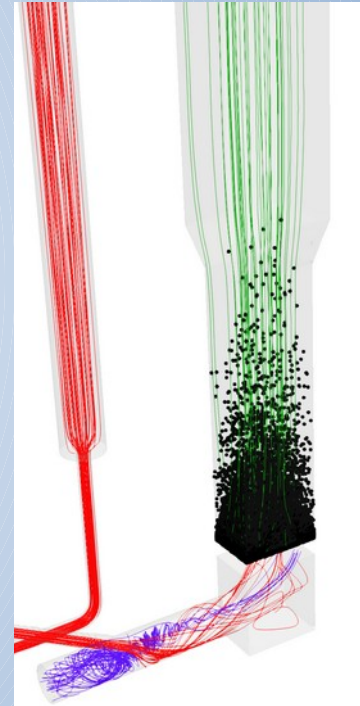
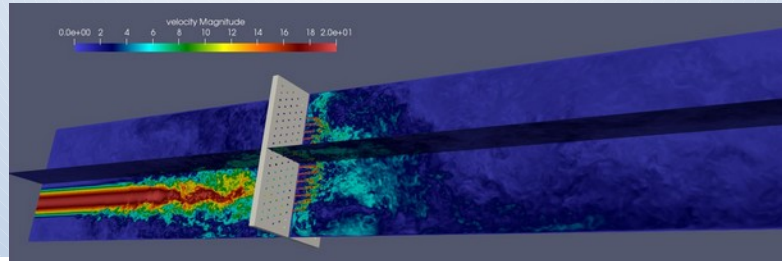
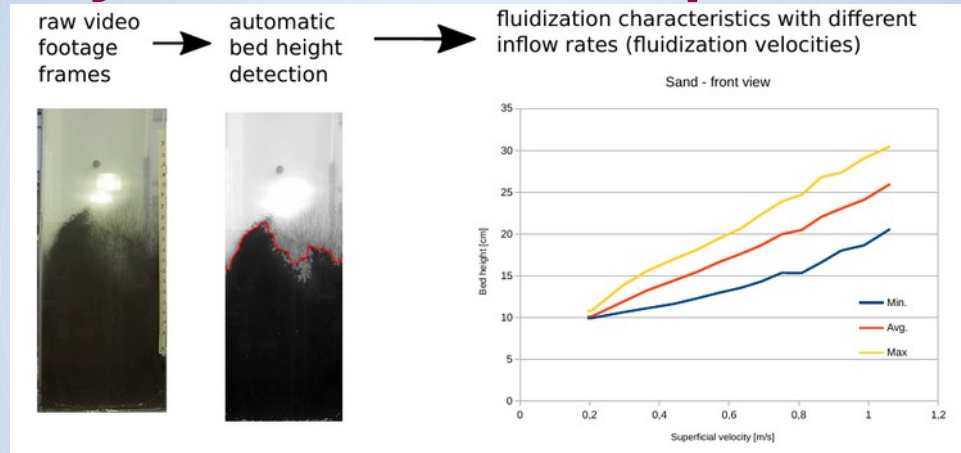
WP5: Effective cleaning of CO₂ by condensation

- air/CO₂-steam model mixture generator
- phase transitions in rapid adiabatic expansions – condensing without a heat exchanger



WP6: Mathematical modelling and numerical simulation of oxyfuel combustion processes

- streamline modelling
- fluidized bed simulation
- model validation
- application of results in further oxyfuel development



Publications, awards...

- Krátký, L., S. Azizov, and T. Jirout. 2018. "Lignocellulosic Waste Treatment in Biogas Biorefinery with Reduced CO₂ Production: A Techno-Economic Study." *Chemical Engineering Transactions* 70: 1975-1980.
- Safar, M., B. -J Lin, W. -H Chen, D. Langauer, J. -S Chang, H. Raclavska, A. Pétrissans, P. Rousset, and M. Pétrissans. 2019. "Catalytic Effects of Potassium on Biomass Pyrolysis, Combustion and Torrefaction." *Applied Energy* 235: 346-355.
- Kůdelová, T., T. Kroulíková, I. Astrouski, and M. Raudenský. 2020. "The Influence of the Fibres Arrangement on Heat Transfer and Pressure Drop of Polymeric Hollow Fibre Heat Exchangers." *Acta Polytechnica* 60 (2): 122-126
- Skopec, P., J. Hrdlička, and M. Vodička. 2021. "Dry Additive Desulfurization in Oxyfuel Bubbling Fluidized Bed Combustor." *Fuel* 283.
- Vodička, M., N. E. Haugen, A. Gruber, and J. Hrdlička. 2018. "NO_x Formation in Oxy-Fuel Combustion of Lignite in a Bubbling Fluidized Bed – Modelling and Experimental Verification." *International Journal of Greenhouse Gas Control* 76: 208-214
- Vodička, M., J. Hrdlička, and P. Skopec. 2021. "Experimental Study of the NO_x Reduction through the Staged Oxygen Supply in the Oxy-Fuel Combustion in a 30 kWth Bubbling Fluidized Bed." *Fuel* 286
- Chojnacki, J., J. Najser, K. Rokosz, V. Peer, J. Kielar, and B. Berner. 2020. "Syngas Composition: Gasification of Wood Pellet with Water Steam through a Reactor with Continuous Biomass Feed System." *Energies* 13 (17)
- Campagna, M. M., J. Hrubý, M. E. H. Van Dongen, and D. M. J. Smeulders. 2020. "Homogeneous Water Nucleation: Experimental Study on Pressure and Carrier Gas Effects." *Journal of Chemical Physics* 153 (16)
- Havlík, J. and T. Dlouhý. 2020. "Indirect Dryers for Biomass drying—comparison of Experimental Characteristics for Drum and Rotary Configurations." *ChemEngineering* 4 (1): 1-11.

*Best paper award at
the 3rd Nordic-Baltic
Drying Conference,
2019*



**THANK YOU FOR YOUR
ATTENTION**



**FACULTY
OF MECHANICAL
ENGINEERING
CTU IN PRAGUE**



EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education



RESEARCH CENTRE OF LOW-CARBON ENERGY TECHNOLOGIES

CZECH TECHNICAL UNIVERSITY IN PRAGUE
FACULTY OF MECHANICAL ENGINEERING
Project reg. Nr. CZ.02.1.01/0.0/0.0/16_019/0000753



FACULTY
OF MECHANICAL
ENGINEERING
CTU IN PRAGUE