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The CTU partner as a player in R&D strategies to reach low carbon industry

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Visegrad Fund

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DEPARTMENT

Specialization of the Department

Prof. Jirout: „The knowledge interconnection diversity of processes and constructions – this is exactly our field of competence."

Technologies and equipment for:

- ***chemical industry*** (basic chemicals, refinery, mining, extraction,...)
- ***food industry*** (food and food complements, agriculture,...)
- ***manufacturing and consumer industries*** (plastics, ceramics, building materials, glass, packaging and packaging ...)
- ***pharmaceutical industry***
- ***waste processing*** (waste water treatment, gaseous pollution control, solid waste treatment, biorefinery, advanced biofuels, bioplastics)




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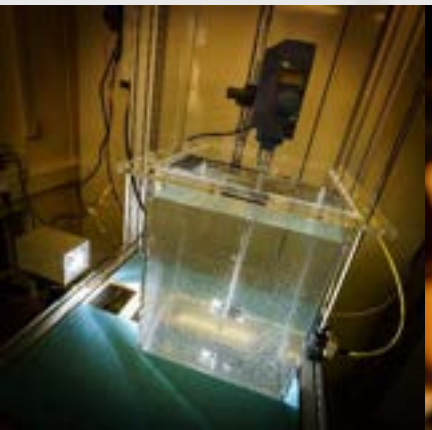
KEY RESEARCH ACTIVITIES => PROCESSES AND EQUIPMENT

- **Hydromechanical processes and equipment** (fluid transportation, filtration, settling, centrifugation, fluidization, mixing, dispersing).
- **Heat processes and equipment** (heat exchange, boiling, evaporation, drying).
- **Difussion-separation processes and equipment** (absorption, adsorption, membranes, distillation, crystallisation, extraction, reactors and bioreactors).
- **Mechanical size reduction** (grinding, milling).
- Rules for **scale-up/scale-down** of processes and equipment.



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KEY RESEARCH ACTIVITIES => TECHNOLOGY

- **Design and construction activities** in the chemical, food and processing industries, biotechnology and related fields.
- **Energy and substance balances, optimization** of production lines and technologies.
- **Technologies and equipment for biorefineries** (waste processing, biofuels, organic substances, bioplastics).
- **Modelling and control** of processes, production lines and equipment.




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RESEARCH AND SCIENCE

flue gas → *CO_2* → *green chemicals, biofuels*

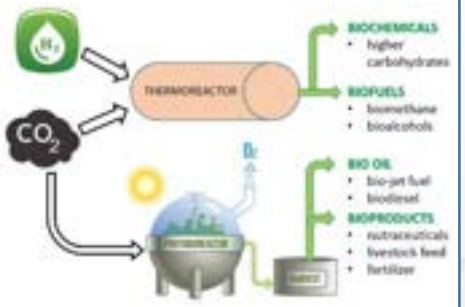
https://www.vectorstock.com/royalty-free-vector/factory-silhouette-with-chimney-polluting-co2-vector-18606630

CAUSE AND CONSEQUENCE?

CAPTURE

https://slideplayer.com/slide/6025299/

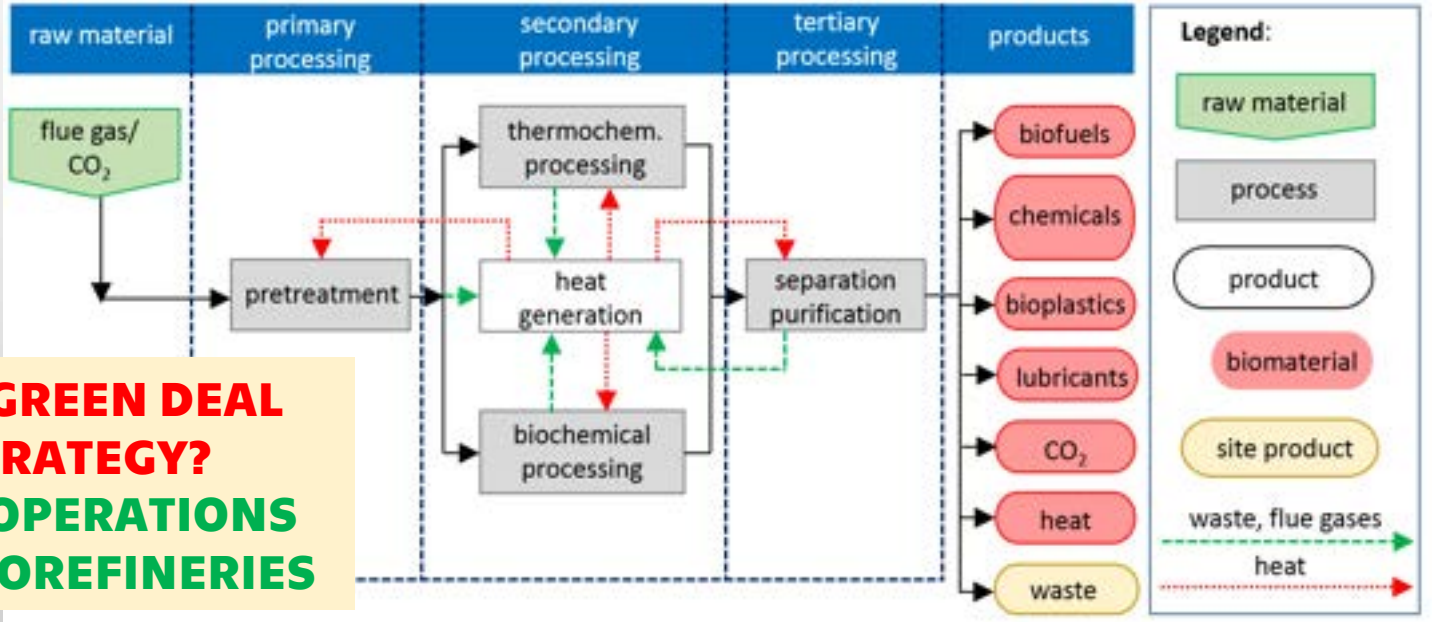
UTILIZATION



https://www.asente.ch/clean-air/photobioreactor//

TESTING

http://www.engineersjournal.ie/2013/10/17/nanocrystal-catalyst-transforms-impure-hydrogen-into-electricity/



OUR GREEN DEAL STRATEGY?
UNIT OPERATIONS FOR BIOREFINERIES

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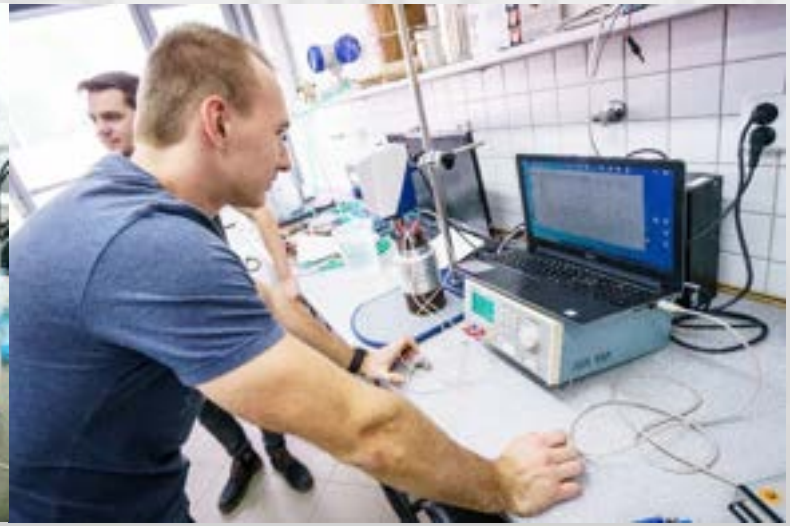
RESEARCH AND SCIENCE

RAW MATERIAL CHARACTERISTICS

- **Density, specific heat capacity (*differential scanning calorimetry*), heat conductivity of substances.**
- **Moisture, total solids, organic solids of chemical and food substances.**
- **Rheological properties of newtonian and non-newtonians fluids.**
- **Particle size characteristics – *optical microscopy, laser diffraction particle size analyser, screen sieve analysis.***





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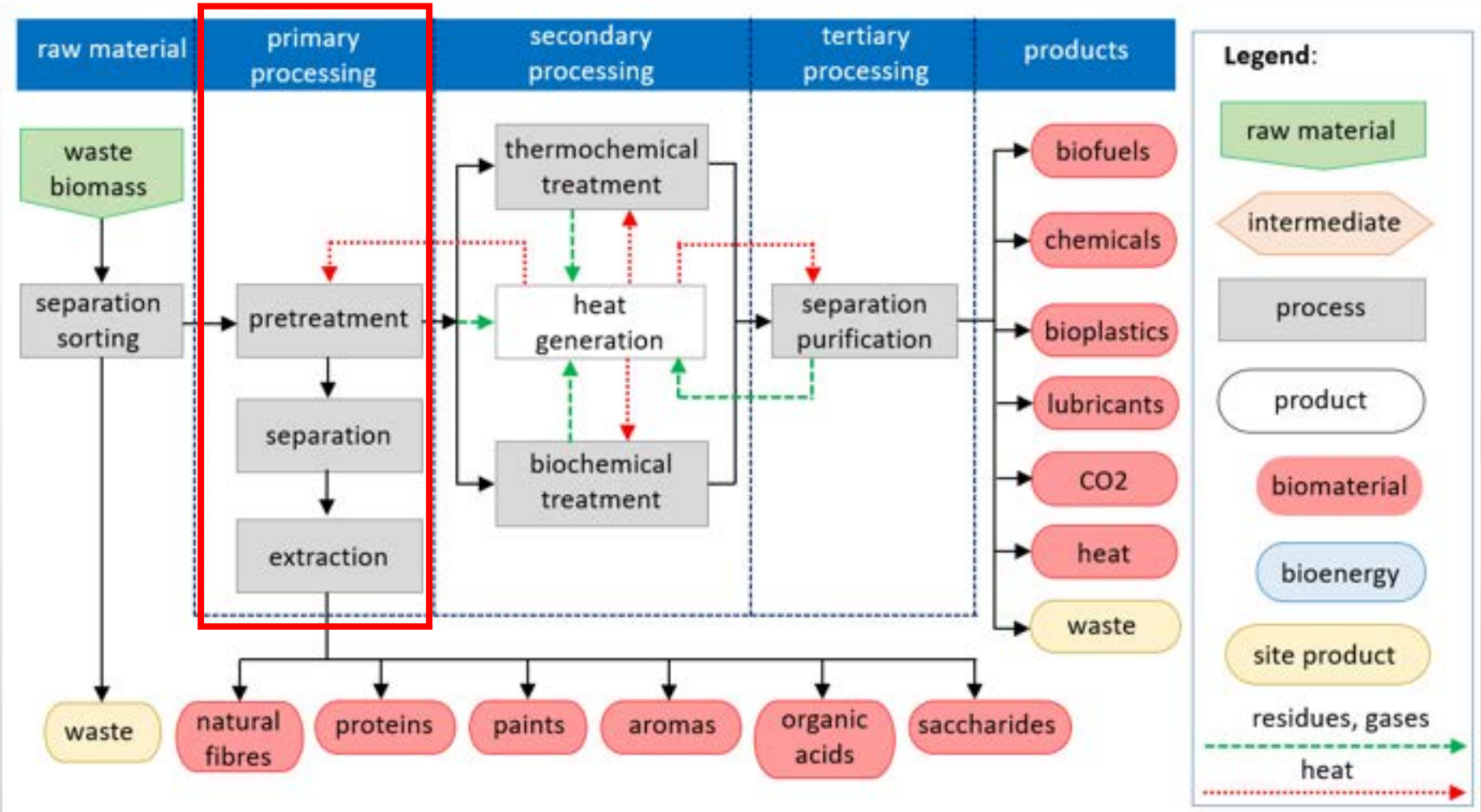
RESEARCH AND SCIENCE

GENERAL CONCEPT OF TECHNOLOGY DESING IN BIOREFINERY CONCEPT



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RESEARCH AND SCIENCE

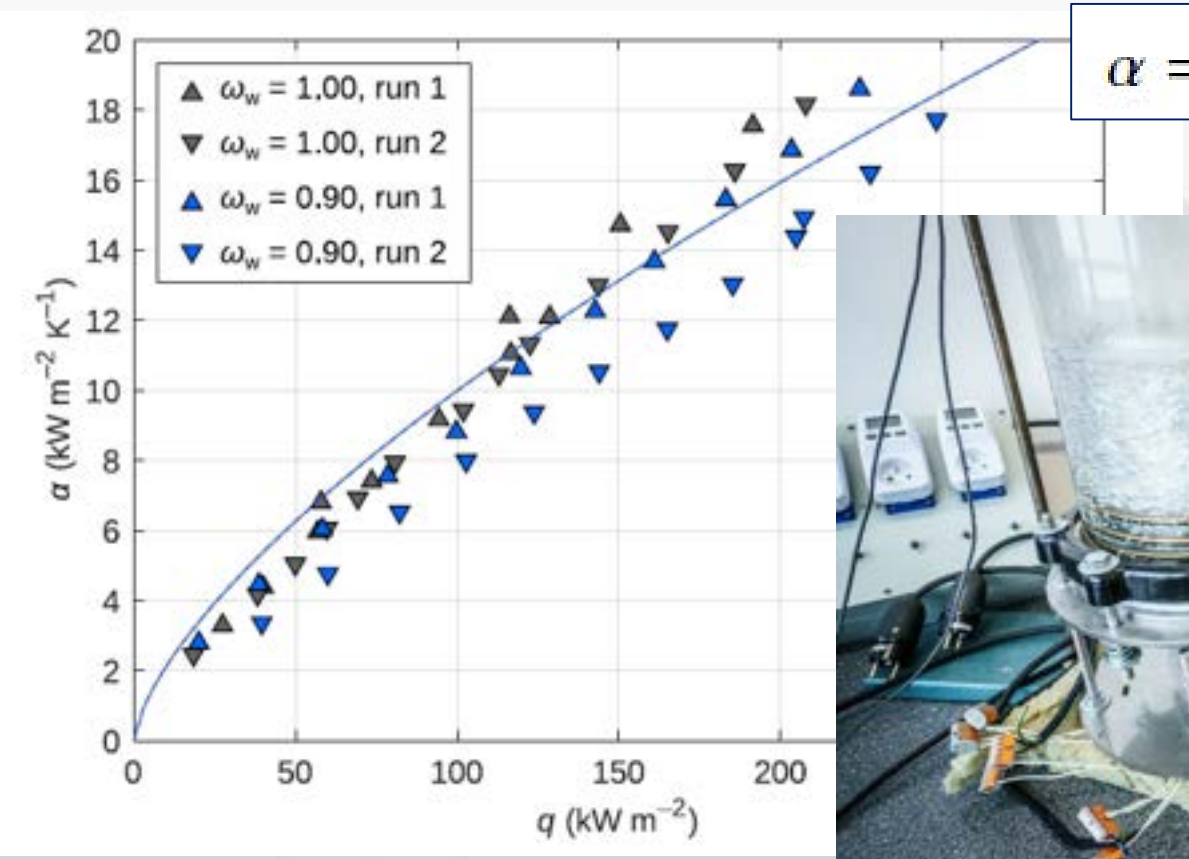
Application of ADSORPTION and ABSORPTION

- **Experimental research and modelling on decentralized O_2 production.**
- **Experimental research and modelling of CO_2 capture.**
- **Applying results to form original gas treatment in hybrid mode.**

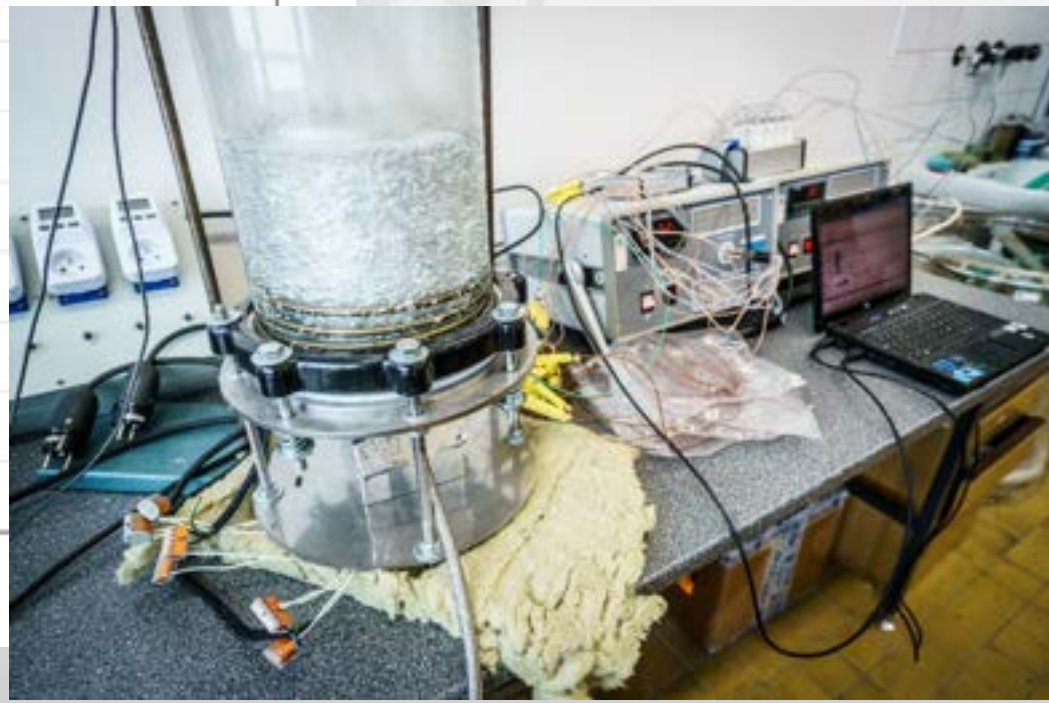
RESEARCH AND SCIENCE

HEAT TRANSFER ANALYSIS DURING BOILING

- **Analysing transfer phenomena during boiling of liquids.**
- **Analytical and CFD process modelling.**



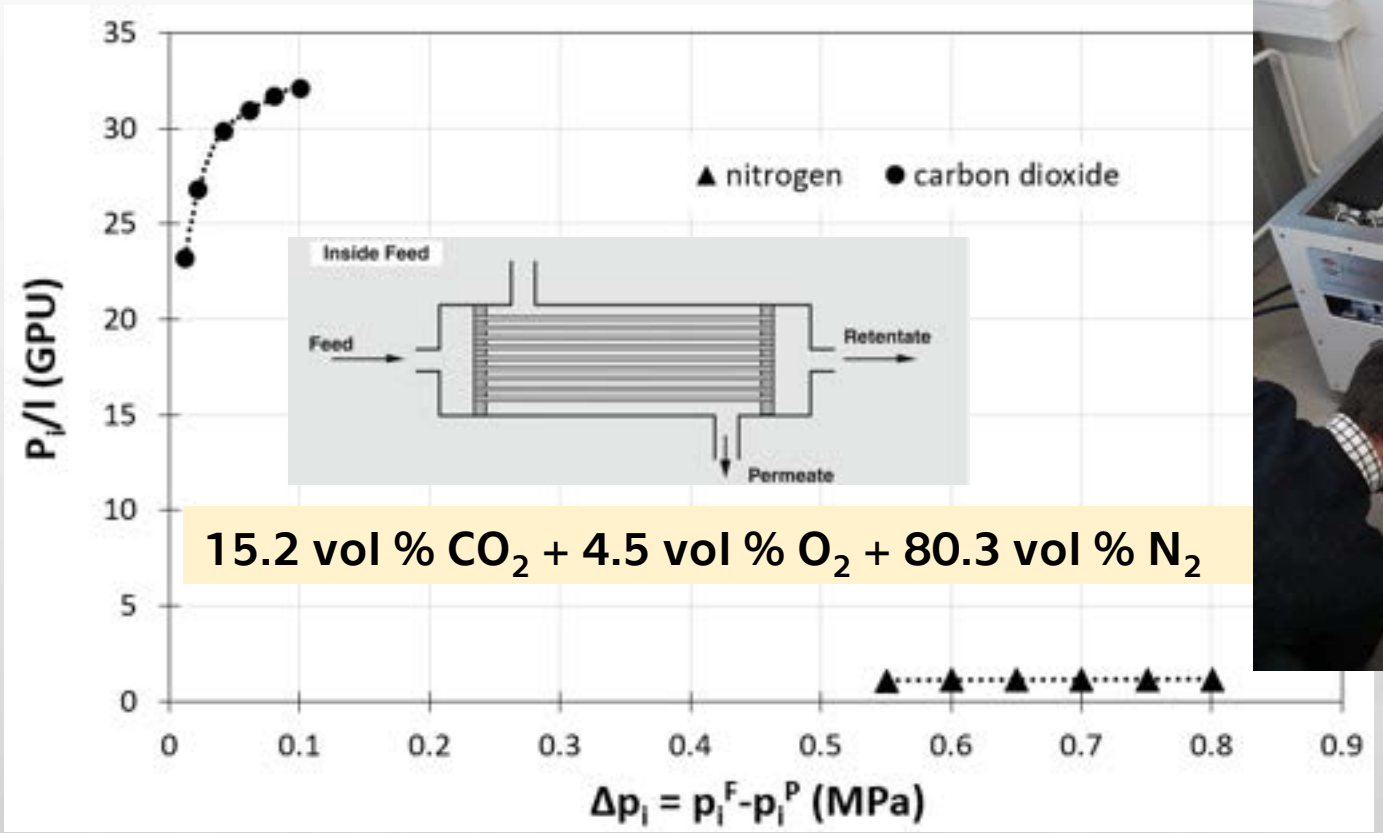
$$\alpha = 1.08\, q^{0.625+0.089\omega_w}$$



RESEARCH AND SCIENCE

Flue gas refinement by MEMBRANE PROCESS

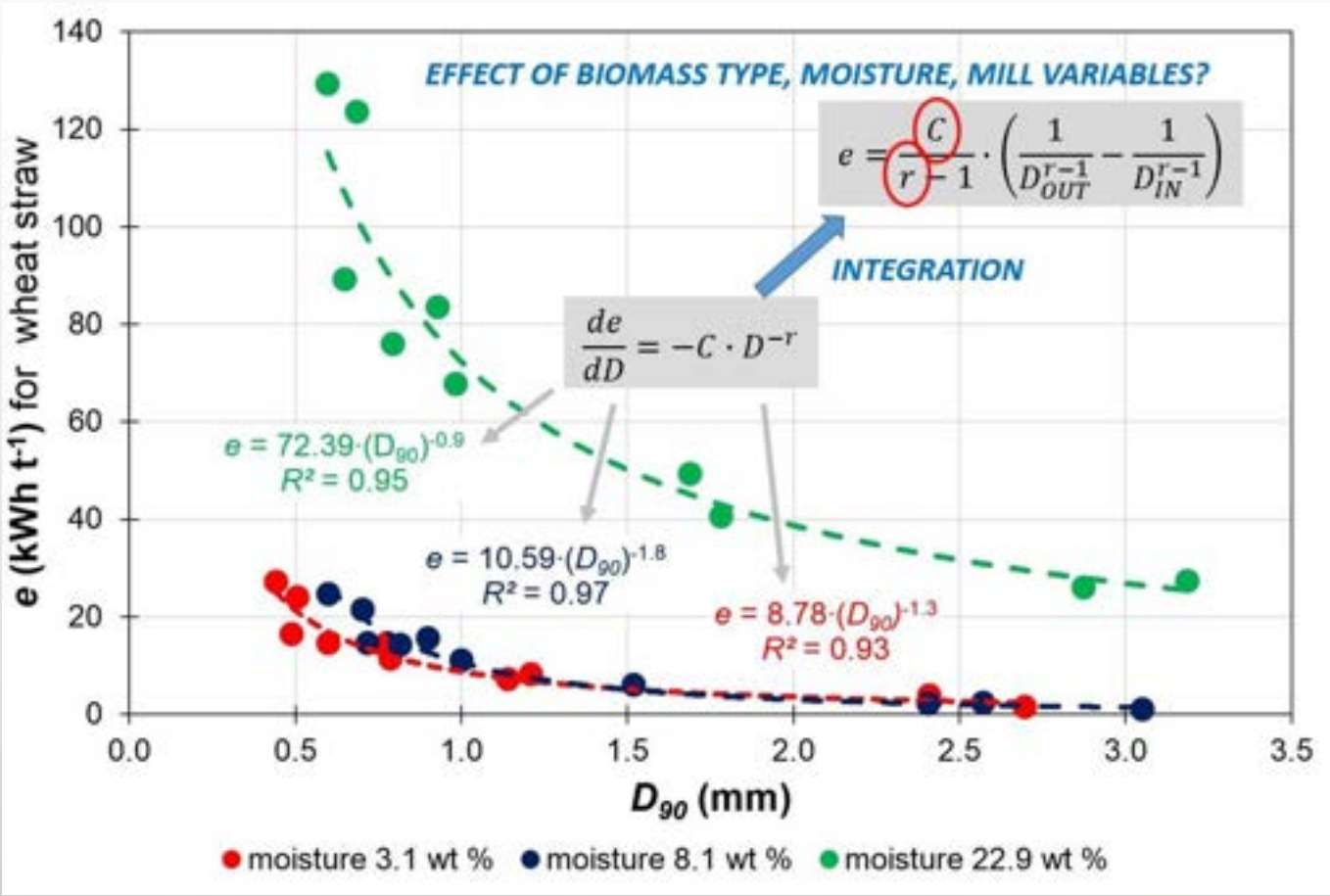
- **CO_2 recovery from exhaust gas.**
- **Energy rich component from gas after wood gasification.**



RESEARCH AND SCIENCE

MECHANICAL SIZE REDUCTION

- Knife, ball, pearl, colloid, retting mills.
- Modelling energy demand and particle characteristics.



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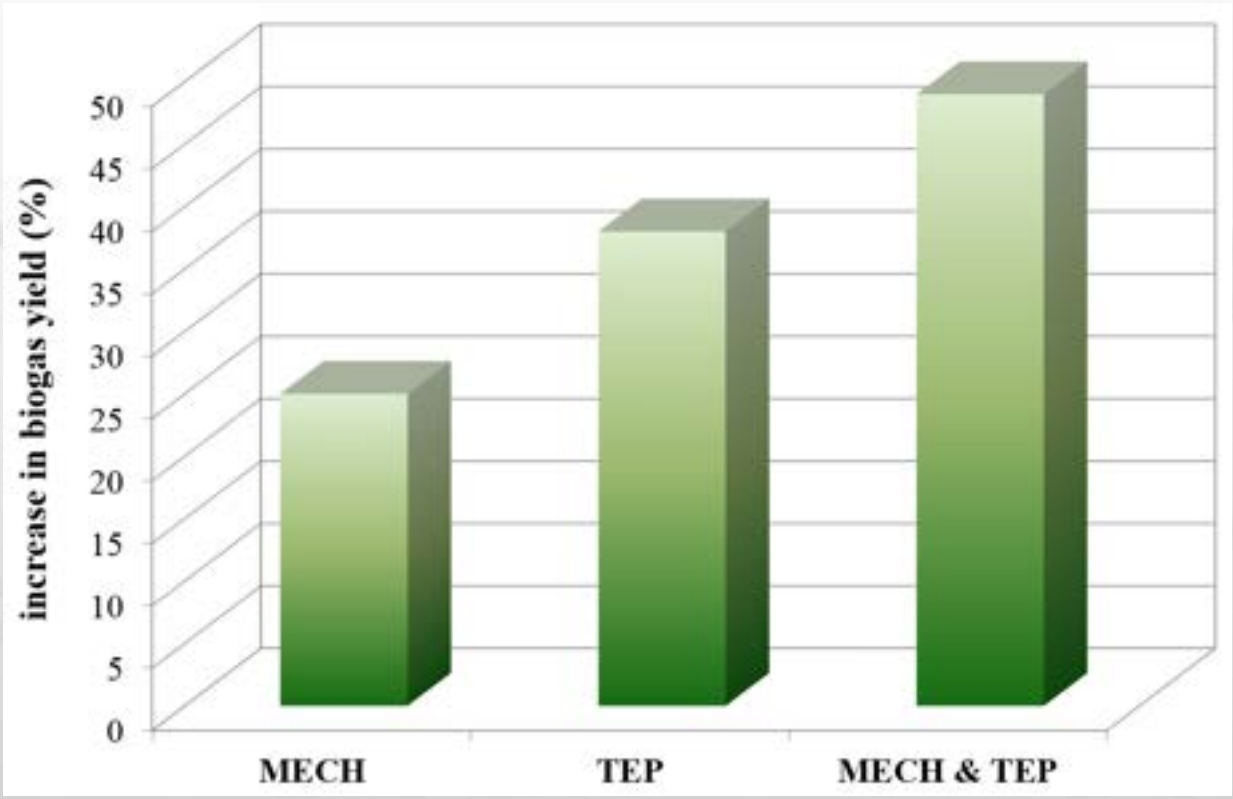
RESEARCH AND SCIENCE

HYDROTHERMAL AND CHEMICAL PRETREATMENT

Analysing transfer phenomena and optimization of process parameters:

- **hydrothermal processing with/without rapid batch decompression,**
- **chemical dissolution of lignocellulosic matrix.**



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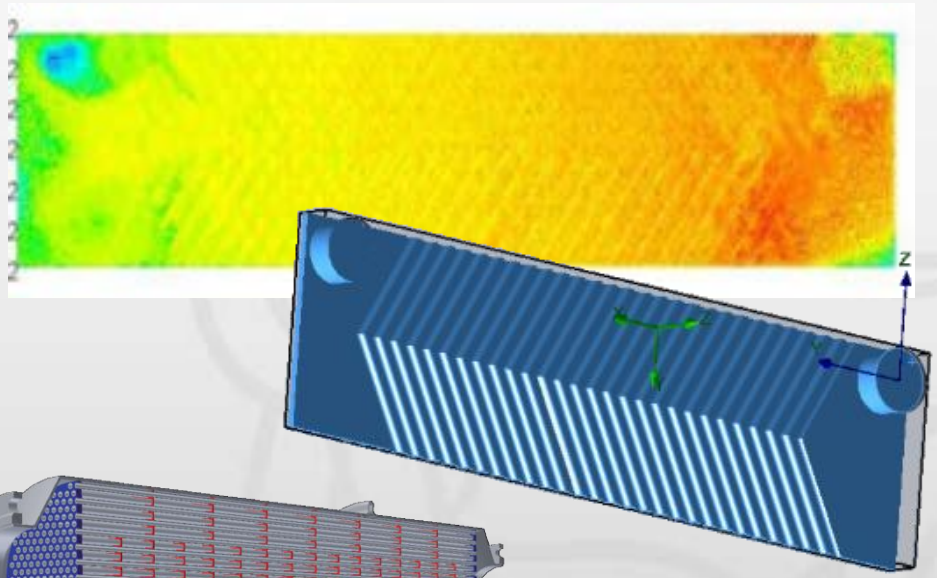
RESEARCH AND SCIENCE

HEAT EXCHANGERS FOR SPECIAL APPLICATIONS

- **design, optimization of heat transfer surfaces**
- **experimental verification of hydraulic characteristics and of heat transfer efficiency**



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RESEARCH AND SCIENCE

HEAT TRANSFER PROCESSES

Analysing transfer phenomena and optimization of process parameters:

- **evaporators**
- **drying and dryers**
- **direct and indirect ohmic heating**

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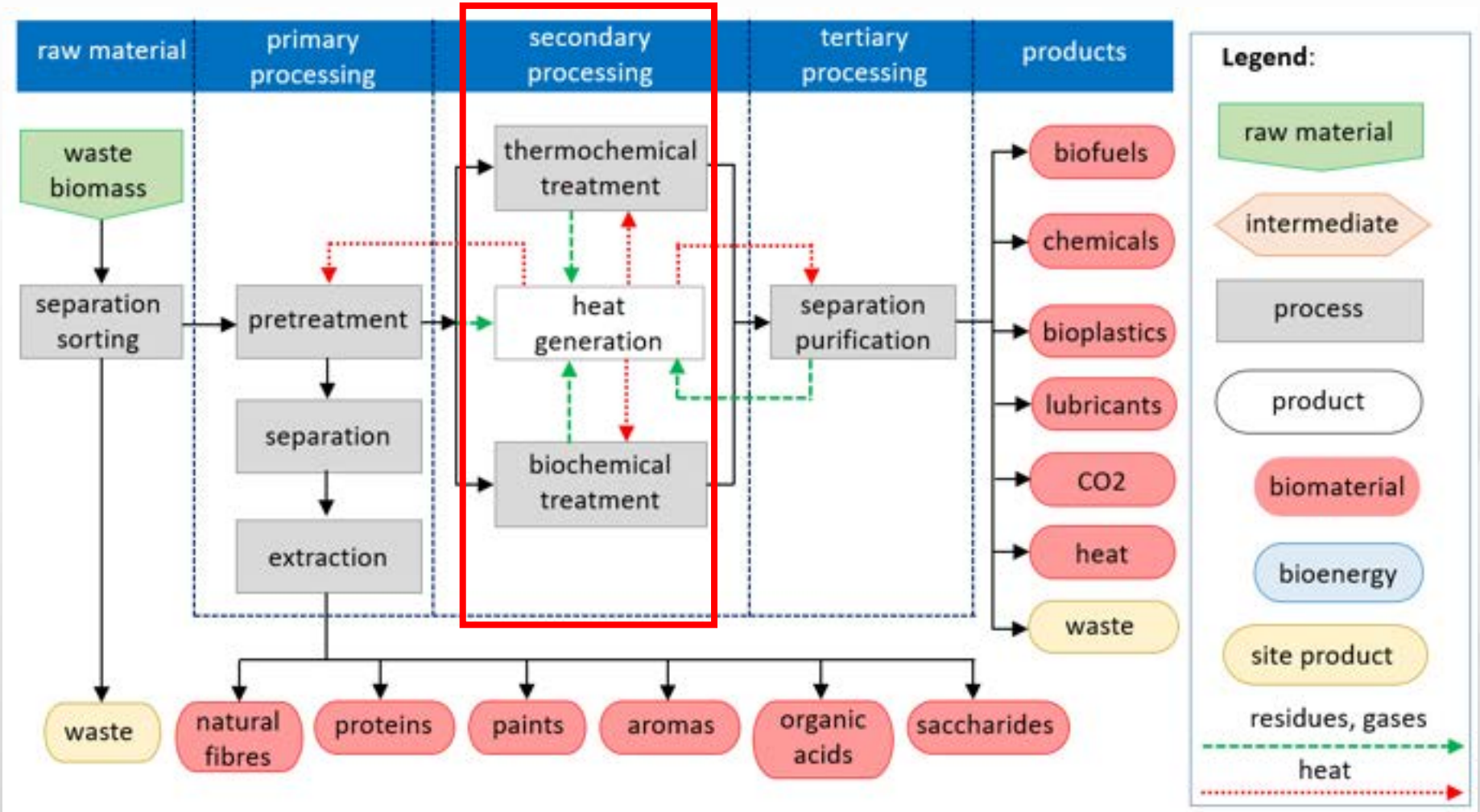
RESEARCH AND SCIENCE

TECHNOLOGY DESING IN BIOREFINERY CONCEPT



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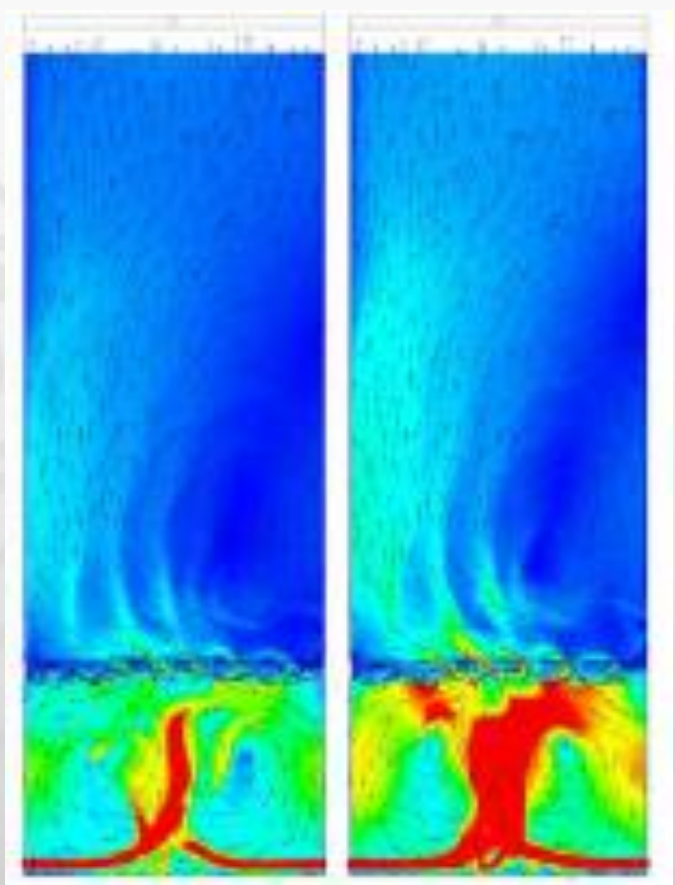
RESEARCH AND SCIENCE

TRANSFER PHENOMENA OF PHOTOBIOREACTORS

- **Experimental and CFD study on hydrodynamics, installing static mixers.**
- **Modelling oxygen generation, batch degasifying.**
- **Growth and proces modelling in hybrid systems.**



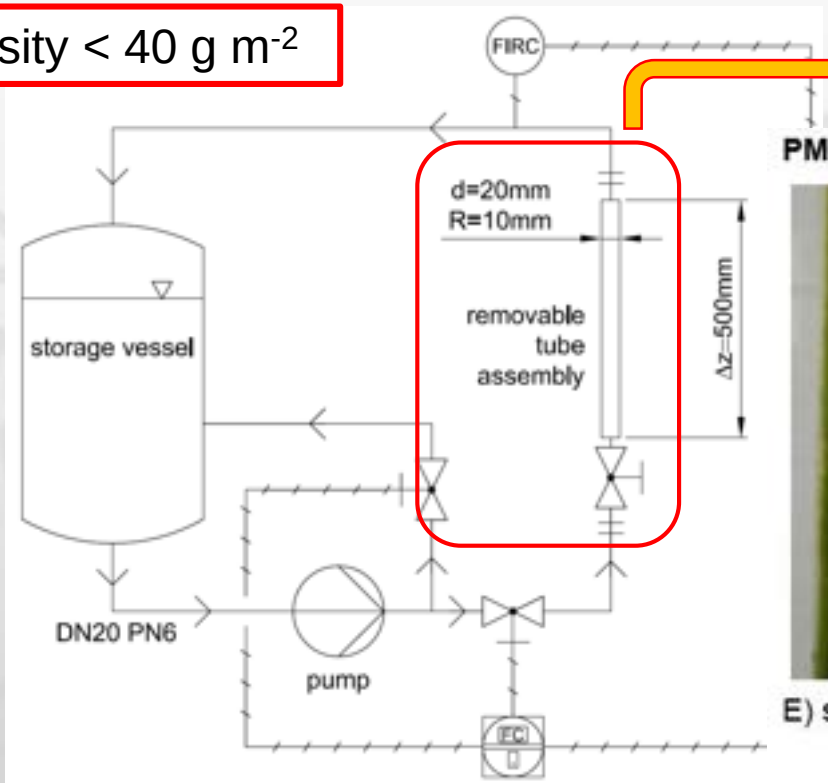
RESEARCH AND SCIENCE

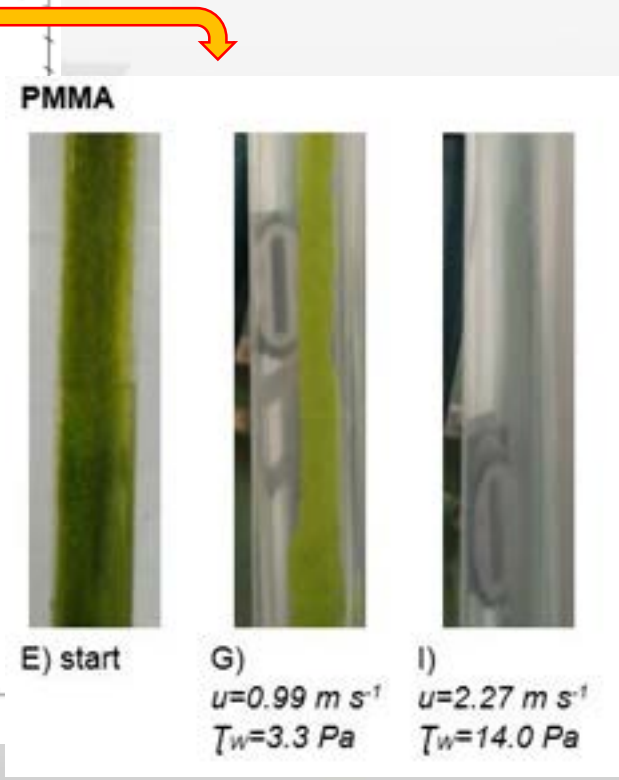
HYDRODYNAMIC BIOFILM REMOVAL STRATEGY

BIOFOULING

- **Non-destructive thickness detection.**
- **Hydrodynamic biofilm removal techniques.**

biofilm density < 40 g m^{-2}





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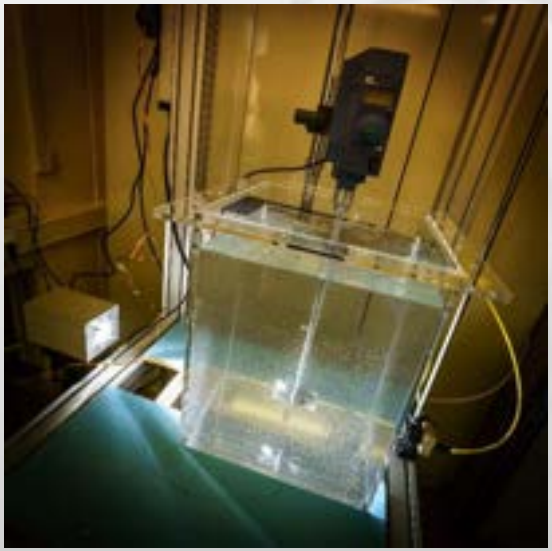
RESEARCH AND SCIENCE

MIXING OF REACTORS AND BIOREACTORS

- experimental and CFD flow analysis in agitated batch
- mixing of heterogeneous systems
- mixing of non-Newtonian fluids
- heat transfer in agitated batch
- dispergation
- static mixers



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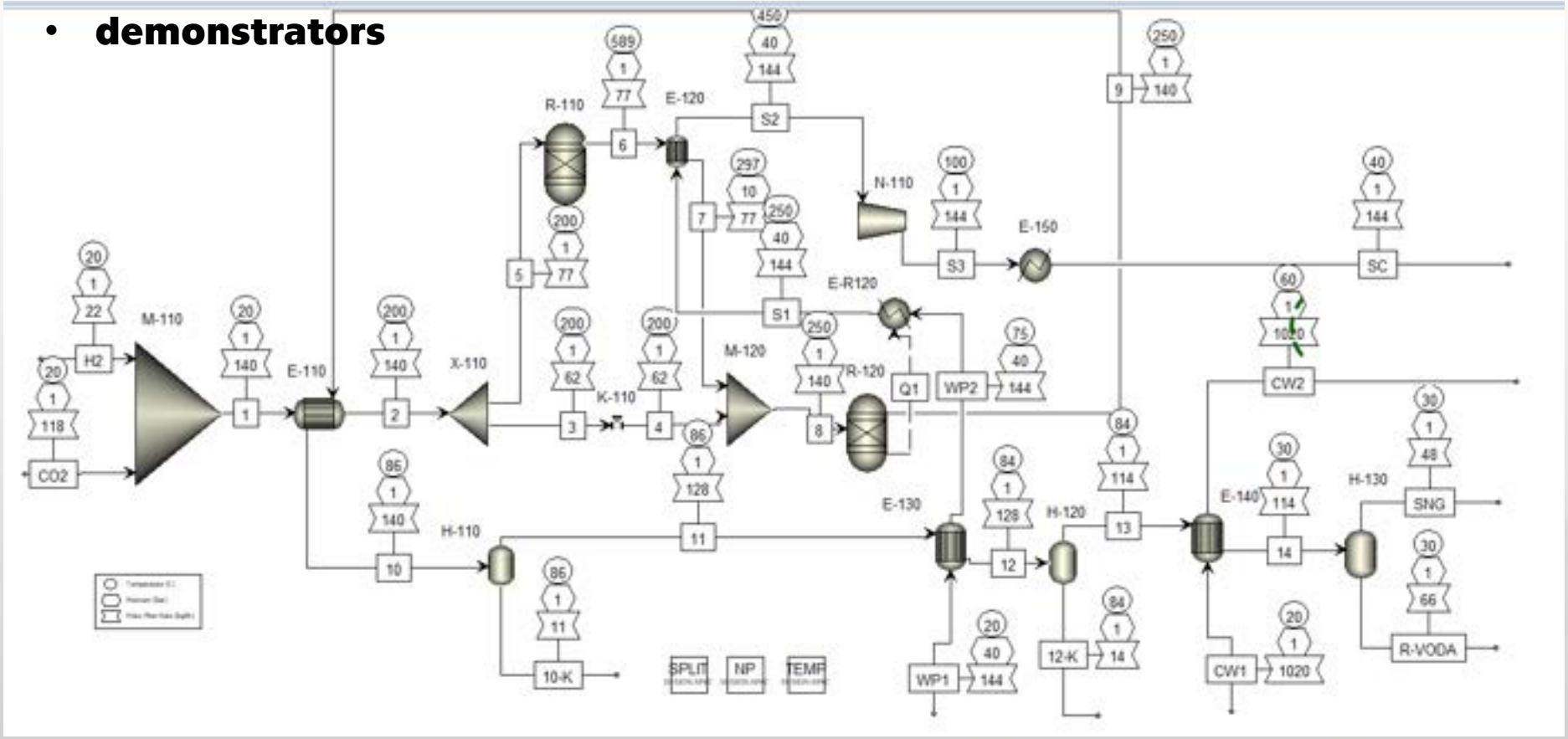
RESEARCH AND SCIENCE

CO_2 TO METHANE: A FEASIBILITY STUDY

- **parametric process modelling followed by sensitivity analysis**
- **economics, TRL limits**
- **demonstrators**



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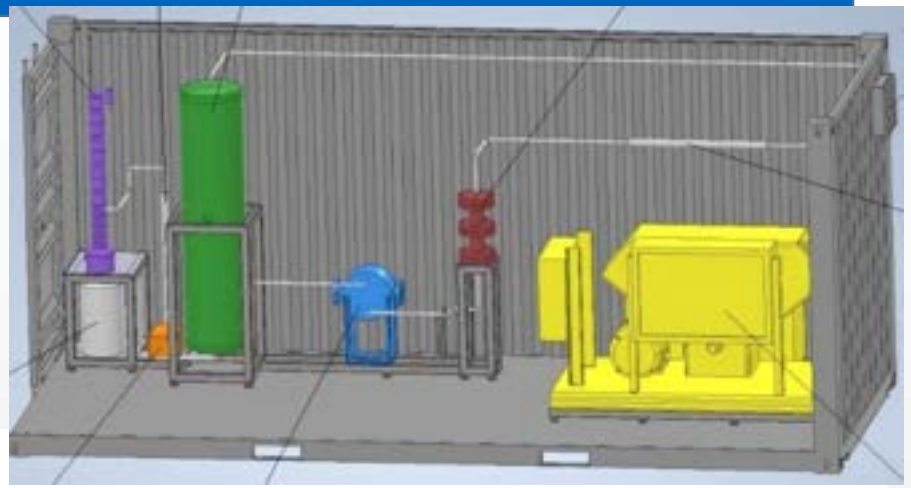
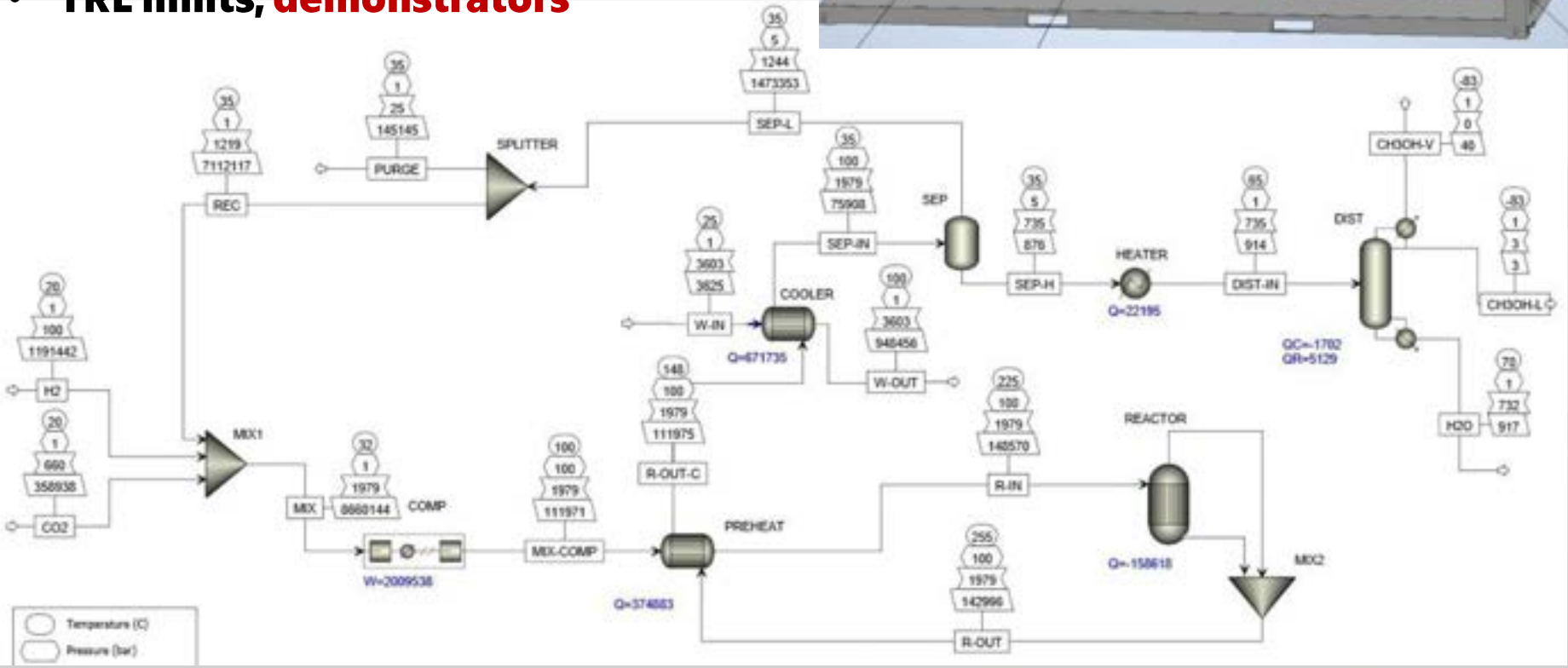
RESEARCH AND SCIENCE

CO_2 TO METHANOL: A FEASIBILITY STUDY

- **parametric process modelling**
- **sensitivity analysis**
- **TRL limits, demonstrators**





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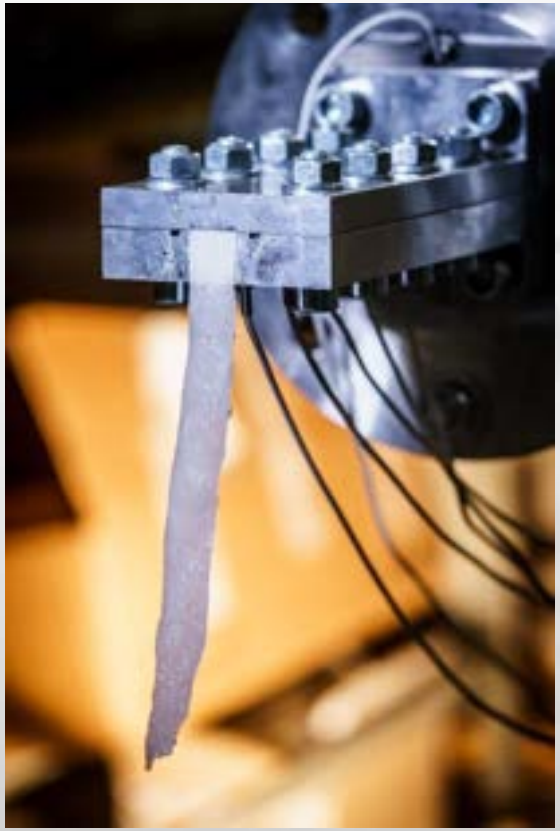
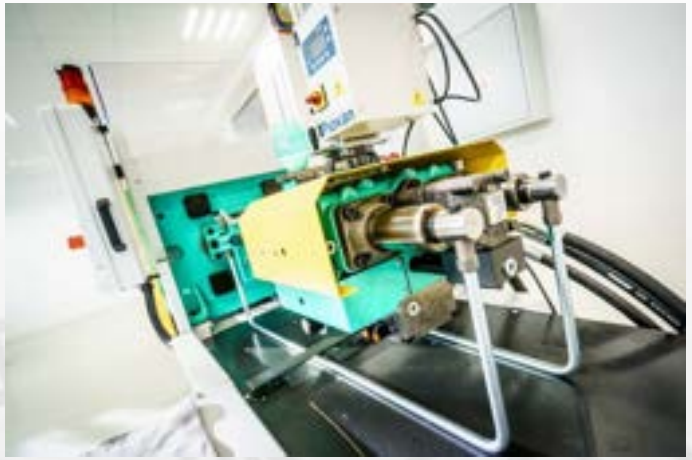
RESEARCH AND SCIENCE

BIODEGRADABLE MATERIALS

- **Experimental analysis of processes (mixing, forming), product mechanics.**

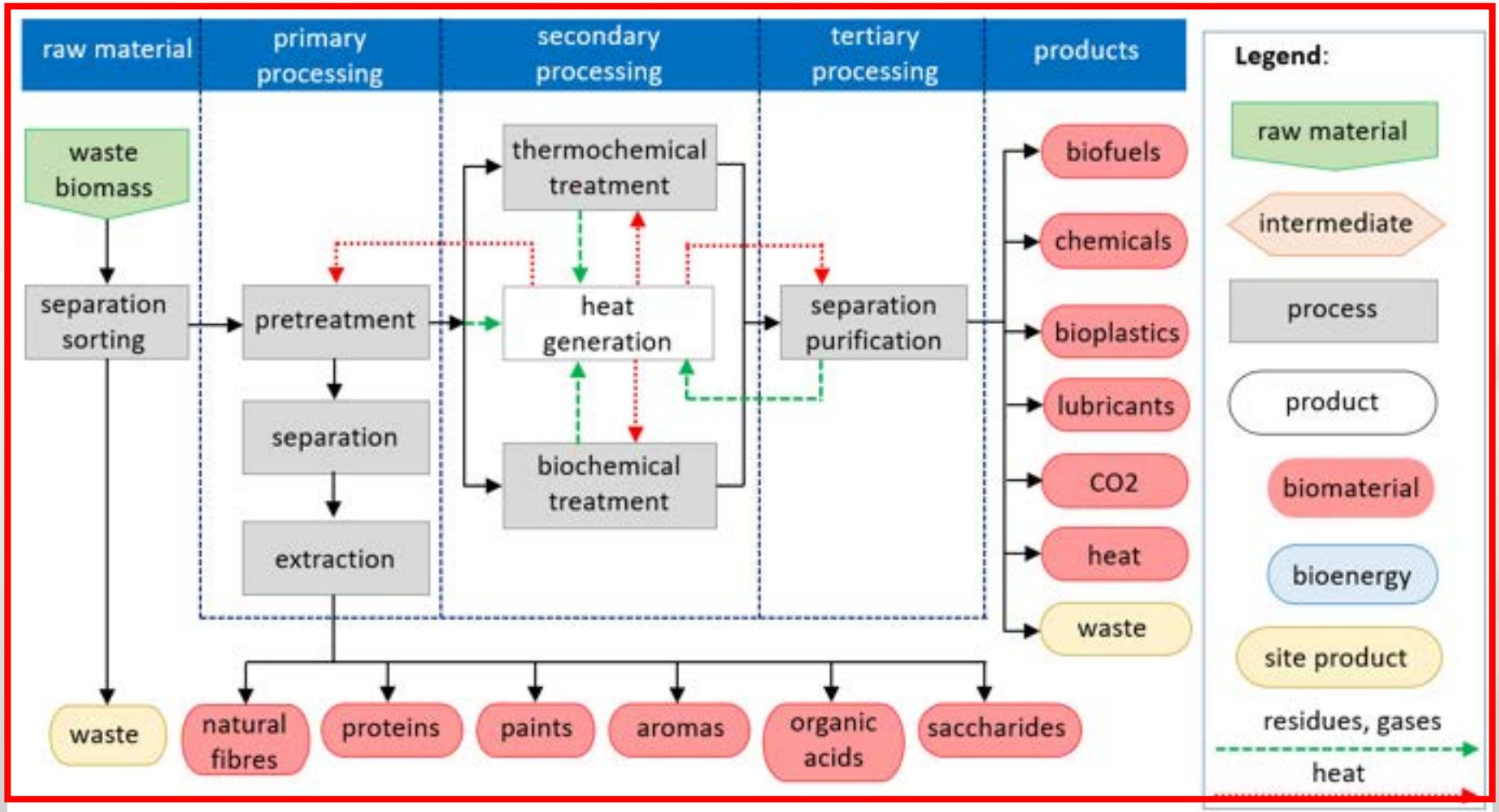




RESEARCH AND SCIENCE

TECHNO-ECONOMIC STUDY OF BIOREFINERY

- **PFDs , balancing, economics, TRL, scale up limits, sensitivity analysis**



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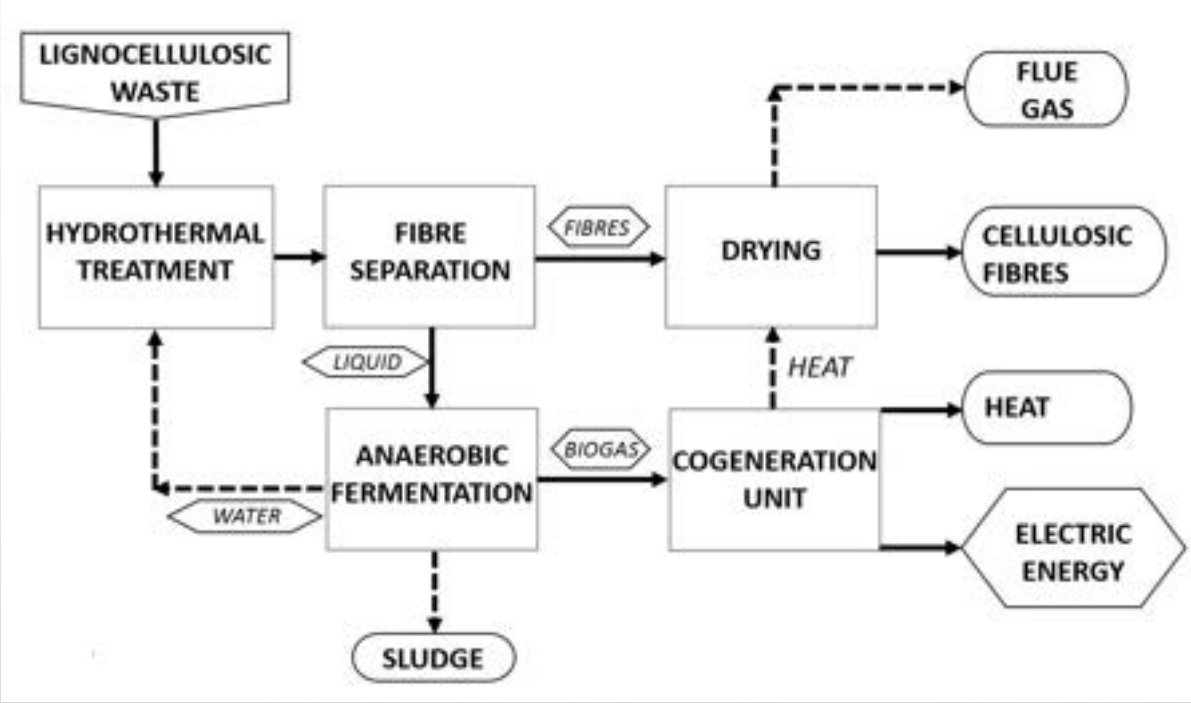
BIOGAS BIOREFINERY

- **annual production straw based wastes was $5{,}4 \cdot 10^9$ t_{TS} of in 2015** *(feed, mostly stored on fields, burned, or unutilized)*



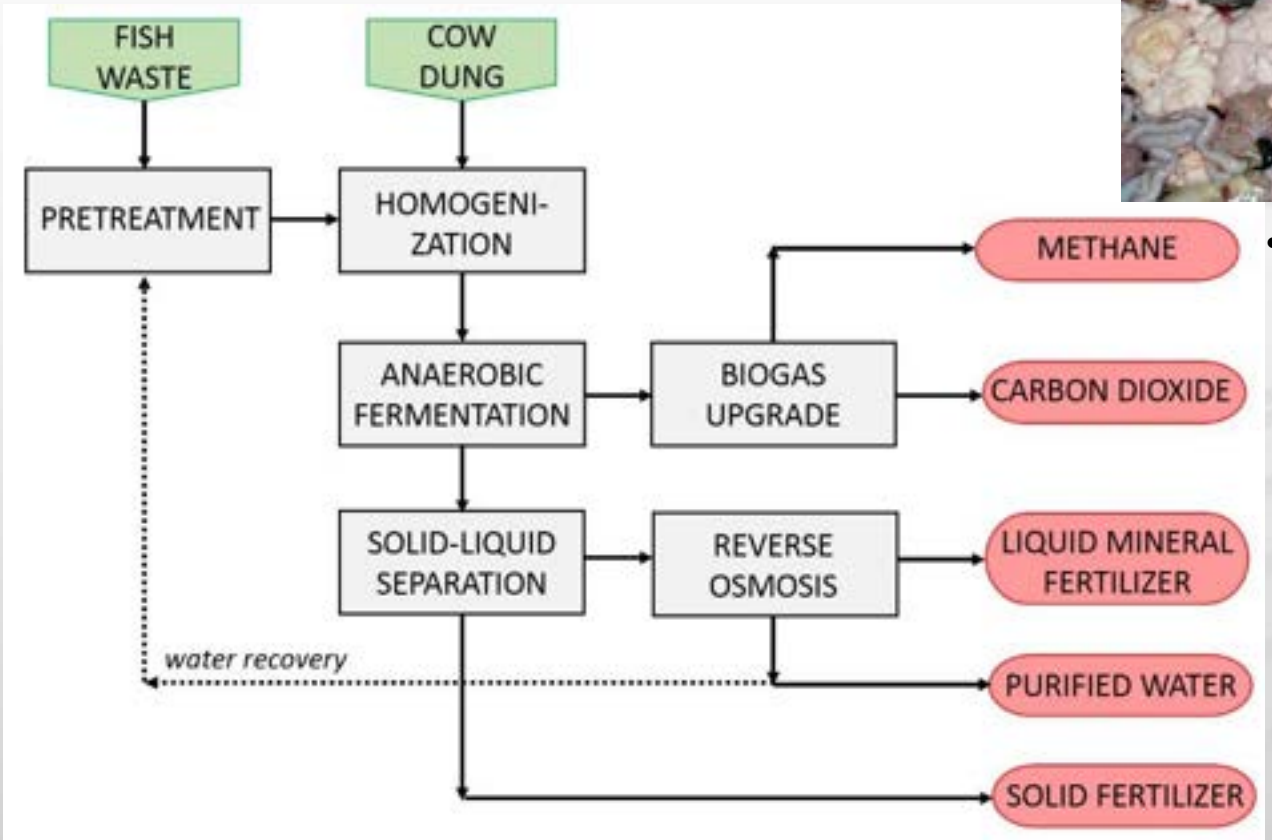
Cellulosic fibres = high potential of applicability

- **insulation material**
- **biodegradable reinforcing element for bioplastics or nanocomposites**
- **furniture production technologies,**
- **automotive,**
- **pharmacy,**
- **electronics,**
- **cosmetics,**
- **membrane component.**

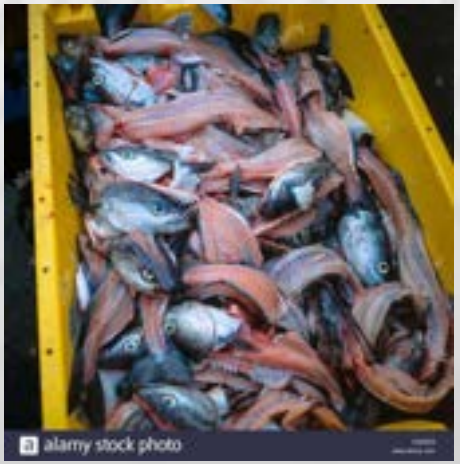
RESEARCH AND SCIENCE

FISH WASTE BIOREFINERY

- **71 million tons in 2020**
- **fish waste production typically ranges between 20 % and 80 % of total fish body**



- **mainly composed of heads, bones, skin, and viscera**



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RESEARCH AND SCIENCE

MESSAGE TO TAKE HOME

CTU partner role for V4 Green Deal strategies

- **Hydromechanical, heat and diffusion-separation processes and equipment** (experimental and CFD process analysis, intensification, modelling)
  - **Technology and equipment for gas treatment** (transfer phenomena, adsorption, absorption, membranes).
  - **Technology and equipment for waste treatment and recycling** (milling, hydrothermal and chemical treatment, heat exchangers, evaporators, dryers).
  - **Technology and equipment for microalgal cultivation** (bioreactor design, transfer phenomena, hydrodynamics, biofilm and O_2 removal).
  - **Technology and equipment for waste to X strategies** (CO_2, hydrogen, pyrolysis, biodegradable materials, modelling, biochemical/thermochemical pathways).
- **Scale-up** of processes**, design** of equipment.
- **Design and balancing of biorefineries, modelling and proces control, economics, sensitivity analysis.**

THANK YOU FOR THE ATTENTION!

Visegrad Fund

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project ID22120032.