Lodz University of Technology (TUL)
Faculty of Proces & Environmental Engineering

Visegrad Fund

TUL Departments contribution to the Project

Green Deal strategies for V4 countries:

The needs and challenges to reach low-carbon industry

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CCUV4 Bratislava 26-27 May 2022

Presentation outline

- Presentation of Lodz University of Technology
- Faculty of Proces & Environmental Engineering
- Research and science activities of Departments:
- Integration of bio- & thermo-chemical platforms for biorefinery -- Department of Bioprocess Engineering K-92
- Chemical equipment for use in environmental protection - Department of Chemical Engineering K-93
- Life Cycle Assesment - Department of Environmental Engineering K-95

ŁÓDŹ UNIVERSITY OF TECHNOLOGY

- The city of unique historical and cultural heritage, constantly changing and developing.
- Third largest city in Poland, over 705 000 citizens.
- 32 ha in the center of the city. Contemporary and revitalised post-industrial buildings surrounded by greenery. Villas and palaces that once belonged to industrialists right next to steel glass structures.

Lodz University of Technology
Faculty of Proces & Environmental Engineering

- **1 234** academic staff,
- **14 936** students,
- **110 000** graduates,
- **54** fields of study,
- **9** faculties,
- **3** collegies,
- International Faculty of Engineering (IFE),
- Interdisciplinary Doctoral School (IDS)

Lodz University of Technology
Faculty of Proces & Environmental Engineering

Department of Occupation Safety

Department of Bioprocess Engineering

Department of Chemical Engng.

Department of Molecular Engineering

Department of Environmental Engineering

Student's Office and Administration
ca. 500 students in 4 courses

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Lodz University of Technology
Faculty of Proces & Environmental Engineering

Integration of bio- & thermo-chemical platforms for biorefinery

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Biorefinery classifcation

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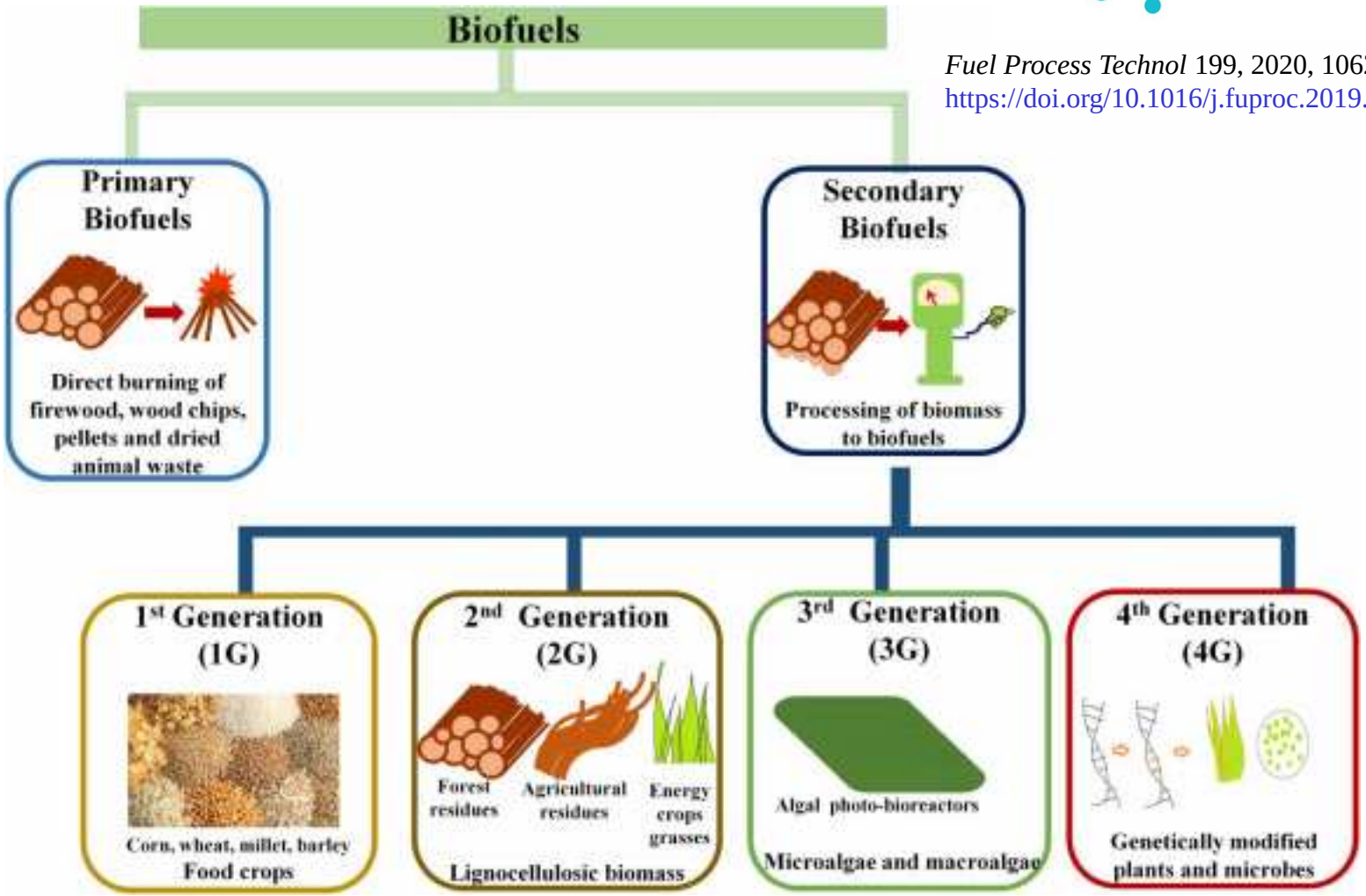

Fuel Process Technol 199, 2020, 106244
https://doi.org/10.1016/j.fuproc.2019.106244

Integration of bio- & thermo-chemical platforms for biorefinery

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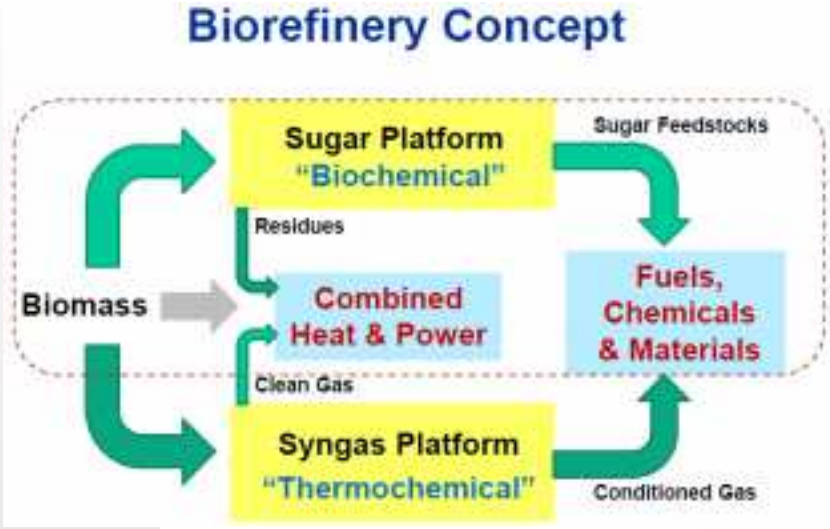


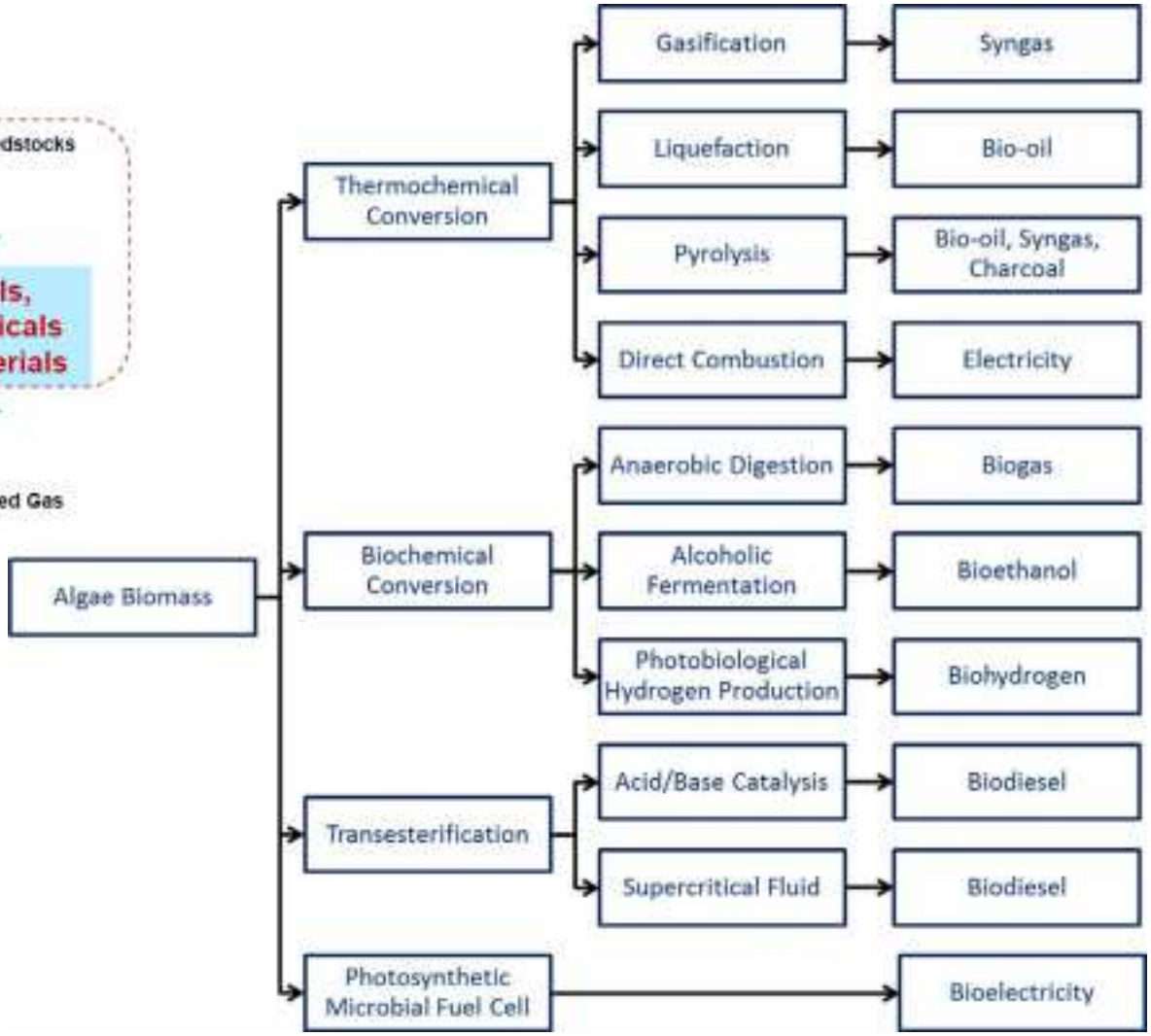
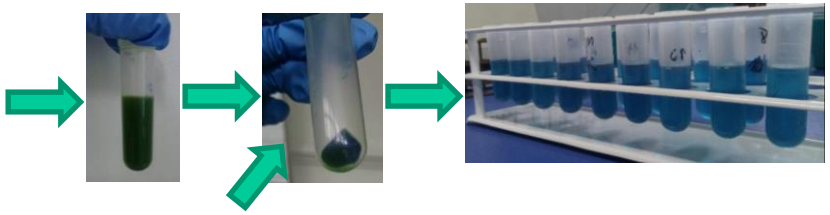


Photo-biosynthesis and down-stream processing of thermostable phycocyanin C-PC

Project NCN, No. 2018/31/B/ST8/00822

- Optimisation of microalgae growth
- Biomass disintegration & recovery of bioproducts (Distraction)
- Downstream processing (DSP) of C-PC
- Characteristics of purified final product

Bioreactor Labfors 5 Lux



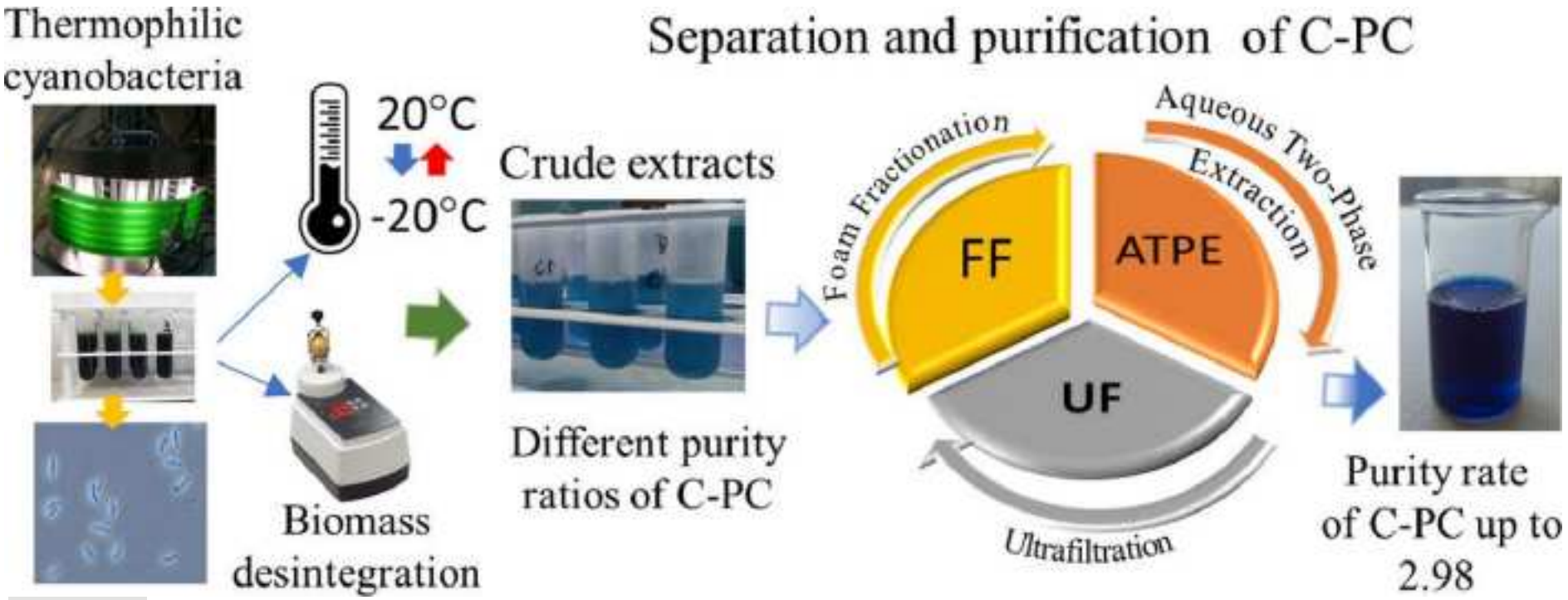
Synechococcus sp. PCC6715

Helikoidalny - BIOSTAT® PBR 2S Sartorius Stedim Biotech

P. Głuszcz, A. Klepacz, S. Ledakowicz: Chemical & Process Engineering 2018, 39 (4), 457 Experimental evaluation of a helical laboratory photobioreactor for the cultivation of thermophilic cyanobacteria – hydrodynamics and mass transfer studies.

A. Klepacz-Smółka *et al.*: *Bioresource Technology 313 (2020) 123700* Effect of light colour and photoperiod on biomass growth and phycocyanin production by *Synechococcus* PCC 6715

Comparison of phycocyanin separation and purification methods



Dextraction of crude C-PC is the most effective method of freezing and thawing biomass in BG 11 buffer.
The following techniques were used to purify thermostable C-PC from Synechococcus sp. PCC6715:
Foam fractionation (FF): recovery efficiency 49%, purification factor PF = 1.472
Aqueous two-phase extraction (ATPE) PEG 6000 - phosphate salt: recovery efficiency 97%, PF=1.466
Ultrafiltration (Hydrosart 10 kDa membrane): recovery efficiency 92%, PF=1.472
Fast FPLC protein liquid chromatography gave PF = 3.4 pharmaceutical purity

A. Antecka et al. Comparison of three methods for thermostable C-phycocyanin separation and purification *CEP - Process Intensification 171, 2022, 108563* https://doi.org/10.1016/j.cep.2021.108563

Pyrolysis and auto-gasification of micro- and macroalgae

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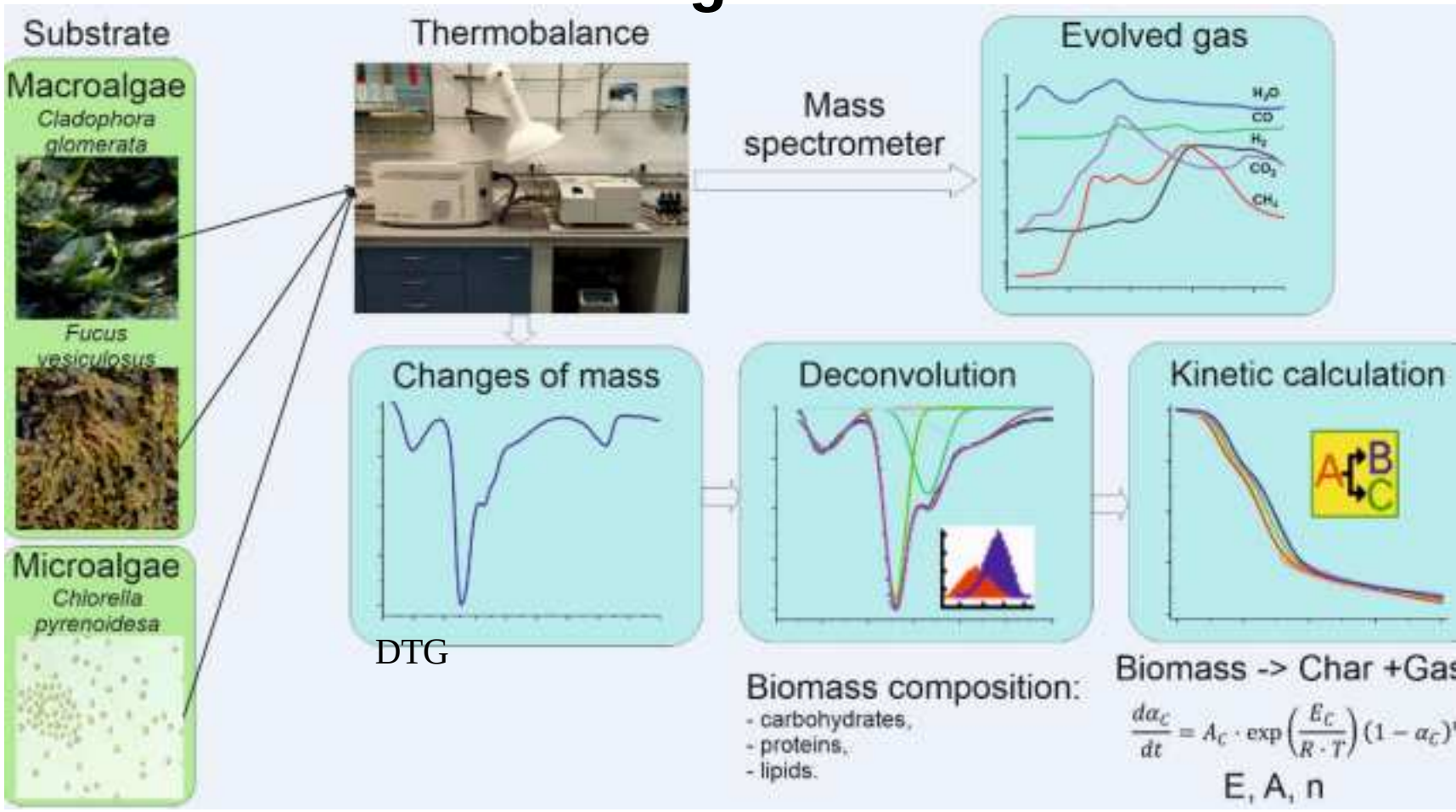

The deconvolution of DTG curves allows to follow the change in the composition and the rate of thermochemical decomposition of individual components of various algae species and, along with the composition of gaseous products (from MS) to determine 3 stages of the process: **evaporation, pyrolysis and auto-gasification**, and to identify the parameters of the kinetic model, which facilitate the design of 3rd generation biorefineries .

R. Ślęzak , S. Ledakowicz. *Algal Research, 2022* Pyrolysis of micro- and macro-algae in thermobalance coupled with MS. *in print.*

Financial suport of Research Centre for Low- carbon Energy Technologies Project Nr.CZ.02.1.01/0.0/0.0/16_019/0000753
Czech Technical University in Prague, Faculty of Mechanical Engineering

Container installation for thermo-chemical treatment of sewage sludge

Visegrad Fund

Sludge throughput 130 kg/h from a wastewater treatment plant P.E. 10,000

METAL EXPERT
EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND
INNOVATIVE ECONOMY
NATIONAL COHESION STRATEGY

Grant NCBR "Development of innovative technology for the pyrolysis of sewage sludge from wastewater treatment plant" Operational Program Innovative Economy

Lodz University of Technology
Faculty of Proces & Environmental Engineering

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Chemical equipment for use in environmental protection

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BIOREFINERY 2G AND 3G

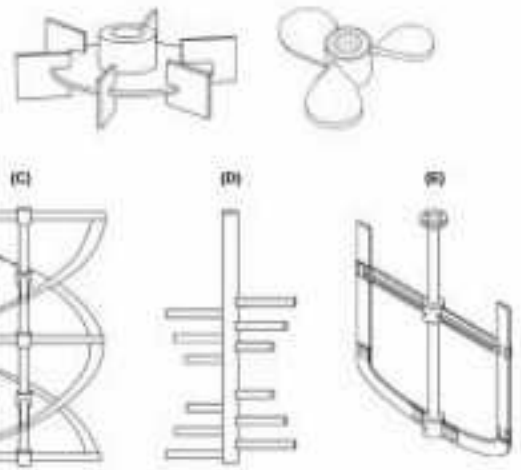
Visegrad Fund

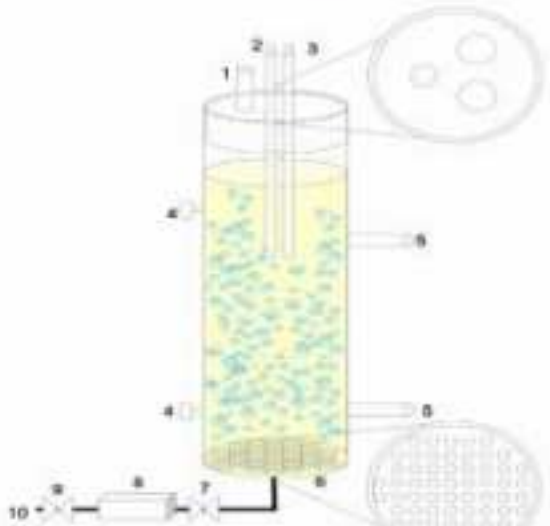
BIOMASS

PRETREATMENT

ENZYMATIC HYDROLYSIS

BIOREACTOR DESIGN & OPERATION AT HIGH SOLID LOADING





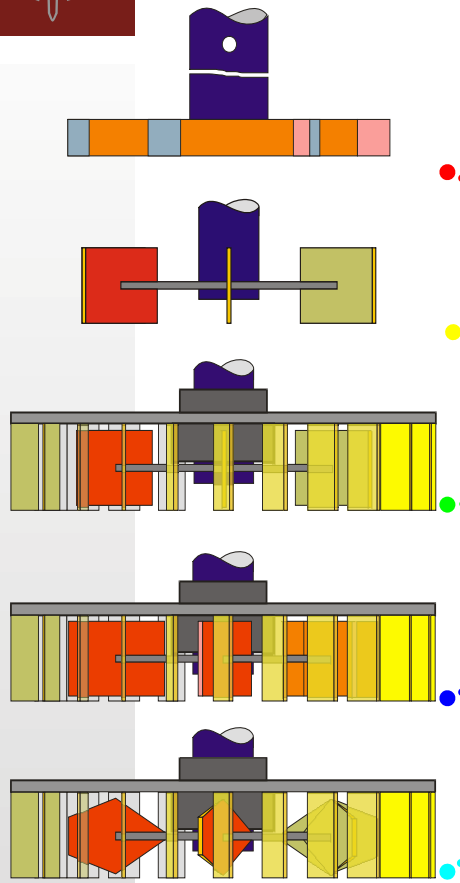
Mixing

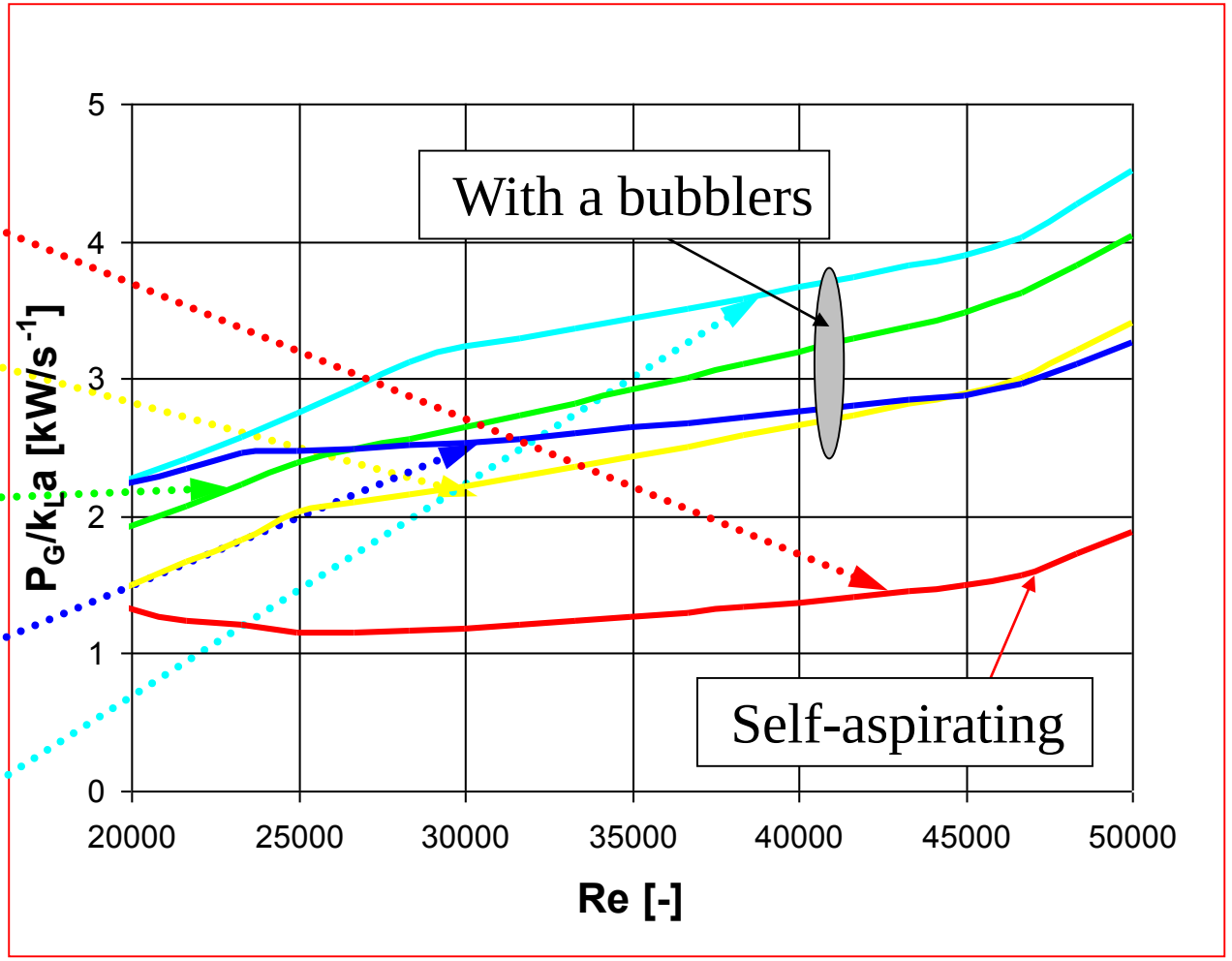
We conduct research and have expert knowledge on the methods of aerating wastewater with the use of self-aspirating mixers. This method does not require the use of additional aeration devices and could be involved in project V4 Green Deal

Patent

D = 300mm N = 600 rpm

Comparison of energy efficiency of different aeration methods





P_G – mixing power withaeration

Agitator with spiral wound ribbon blades for use in bioreactors with media requiring low shear stress

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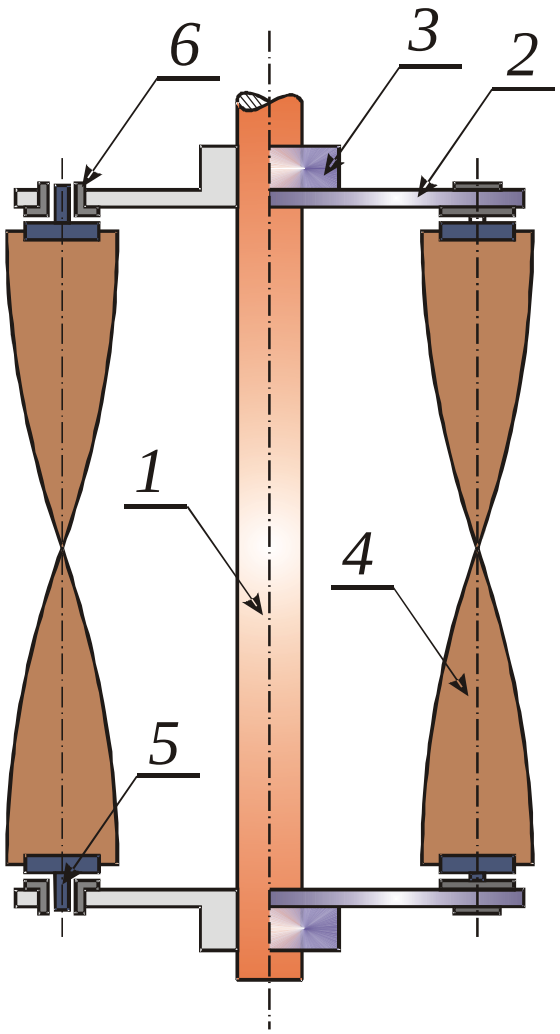
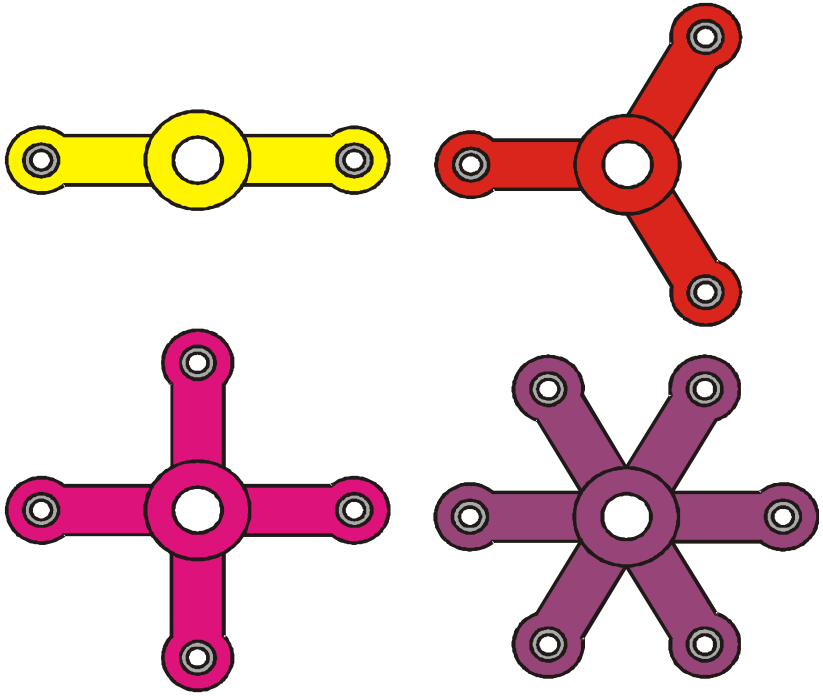


1. shaft
2. arm
3. hub
4. ribbon blade
5. ribbon mount
6. bushing



Patent

Granulation of fine-grained materials

4 dispensers and a mixing unit

Granulator drum

Pressure vessel with heating jacket

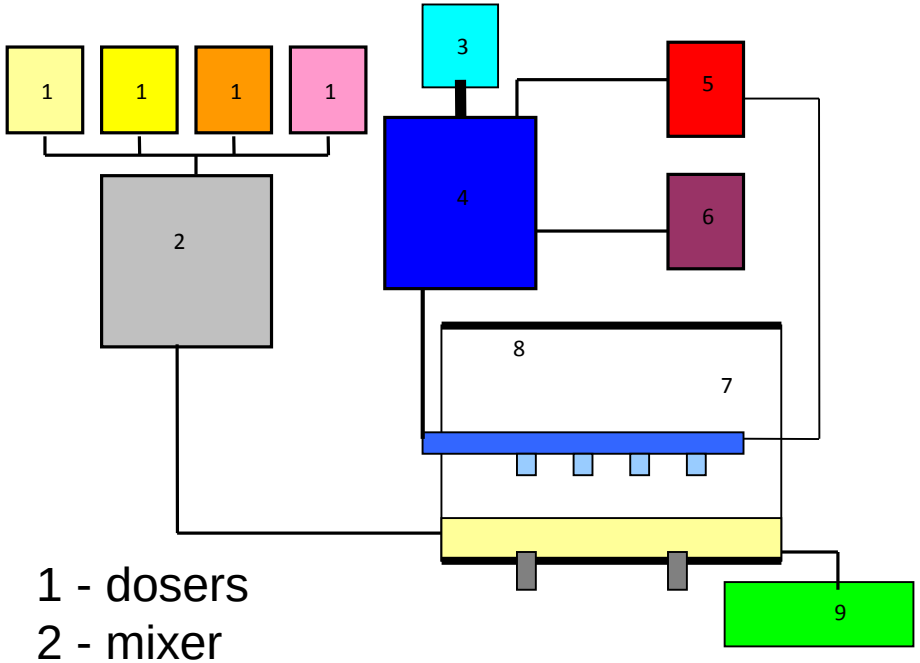
Semi-technical installation assemblies – 500kg/h

Fly ash

Fly ash granules

Semi-technical installation for testing the process of continuous drum granulation

The apparatus enables the achievement of research goals by regulating the following apparatus and process parameters:
- rotational speed,
- fill factor,
- residence time,
- tilt angle,
- drum length,
- nozzle outlet diameter,
- liquid flow rates
- wetting and air and their pressure
- temperature of the wetting liquid.



1 - dosers
2 - mixer
3 - engine
4 - pressure vessel with a water jacket
5 - compressor
6 - thermostat
7 - set of nozzles
8 - granulator drum
9 - sieves

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LIFE CYCLE ASSESEMENT

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Life Cycle Assessment - LCA

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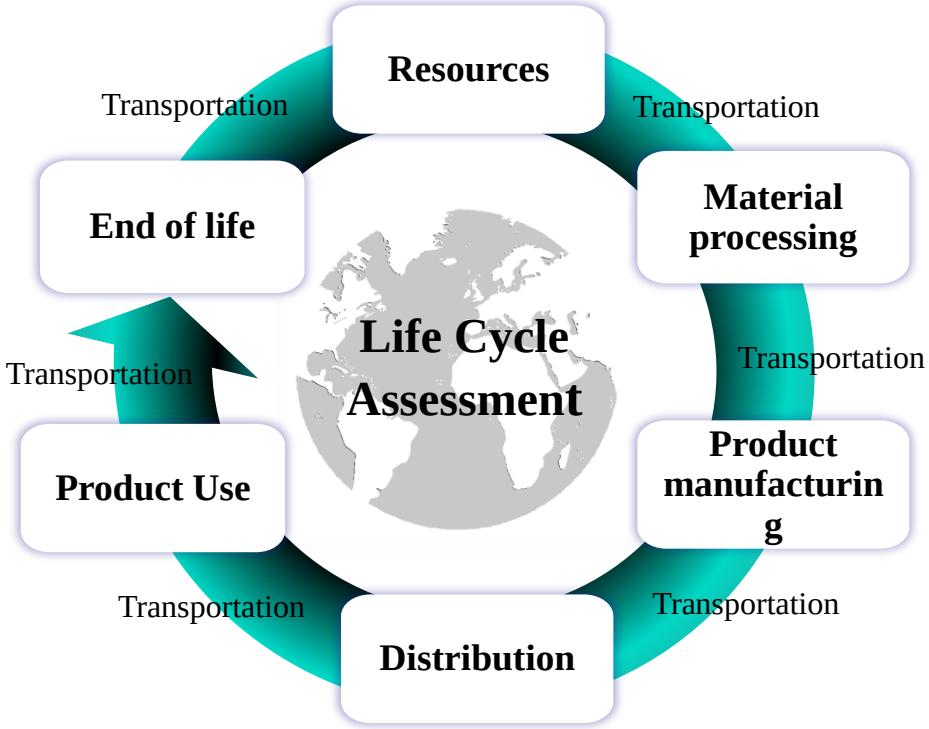
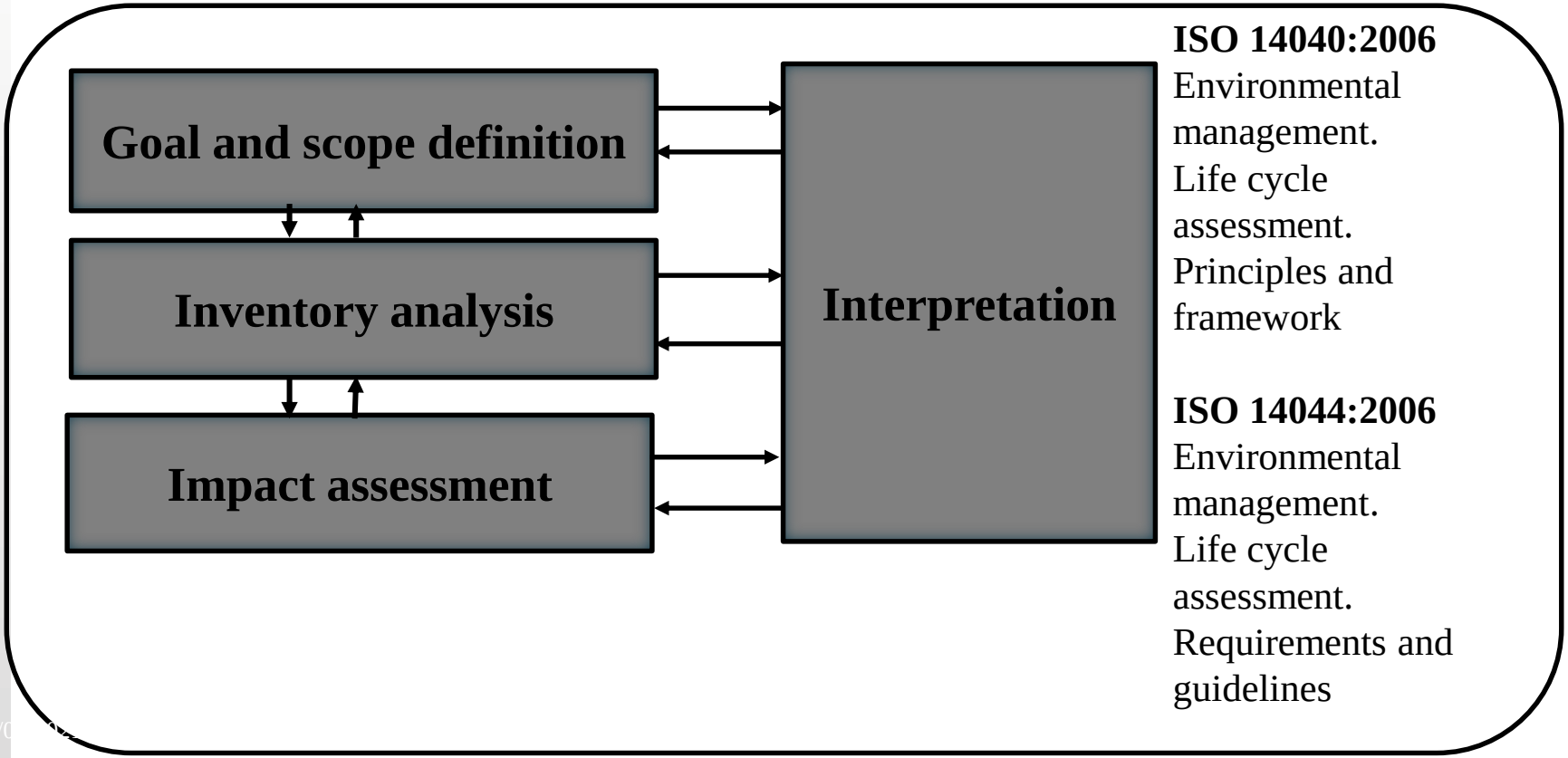
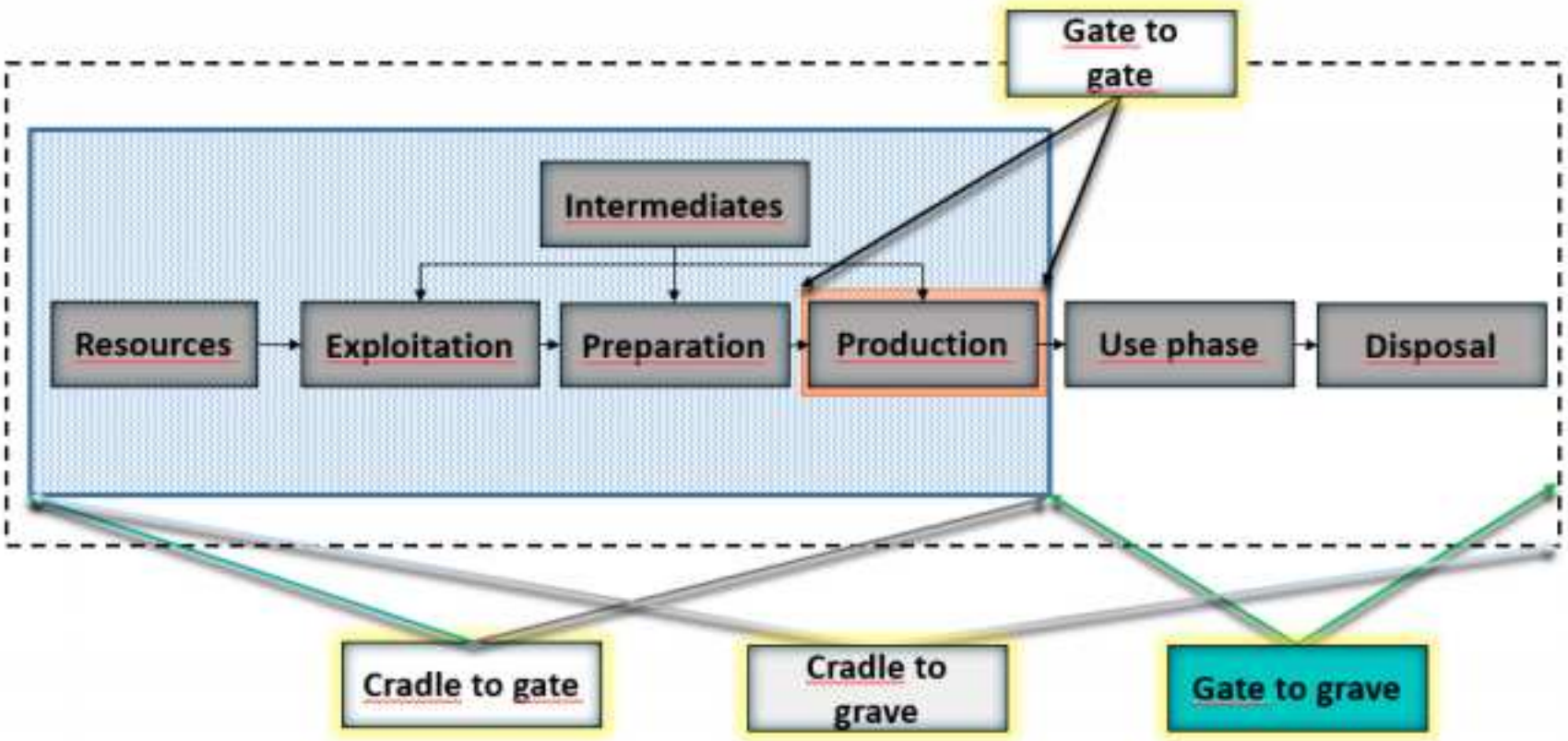
Life cycle assessment is technique to assess environmental impacts associated with all the stages of a product's life.



Life Cycle Assessment according to ISO standards framework

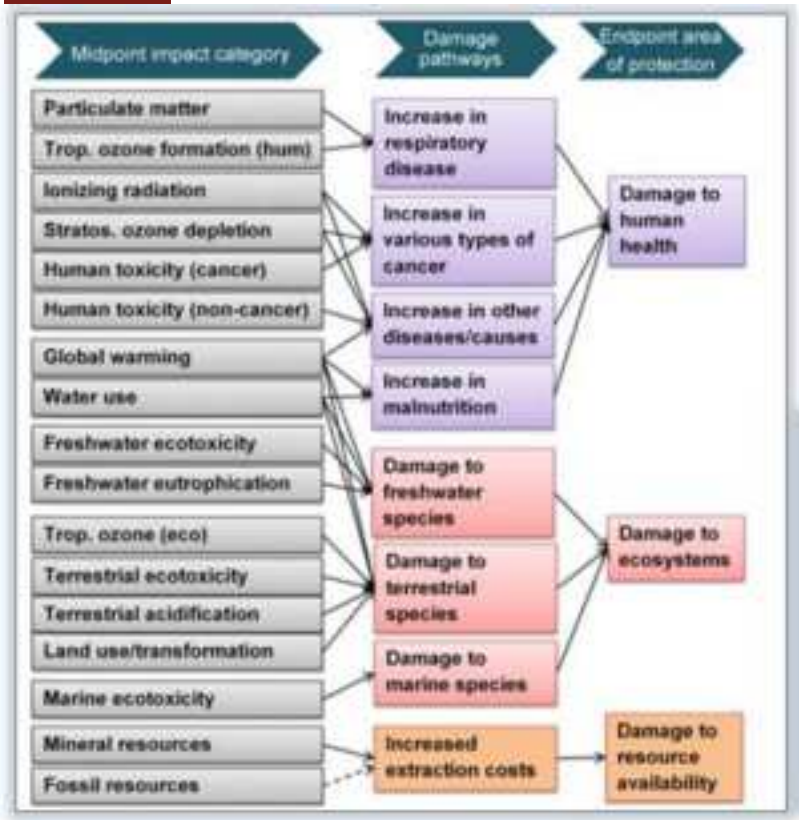


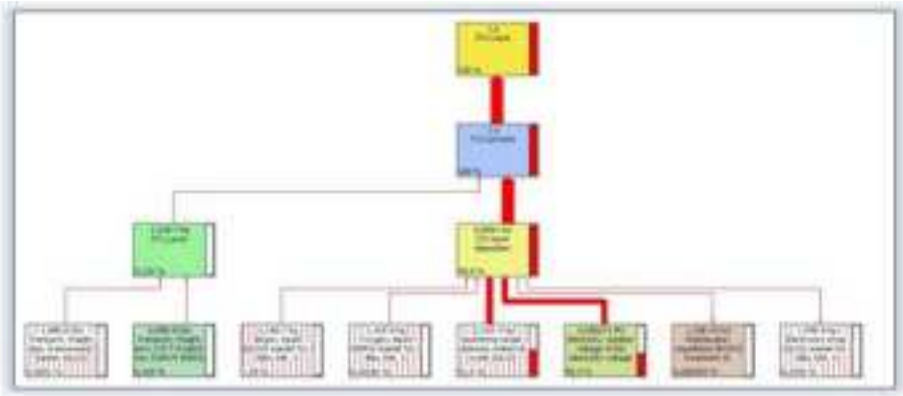
Scope of LCA

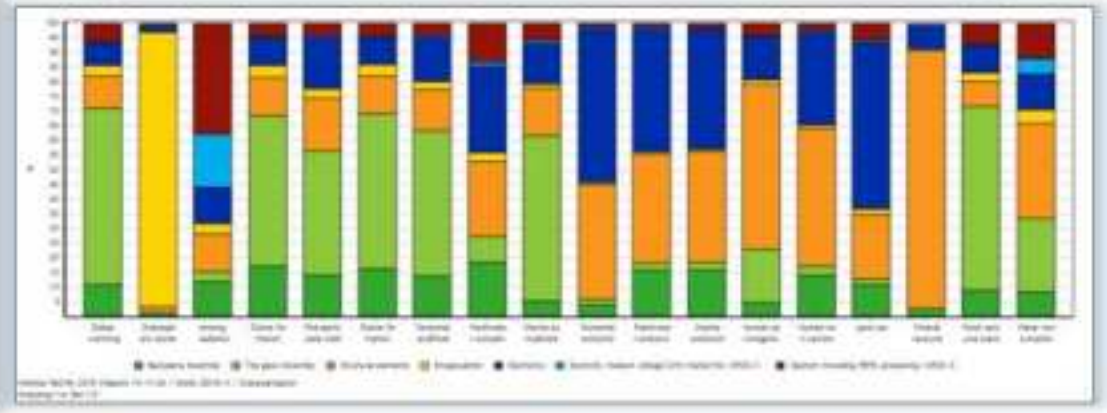


Cradle to Grave - the most popular range,
Cradle to Plant Gate,
Gate to Grave,
Gate to Gate if only manufacturing is considered.
The slide also shows the processes that will be considered in each of the scopes. The scope of the analysis in V4 Green Deal will be determined during the project activities

Environmental Models to be applied in V4 Green Deal : ReCiPe2016







One of the two environmental models that will be used in V4 Green Deal, ReCiPe2016, enables a detailed analysis of impact categories and damage categories (human health, damage to ecosystem and damage to resources availability).
The slide shows the impact categories for an example solution and a tree proces.

Environmental Models to be applied in V4 Green Deal: IPCC 2013 GWP 100a

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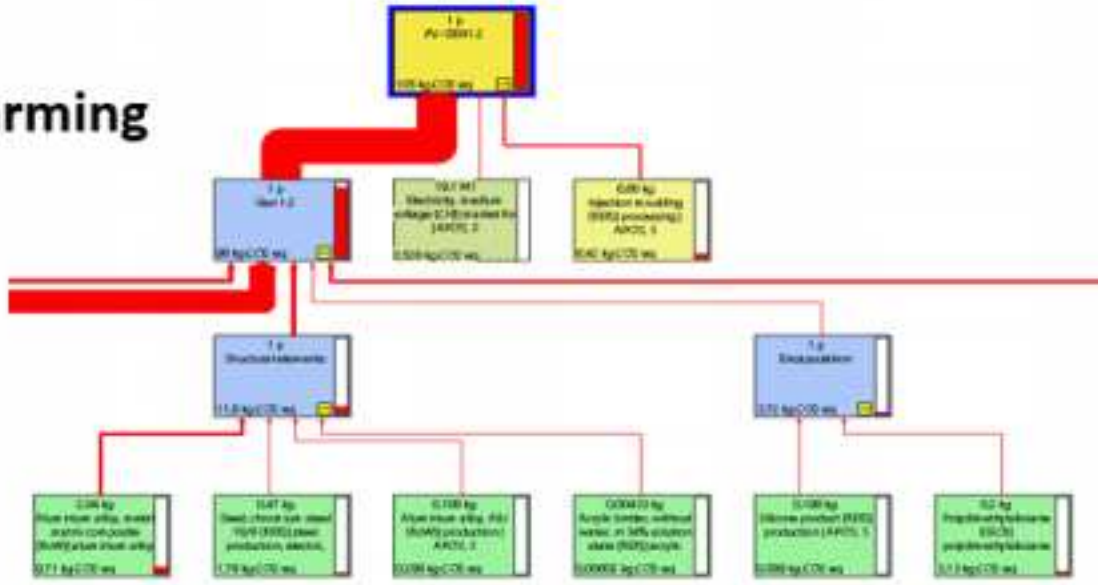
The IPCC 2013 GWP 100a methodology was developed by the Intergovernmental Panel on Climate Change.

This method lists the Global Warming Potential (GWP) factors with a timeframe of 100 years.



The second model to be used in the IPCC 2013 GWP 100a project, which only serves to define the carbon footprint. The solution is the single score, which makes it easy to compare our solutions with other technologies .

LCA will determine an environmental profile of the system expressed in one single score representing the environmental impact of a product to assess sustainability of the new technology.

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Faculty of Process & Environmental Engineering, Lodz

Acknowledgement

Green Deal strategies for V4 countries: The needs and challenges to reach low-carbon industry. The International Visegrad Fund's Strategic grate No.22120032 (1.1.2022 - 31.12.2023)