BECOOL

Brazil-EU Cooperation for Development of Advanced Lignocellulosic Biofuels

Development of advanced lignocellulosic biofuels from sustainable agricultural value chains – the BECOOL project

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RE-CORD

IEA T33 Workshop 2/12/2021 – Trisaia (Italy) & online

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BECOOL PROJECT AT GLANCE

- **12 Partners**
- **General objective:** Strenghten the EU-Brazil cooperation on advanced lignocellulosic biofuels
- **Twin Brazilian Project:** BioValue (20 Partners)

1 June 2017- 31 May 2022
5 M€ EU contribution
Coord. Prof. Andrea Monti (UNIBO)

ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA

biochemtex

btg biomass technology group

Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

crea Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria

ΚΑΠΕ CRES

DBFZ

etaflorence renewable energies

TNO innovation for life

IIASA International Institute for Applied Systems Analysis

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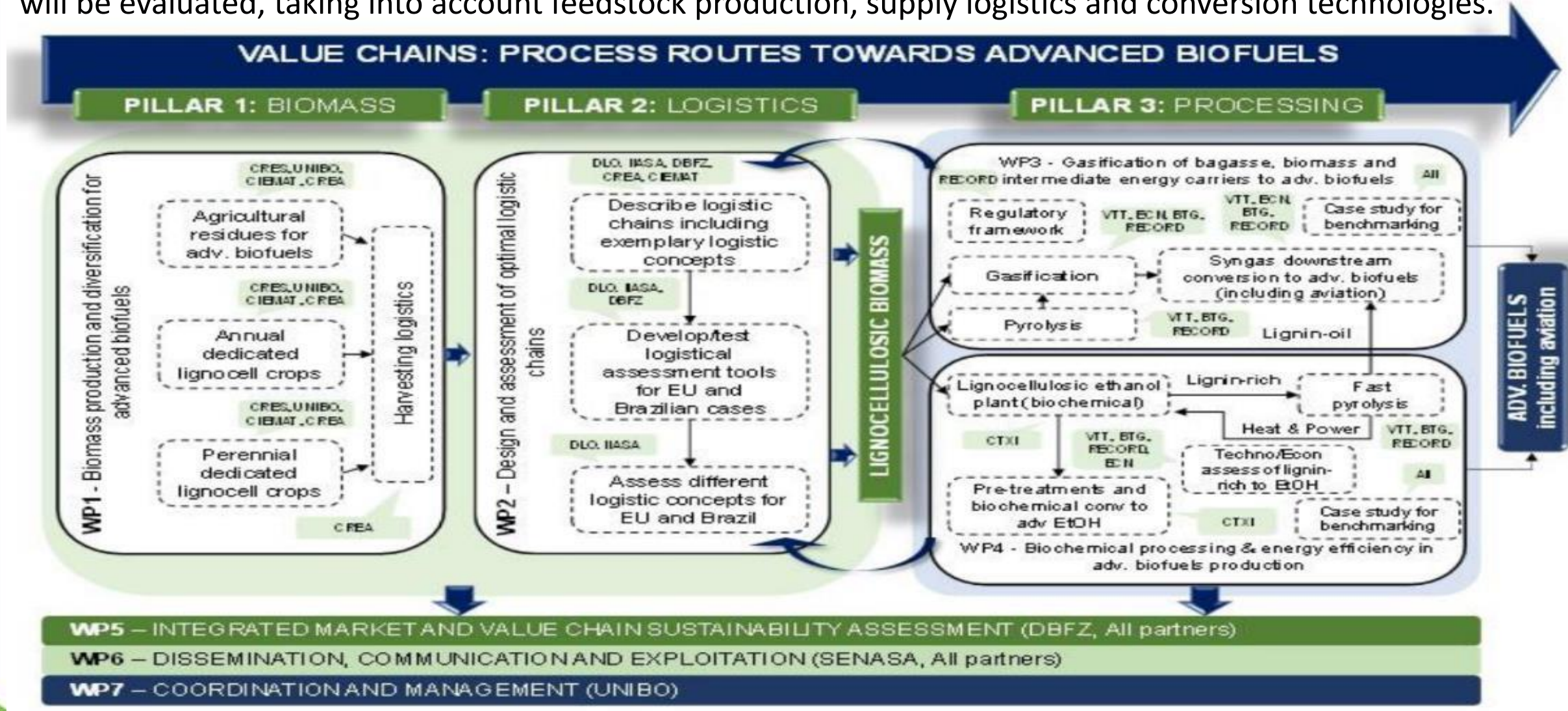
WAGENINGEN UNIVERSITY & RESEARCH

BECOOL concept & workflow

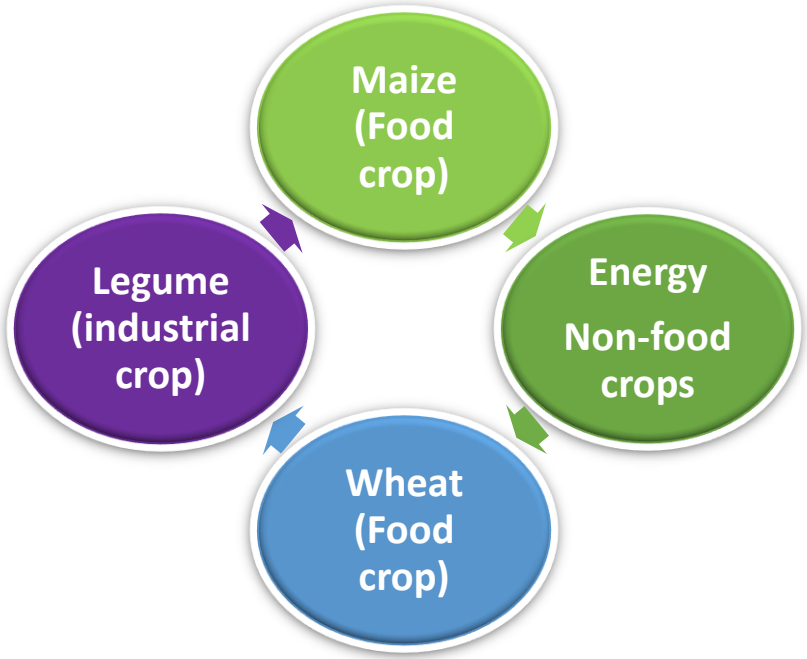
In the BECOOL project, credible, cost-effective and sustainable **value chains** for several biomass types will be evaluated, taking into account feedstock production, supply logistics and conversion technologies.



BECOOL Main results

Feedstock production

Among others, BECOOL investigated innovative **crop rotation systems** to diversify crops and increase the annual quantity of lignocellulosic feedstock without negatively impacting on food production, soil quality, and customary land uses.



Crop rotation systems: experimental sites in Italy, Greece, and Spain

- Cumulated biomass (feedstock) yields increased between 1.7 to 2.4 times when the energy / industrial crops were included in the rotation scheme.
- Cereal grain (food) yields were maintained within the regional levels.
- The innovative **crop rotation systems** allowed to increase and diversify the biomass production per unit of land without decreasing food.

Cropping system performance in quantitative terms

	2017									2018													2019													2020													2021													2022				
	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M
C	Maize																		Wheat																	Maize																								Wheat					
R1	Maize												Sunn Hemp						Wheat								Sunn Hemp									Maize																				Sunn Hemp						Wheat					
R2	Maize												Fiber sorghum						Wheat								Sunn Hemp									Maize																				Fiber sorghum						Wheat					
R3	Maize												Kenaf						Wheat								Sunn Hemp									Maize																				Kenaf						Wheat					
R4	Maize												Hemp						Wheat								Sunn Hemp									Maize																				Hemp						Wheat					
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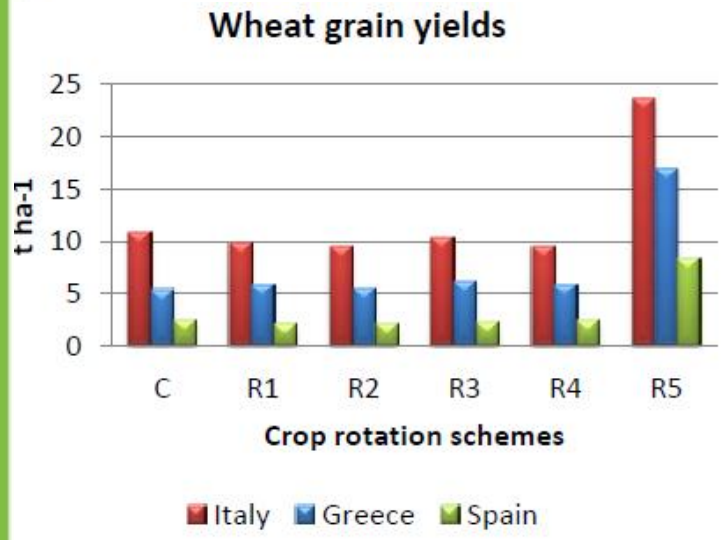
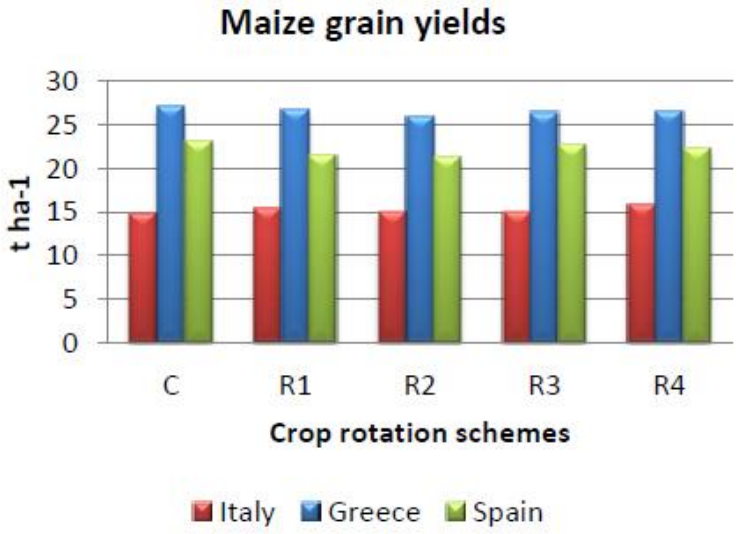
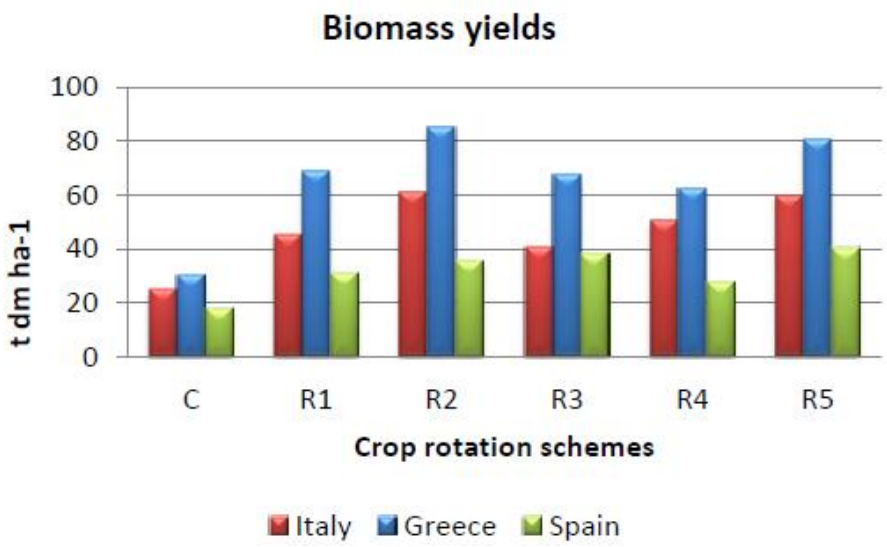


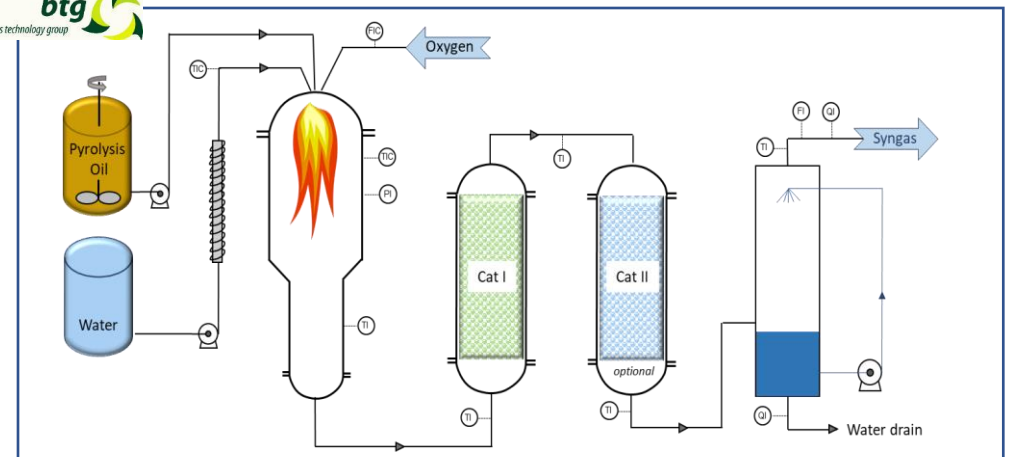




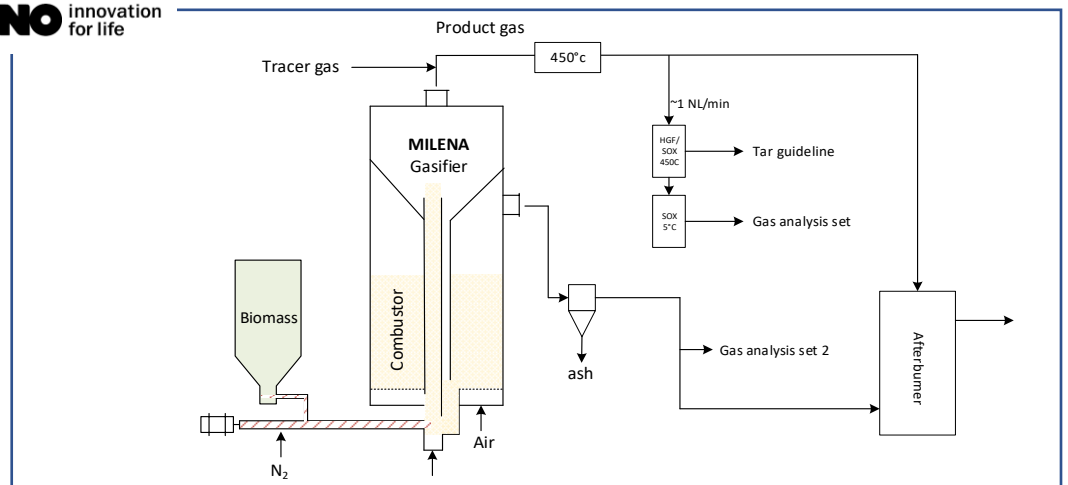
- Wheat grain yields were the highest in the R5 rotation in all environments
- Maize grain yields were not affected by the rotations in all environments
- R2 and R5 rotation resulted in highest biomass yields in all environments
- The observed trend are similar, hence analogous value chains schemes could be replicated in different regions

Gasification of bagasse, biomass and intermediate energy carriers to advanced biofuels

- Experimental data created for gasification of solid biomasses/liquid intermediates/ slurries to crude FT intermediate*
  - **Solid biomasses:** Milena gasifier (TNO) → C conversion rate 70-80% achieved
  - **Liquid intermediates:** BM conversion to FPBO, then gasification in EFG → gas quality virtually independent from feedstock
  - **Slurries:** biochar/FPBO
- Performance and costs for advanced biofuel value chains using AspenPlus models have been created and is on-going



Flowsheet of liquid fuel gasifier (catalytic/non-catalytic)

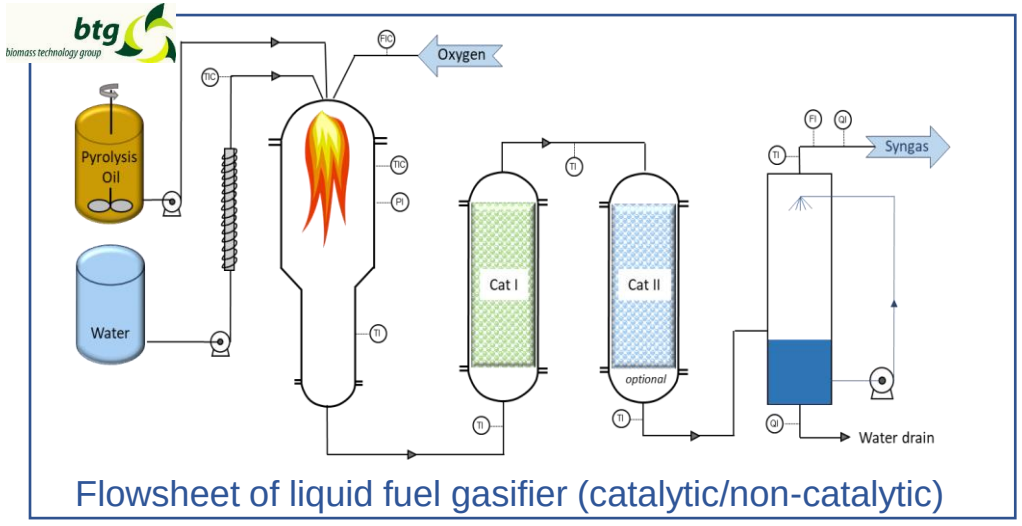


MILENA gasifier

* https://www.becoolproject.eu/news/

Gasification of bagasse, biomass and intermediate energy carriers to advanced biofuels

- New data** on fast pyrolysis of lignin residues into liquid fuels created
- Regulatory framework of standards for advanced biofuels from gasification have been gathered
- Collaboration with BioValue (BR)
  - Comparison of the experimental results on i) pyrolysis and ii) gasification of bagasse and eucalyptus
  - Catalyst development and testing
  - Comparison of analytical methods
  - Harmonisation of models



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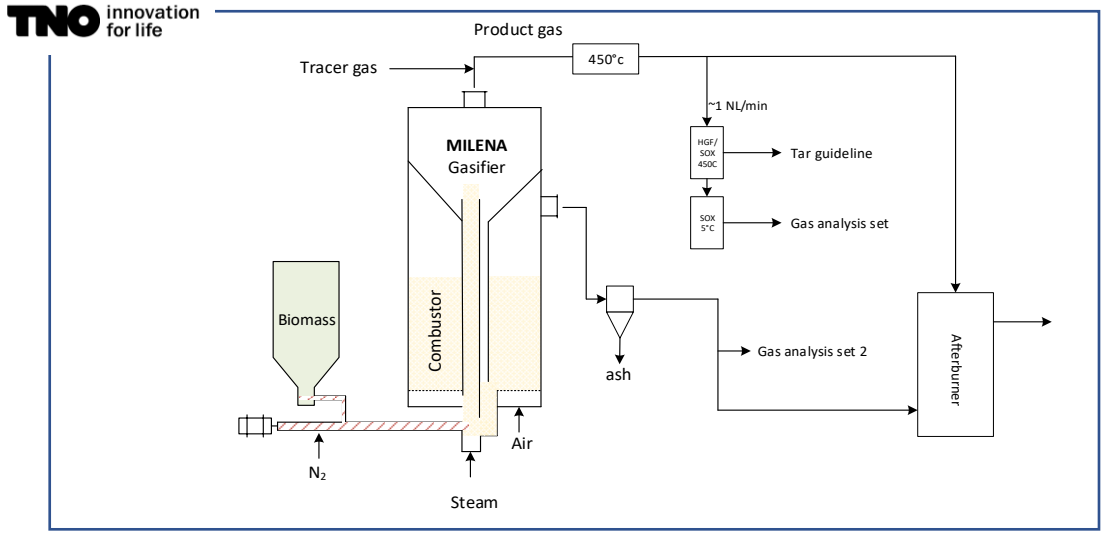
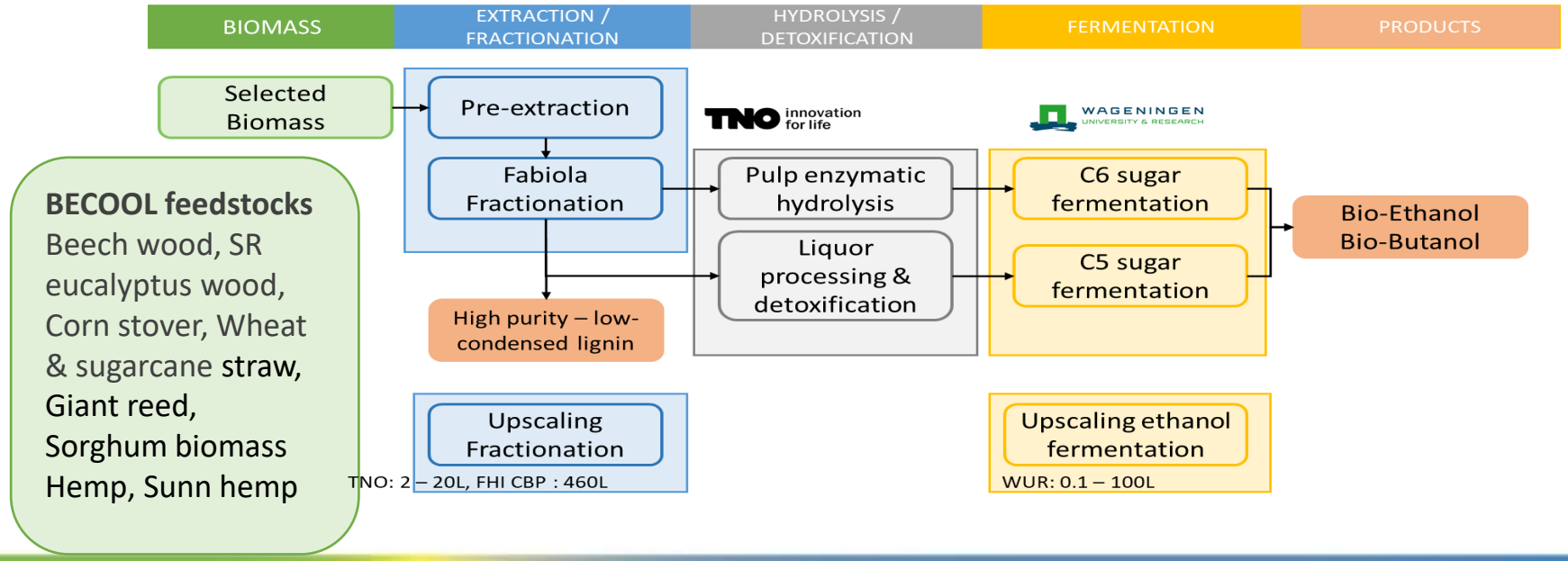


** Energy Fuels 2021, 35, 18, 14758–14769, https://doi.org/10.1021/acs.energyfuels.1c01719

BECOOL Main results – biochemical conversion

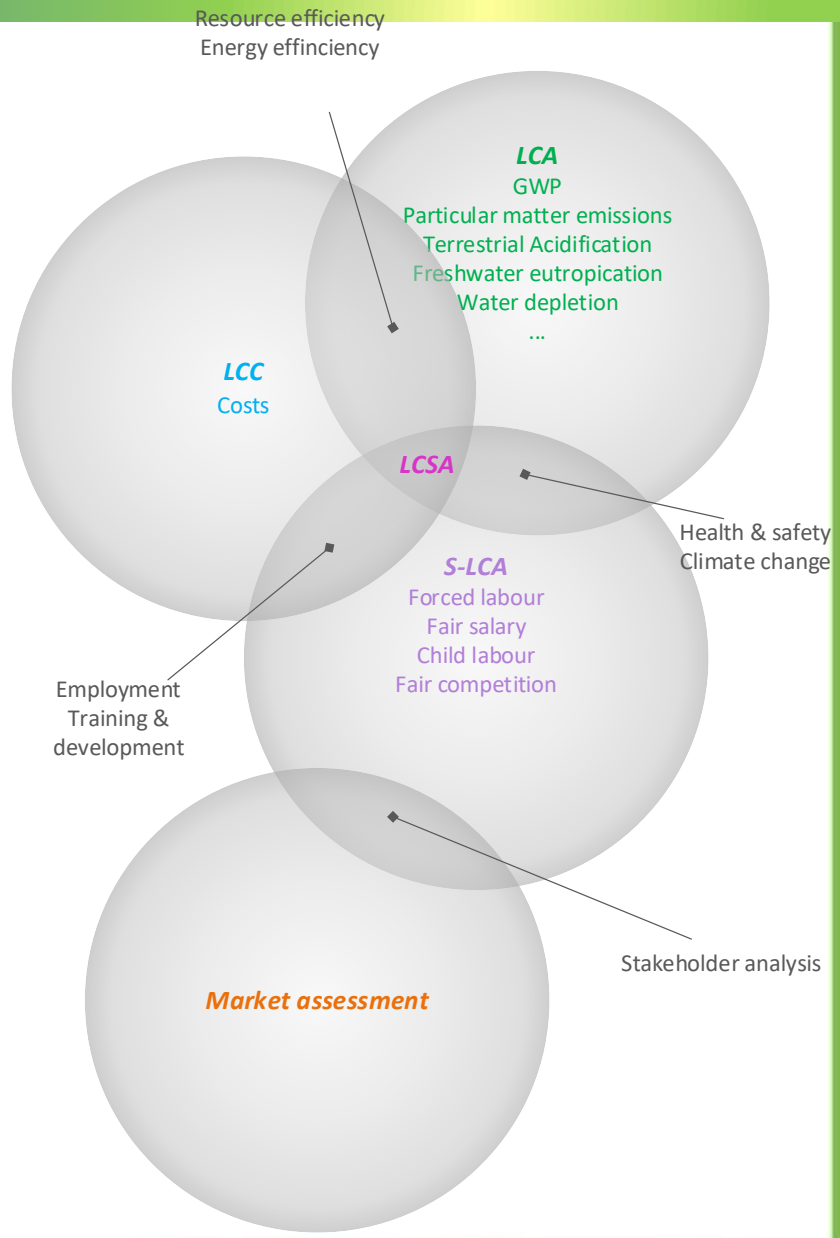
Biochemical conversion

- **Feedstocks screened throughout extraction+fractionation, hydrolysis and detoxification**: Realistic sugar yields quantified via Acetone organosolv fractionation (Fabiola™).
- **Ethanol fermentation of C5 and C6 sugars optimized** for beech wood and fermentability assessed for selected agricultural residues and herbaceous biomass.
- **Beech wood fractionation and C5/C6 sugar conditioning validated at pilot scale**; product sugars to be fermented in 10L reactor to validate scalability.



Integrated sustainability and market framework assessment

- Market framework assessment
  - Identification of factors of the macroenvironment of BECOOL supply chains, translating them into enablers and hindrances in order to be able to derive strategies (by using strategic management methods)
- Attributional LCA and LCC
  - Cost and GHG emissions associated with the production of syngas via (i) MILENA gasification and via (ii) EFG gasification of FPBO from fast pyrolysis
  - Extension of the system boundaries to include the downstream processes of FT-synthesis assuming a conversion efficiency from syngas to FT-product of 68%
- Consequential LCA
  - EU feedstock potential from abandoned agricultural land, double cropping and crops residues exceeds 200 M t dm at a production cost of 80 €/t dm (at farm gate).
  - There is a trade off between abandoned land available for perennials and cereal land available for double cropping and harvest of residues
- Interactions with BioVALUE
  - Harmonisation of methods
  - Development and assessment of BR-EU joint value chains



BECOOL – summary of achievements

- Leveraging innovative cropping systems, biomass for biofuel production can be obtained without negatively impacting on food production, soil quality, and customary land uses.
- Knowledge, know-how and models for conversion of several biomasses and intermediate energy carriers (FPBO e slurry) into syngas for liquid biofuel production, including aviation blendstock;
- Development of new fermentation technologies for advanced liquid biofuels and applied research to increase the energy efficiency of advanced biofuel processes.
- Holistic assessment of complete BECOOL value chains, including logistics, LCC/LCA/S-LCA & Market assessment

Partners

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etaflorence renewable energies

TNO innovation for life

IIASA International Institute for Applied Systems Analysis

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Thank you for your attention!

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