biotrend

experts in bioprocessing

Prospects for algae in high-volume applications: focus on bioplastics

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a4f algae for future

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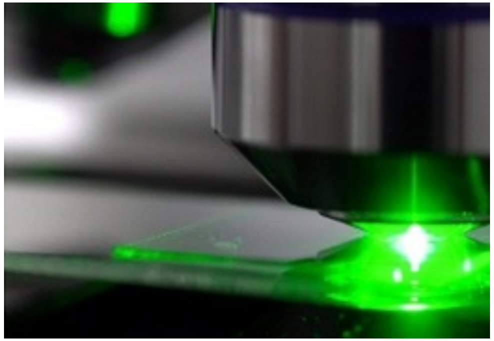
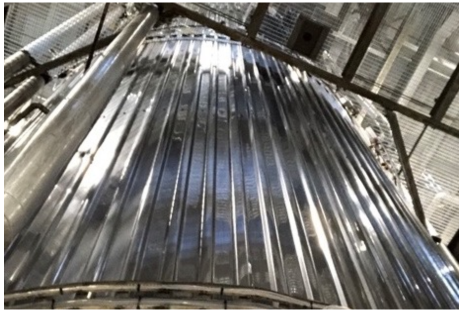
A4F Group

APPLIED R&D	CONTRACT R&D TECHNOLOGY SUPPLY	INDUSTRIAL PRODUCTION MANAGEMENT
		
		

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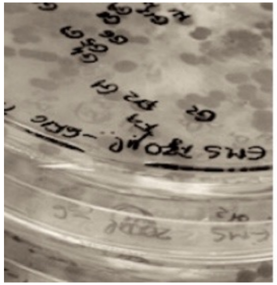
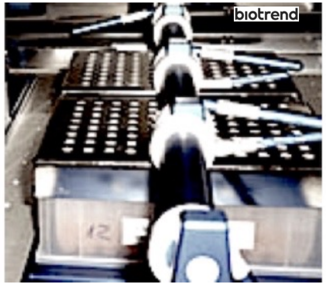
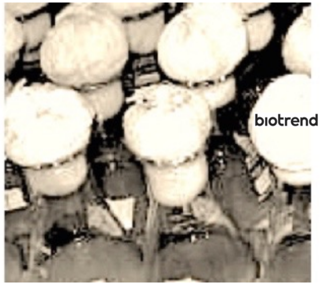
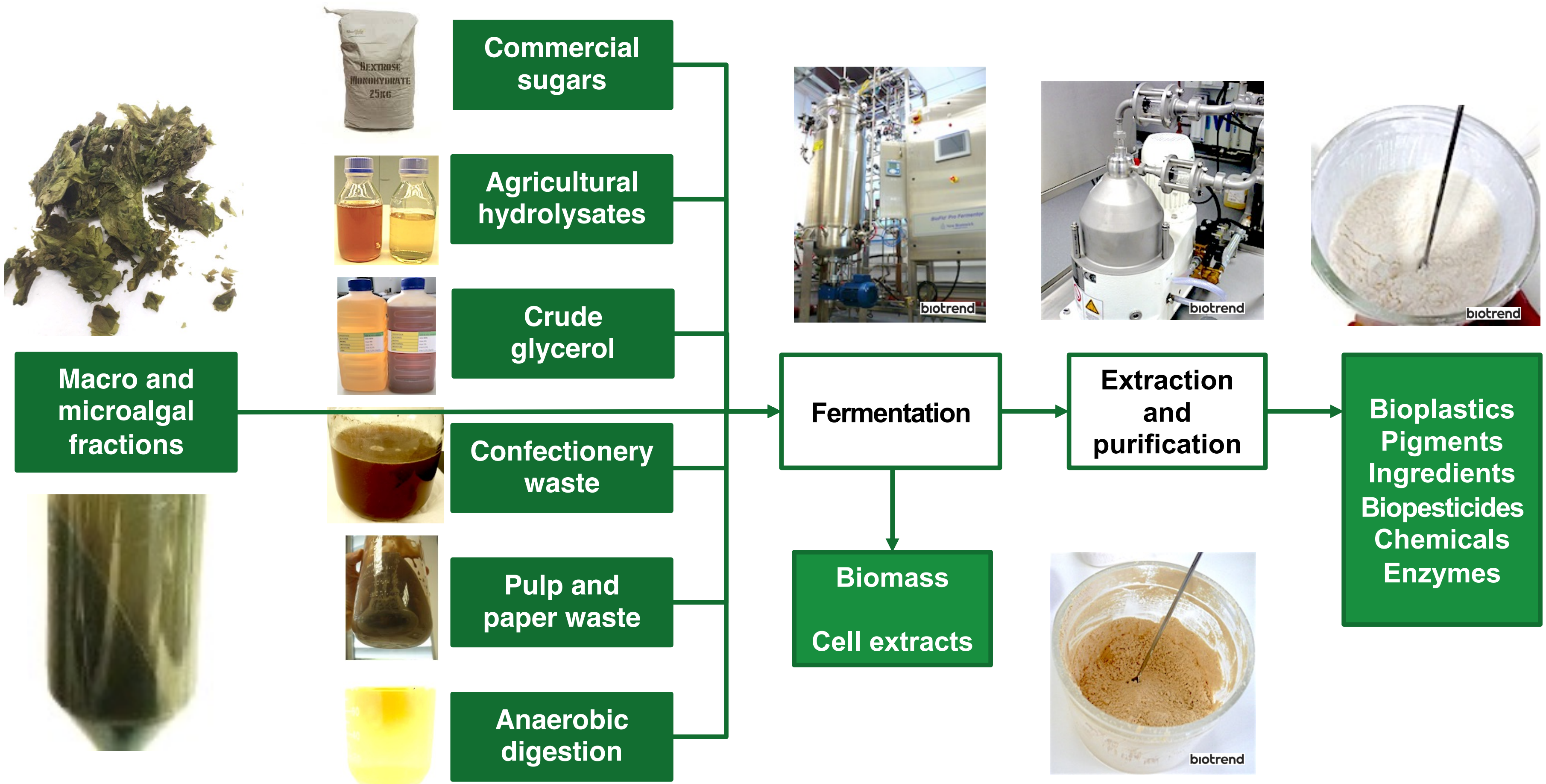
About







Real life materials



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Experienced with biodiversity

Bacteria:

Sphingomonas sp.
Pseudomonas sp.
Cupriavidus necator
Cupriavidus taiwanensis
Bacillus megaterium
Bacillus amyloliquefaciens
Alcaligenes latus
Sphyngopyxis macrogoltabida
Paraburkholderia sacchari
Hydrogenophaga pseudoflava
Pseudomonas citronellolis
Pseudomonas putida
Lactobacillus casei
Lactobacillus reuteri
Escherichia coli
Pseudoalteromonas sp.
Mycobacterium sp.
Vibrio sp.
Rhodothermus marinus
Rhodococcus sp.
Sulfitobacter sp.
Actinobacillus succinogenes
Basfia succiniciproducens
Corynebacterium glutamicum

Yeasts and Fungi:

Saccharmoyces cerevisiae
Kluyveromyces lactis
Schizosaccharomyces pombe
Aureobasidium pullulans
Cryphonectria parasitica
Yarrowia lipolytica
Torulaspora delbrueckii
Metschnikowia pulcherrima
Hanseniaspora uvarum
Kazachstania turicensis

Protists:

Schyzochytrium sp.
Aurantiochytrium sp.

Microalgae (heterotrophic):

Chlorella vulgaris
Chlorella sp.
Haematococcus pluvialis
Euglena gracilis

Resources

Highly qualified and experienced team

- Combined experience of +1000 fermentation runs at various scales
- Team with international experience
  [Portugal, The Netherlands, Canada, France, Germany, Switzerland, Brazil]



State-of-the-art facilities

- Process development, optimization and integration
- Process scale-up, de-risking and validation
- On-line monitoring and at-line analysis of metabolites (HPLC, GC-MS, etc.)

Algae for the Future

More efficient than any other crop

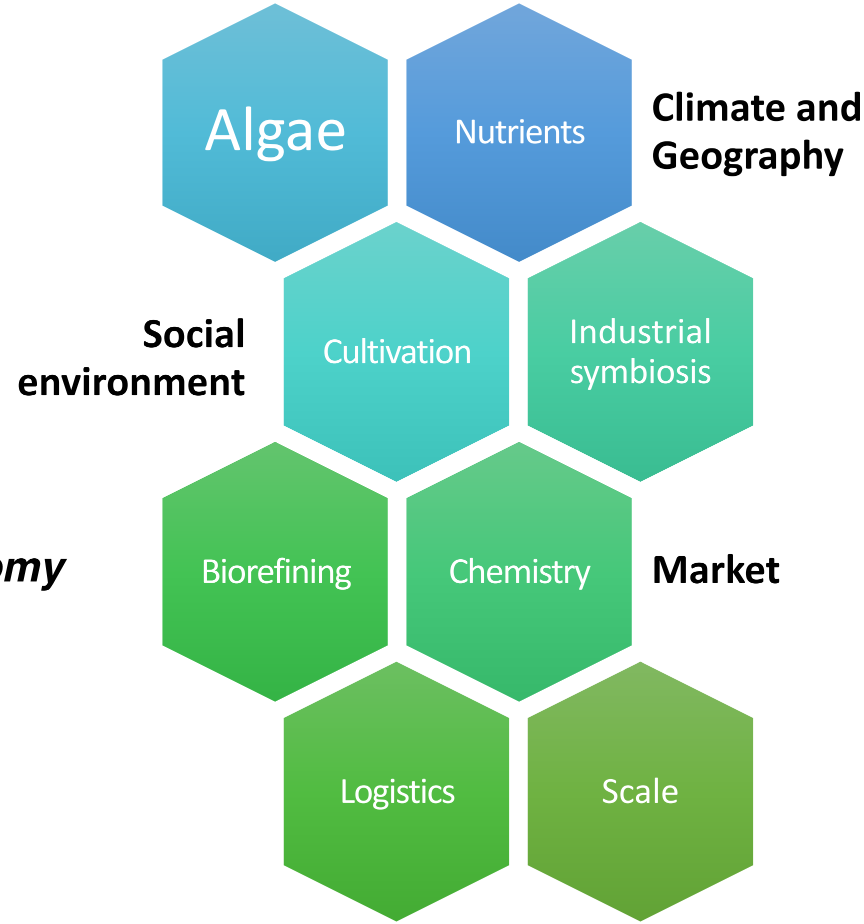
- Microalgae: 5.0 g/m^2.day protein
- Seaweed: 4.1 g/m^2.day protein
- Soya: 0.11 g/m^2.day protein

Algae cultivation is a technology

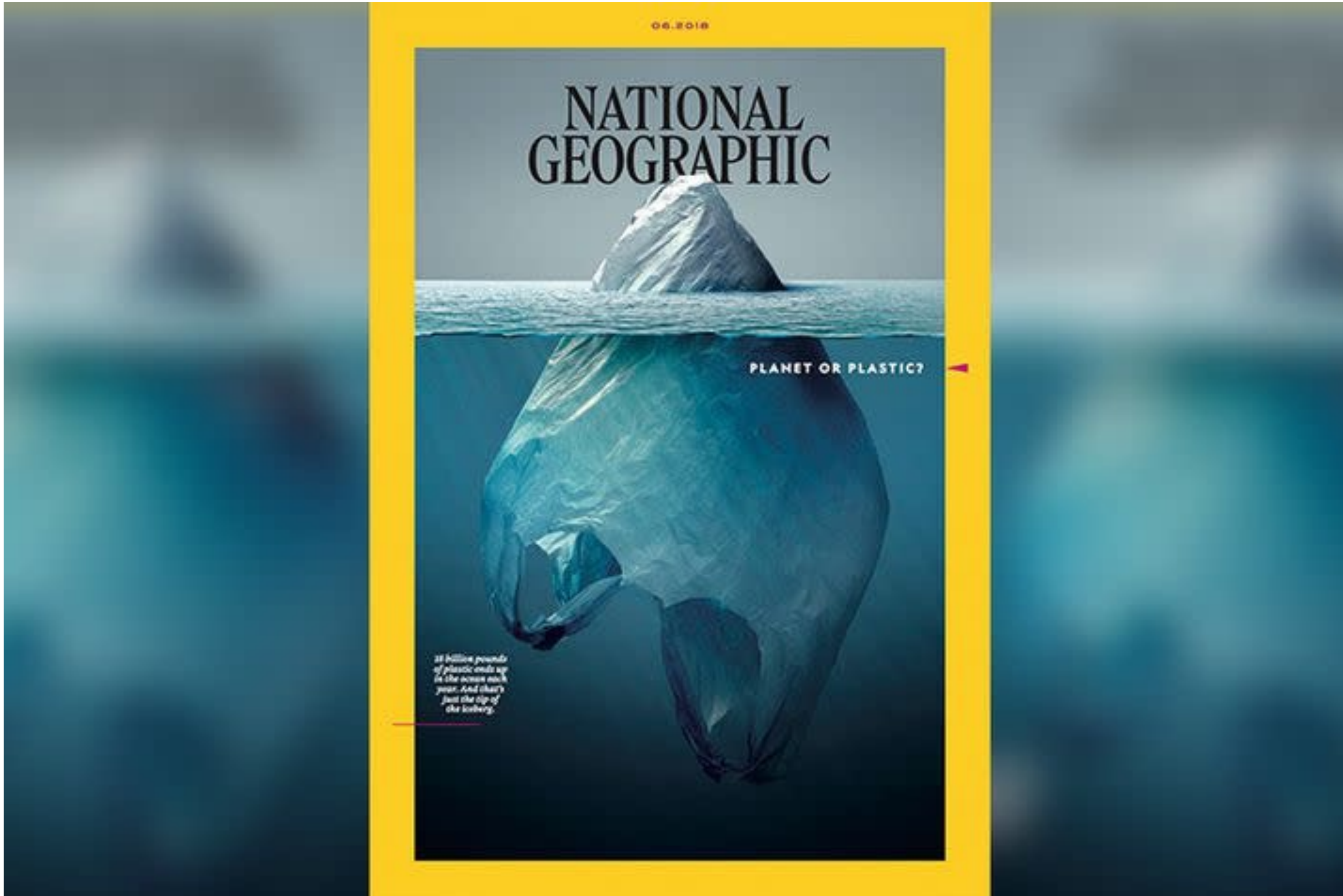
- Not an end itself but a means to an end.
- Enabling ***carbon neutrality*** and ***circular economy***

Technical, economic, feasibility and environmental and social sustainability

- Algae are a central piece of the puzzle, but the broader context needs to be understood

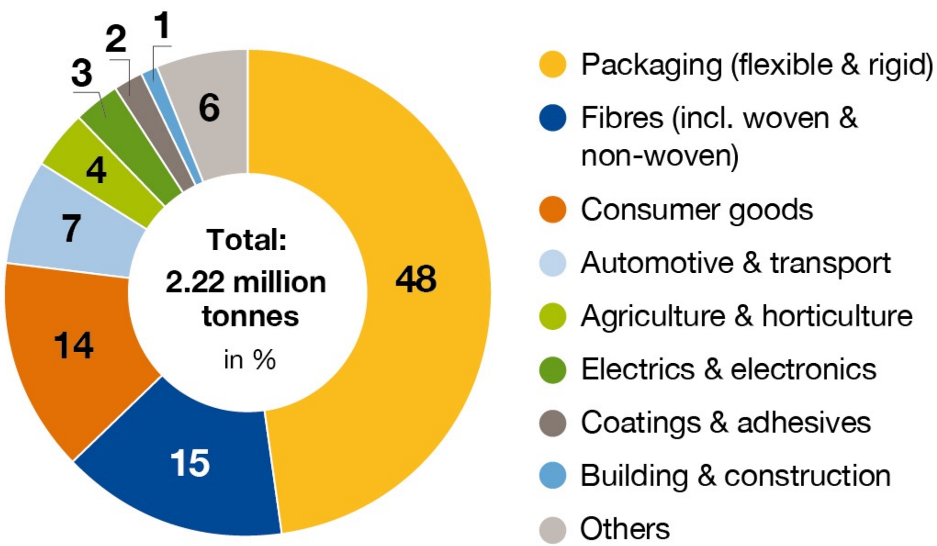


Algae for Bioplastics



Bioplastics

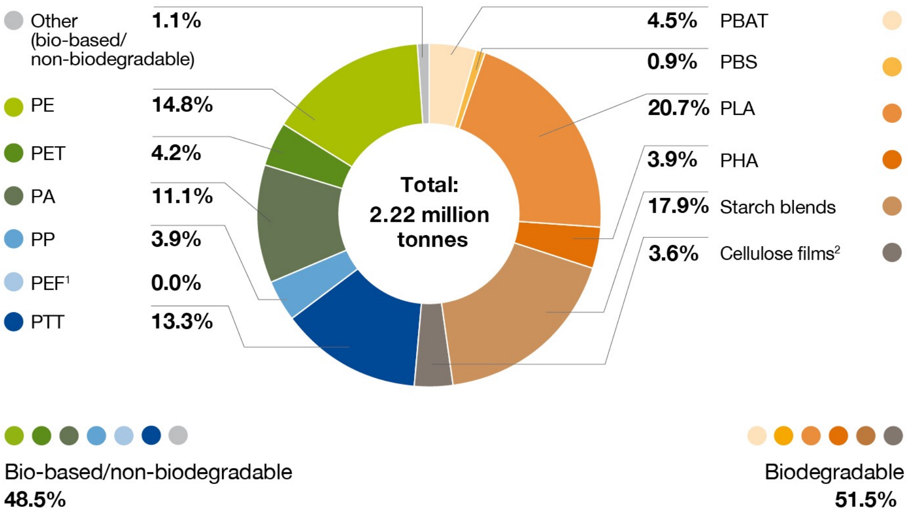
Global production capacities of bioplastics in 2022 (by market segment)



Source: European Bioplastics, nova-Institute (2022).
More information: **www.european-bioplastics.org/market** and **www.bio-based.eu/markets**

Bioplastics

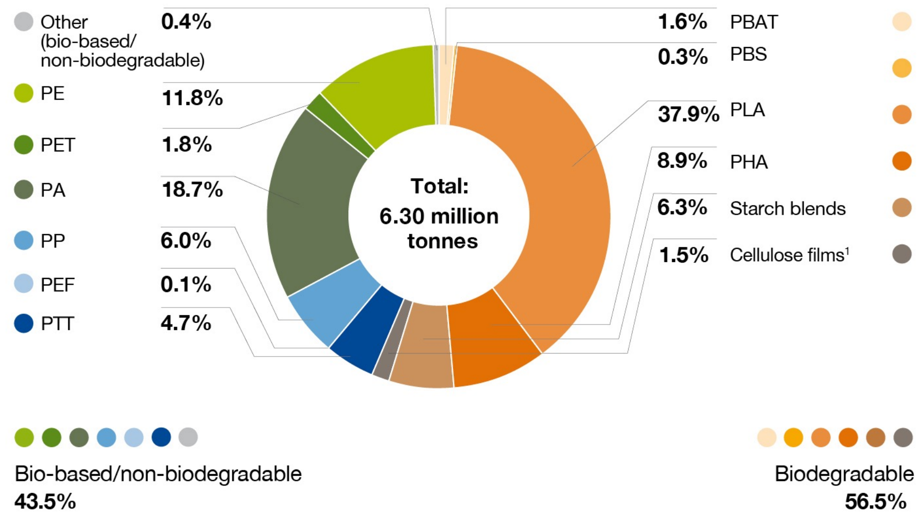
Global production capacities of bioplastics 2022
(by material type)



[1]PEF is currently in development and predicted to be available at commercial scale in 2023. [2]Regenerated cellulose films

Source: European Bioplastics, nova-Institute (2022). More information: **www.european-bioplastics.org/market** and **www.bio-based.eu/markets**

Global production capacities of bioplastics 2027
(by material type)



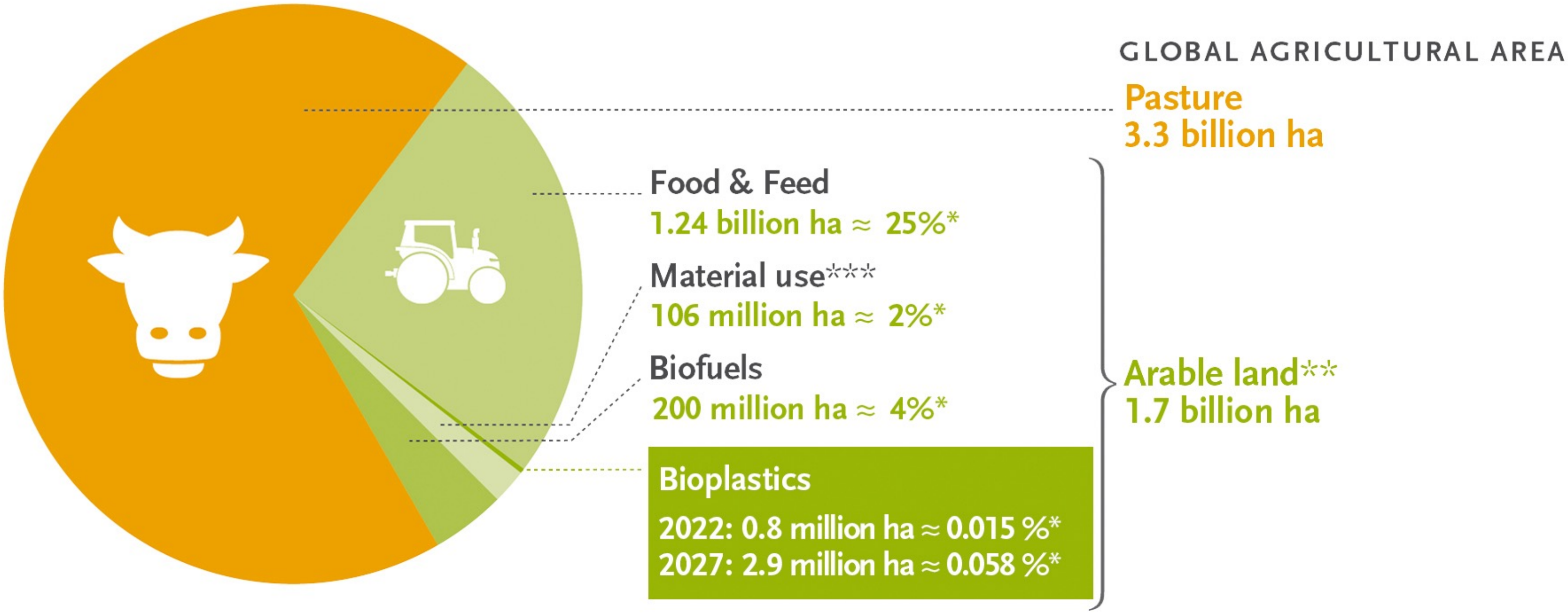
[1] Regenerated cellulose films

Source: European Bioplastics, nova-Institute (2022). More information: **www.european-bioplastics.org/market** and **www.bio-based.eu/markets**

Focus areas:

Starch blends:	397 ktonnes [2022] to 397 ktonnes [2027]	stagnant!
PHA:	86 ktonnes [2022] to 561 ktonnes [2027]	CAGR 45.5%!!!

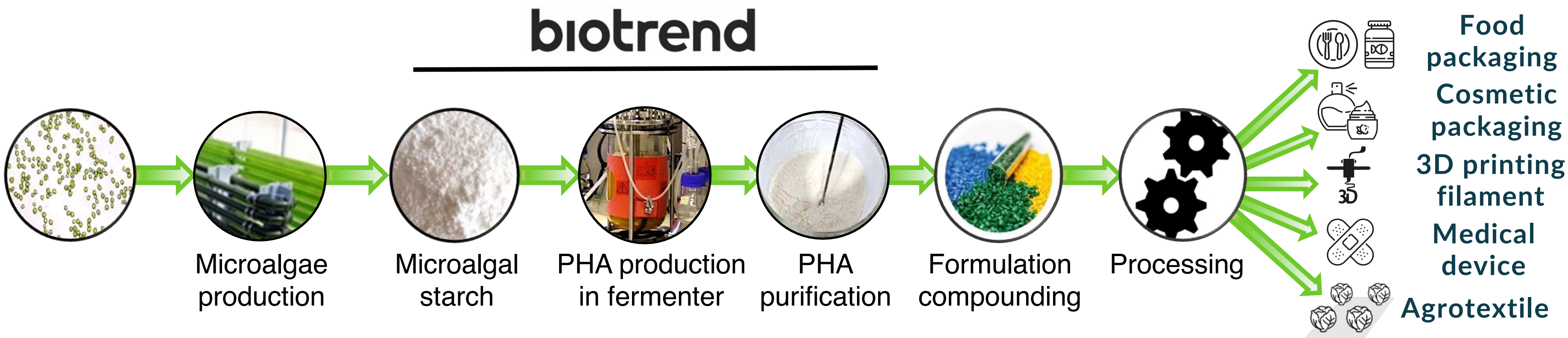
Land use estimation for bioplastics 2022 and 2027



Source: European Bioplastics (2022), FAO Stats (2020), nova-Institute (2022), and Institute for Bioplastics and Biocomposites (2019), University of Virginia (2016). ***Info: www.european-bioplastics.org***

**In relation to global agricultural area, ** Including approx. 1% fallow land, ***Land-use for bioplastics is part of the 2% material use*

Research



nenuPHAr

For a sustainable and European value chain of PHA-based materials for high-volume consumer products

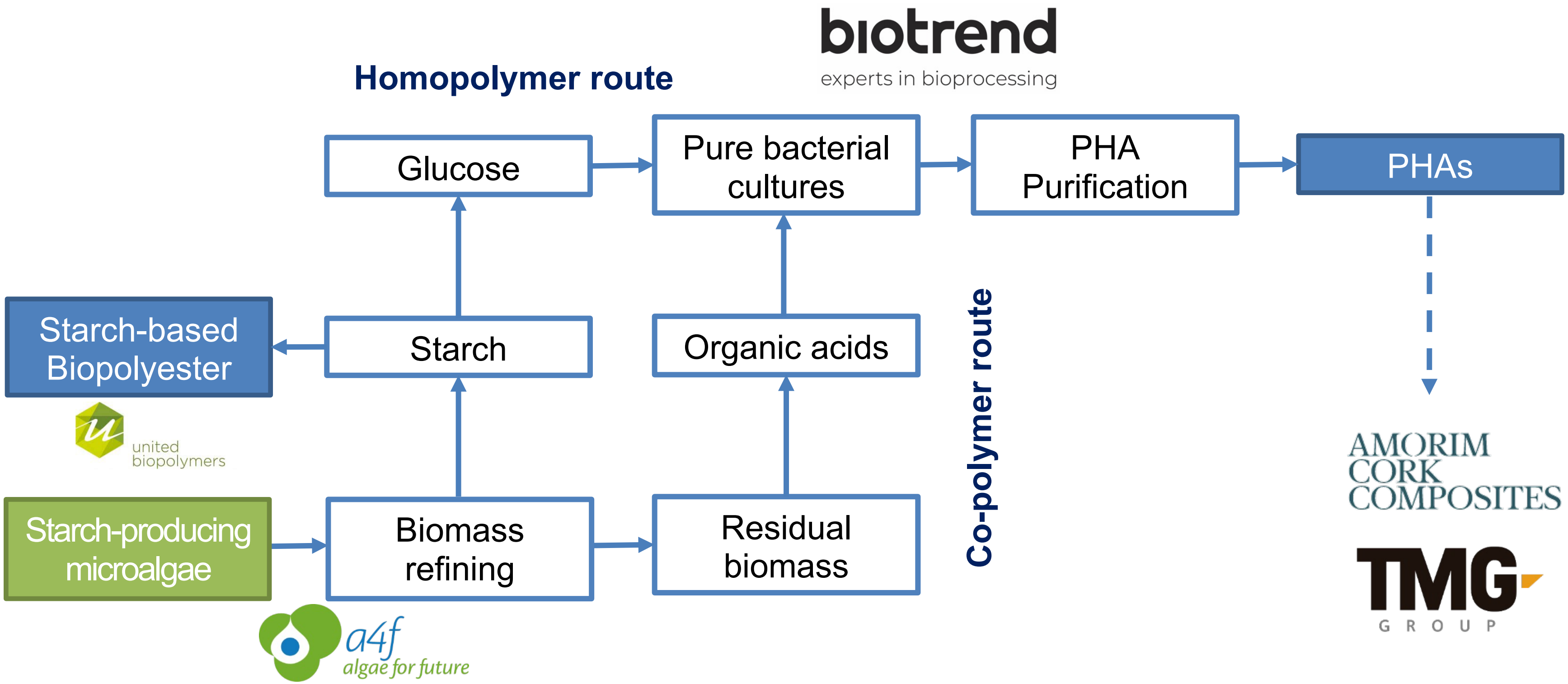
BBI JU contribution: €4.9 million, Research and Innovation Action

Duration: September 2020 – February 2024

This project has received funding from the Bio Based Industries Joint Undertaking (BBI-JU) under grant agreement No 887474. The JU receives support from the European Union's Horizon 2020 research and innovation programme and the Bio Based Industries Consortium.

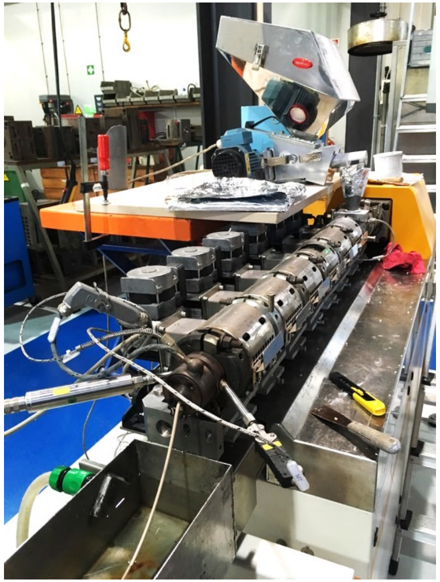
From research to demo

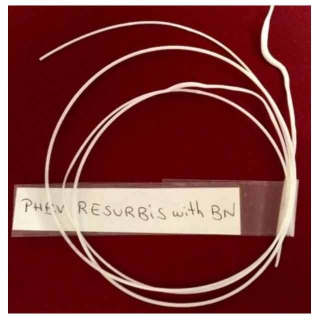
Investment in algae-derived biomaterials project [1.7 M€ A4F and BIOTREND combined]

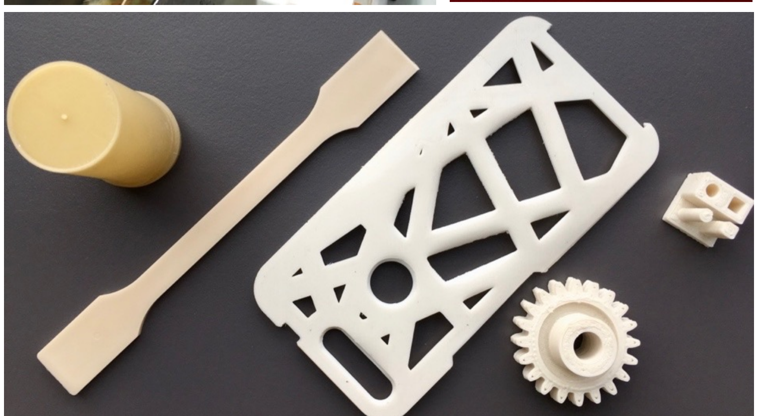


PACTO DA BIOECONOMIA AZUL
PRR Plano de Recuperação e Resiliência
REPÚBLICA PORTUGUESA
Financiado pela União Europeia NextGenerationEU

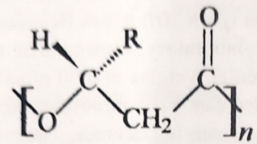
Modulating the properties







bacterial species as intracellular carbon and energy reserve materials (Anderson and Dawes, 1990; Dawes and Senior, 1973; Doi, 1990). The general structure for the PHA subset of β-linked PHAs is shown below. When R is methyl, the polymer is poly(3-hydroxybutyric acid), PHB.



A number of reviews on PHAs that describe biochemical aspects of polymer formation, structural variability, and properties have been published (Anderson and Dawes, 1990; Brandl et al., 1990; Doi, 1990; Gross, 1994; Steinbuchel, 1991; Steinbuchel and Valentin, 1995). An important benefit of many microbial polyesters is that they have been found to be biodegradable upon disposal (Abe and Doi, 1996; Molitoris et al., 1996; Doi et al., 1990).

Although the biochemistry of PHA (mainly PHB) biosynthesis has been the subject of much recent work (Byrom, 1994; Kidwell et al., 1995; Steinbuchel et al., 1995; Wieczorek et al., 1995), the mechanisms of polymer growth and control of chain molecular weight are not understood. Hence, rational methods for PHA molecular weight control other than our investigations into the use of polyethylene glycol (PEG) in culture media (Shi et al., 1996b; Ashby et al., 1997) have not been reported. However, the variation of PHA molecular weights remains of considerable interest.

Examples of work carried out to study molecular weight variation are as follows. PHB molecular weight was affected by the method of polymer isolation from cells. Neutral solvent extraction results in higher degree of polymer-

Our experience

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BUGWORKERS

Fungus chain

PHB 2 Market

BRIGIT

nenuPHAr 2

Bionanopolys

Commercial projects

Volatile

CAFIPLA

ELLIPSE

Macro and microalgal fractions

- Commercial sugars
- Agricultural hydrolysates
- Crude glycerol
- Confectionery waste
- Pulp and paper waste
- VFAs from AD

Fermentation → **Extraction and purification** → **Bioplastics**
Pigments
Ingredients
Biopesticides
Chemicals
Enzymes

Biomass

Cell extrac

SMART-Plant

INCOVER
Innovative Eco-Technologies for Resource Recovery from Wastewater

RECOURBIS

YPACK

Partners for applications

NOVAMONT

FERRERO

FIAT

CENTRO RICERCHE FIAT

CENTRO TECNOLÓGICO ITENE

AIMPLAS PLASTICS TECHNOLOGY CENTRE

DANONE ONE PLANET. ONE HEALTH

bio-mi SUSTAINABLE SOLUTIONS

ecodek®

united biopolymers

AMORIM CORK COMPOSITES

TMG GROUP

SABIOMATERIALS

CeNTI Centre for N… and Smart M…

Bioinicia Innovative Polymer Applications

Fraunhofer

TECNARO GESELLSCHAFT ZUR INDUSTRIELLEN ANWENDUNG NACHWACHSENDER ROHSTOFFE mbH

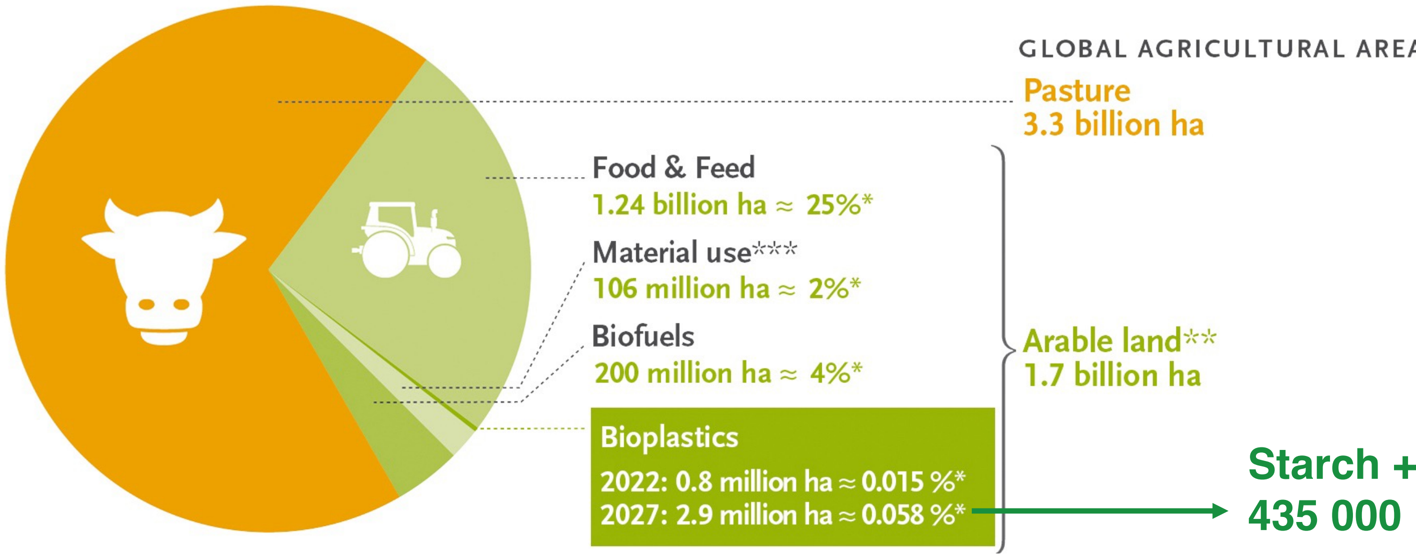
piep

DAREN LABS MATERIALS EXPERTS

kp

LINPAC® fresh thinking!

Algae for bioplastics



Starch + PHA ~15%
435 000 ha (arable)

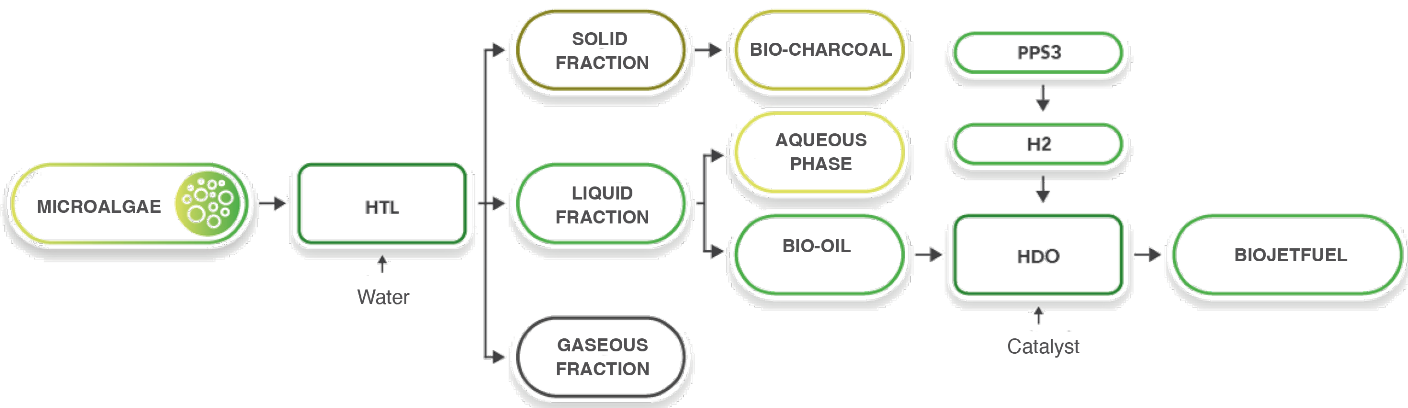
Microalgal production of starch: 10 ton/ha.year

Starch blends: 397 kton/year — 40 000 ha (non arable)
PHA: 561 kton/year
~ 2.8 million ton/year starch (for sugars) — 280 000 ha (non arable)

Total: 320 000 ha (non arable): from Arable to Non-Arable land, 25% Reduction of area

Doing our part

MOVE2LOWC



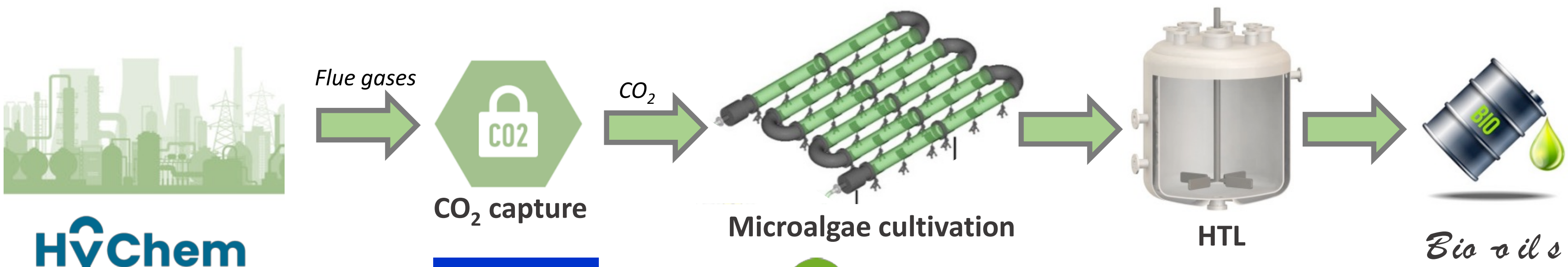
Coordinator: a4f algae for future

Cofinanciado por:
COMPETE 2020
PORTUGAL 2020
UNIÃO EUROPEIA
Fundo Europeu de Desenvolvimento Regional

Doing our part

CAPTUS

Construction and operation of a dedicated Demo facility.



HyChem Química Sustentável

novis BioBased Technology

a4f algae for future

circe

Application in sectors hard to electrify: aviation, maritime transportation, heavy-duty road transportation.

Large volume and bulk production of biomass, integrating circular economy concepts as access to low/negative cost nutrients.

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