European Commission

Life and Biological Sciences and Technologies as Engines for Bio-based Innovation

Sven Wydra, Presentation Nov 15, 2021

Mobilizing financial investment into bioeconomy related innovation in the Central and Eastern European countries

Financing bioeconomy projects - Adding value to primary production.

Studies on support to R&I policy in the area of bio-based products and services

Research and Innovation

Background and Purpose of the study

Project

- Tender study for the European Commission, DG Research & Innovation, 12/2019-02/21, commissioned by Fraunhofer ISI, btg, ICONS

Key research questions

- **Which life and biological sciences and technologies are required** as main enablers and engines for innovations for the bio-based sectors?

⇨ *identify and characterize the 50 most significant innovations*

- **How will the EU and its member states be able to realize their potential for economy and society**?

Methodology

Literature screening, screening of funded projects, patent & publication analysis, interviews, online survey, 3 workshops,,....

Top50 innovations: Scope and selection criteria

Scope

- **Life and biological sciences** as main enablers of bio-based innovation
  - life, biological and digital technologies that **enable** bio-engineering and production
  - **use** of those technologies **to produce goods and services**
- **Agricultural, industrial, marine and environmental** innovations
  - **Excluded:** energy, pulp/paper, wood and food as such, health biotechnology, biological medicines

Selection criteria

- **High impact** expected for **knowledge generation, economy, environment, society, contribution to SDGs**
- **Time horizon 5-20 years**; **TRL 3 to 7 in 2020**
- **Well-balanced portfolio**, cover the complexity and potential of this area

Top50 innovations: Field Cross-cutting technologies

Analytical techniques and bioprospecting	Design and engineering of biomolecules for desired functions	Novel industrial production concepts
Screening biodiversity	Macromolecular design	Novel microbial cell factories
-omics technologies	Multi-enzyme biocatalysis	Engineering microbial consortia
Analysing microbial consortia	New enzymes	Microbial Electrosynthesis
Lab-on-a-chip		
Biosensing		
Digital technologies	**Design and engineering of biological systems, cell factories; synthetic biology**	**Enabling bio-based production at industrial scale**
FAIR principle for databases	Precision genome editing	Optimising biorefineries
Deep Learning	Synthesis and assembly of long DNA fragments	Biorefineries for new feedstocks
Computational protein design	Modular cloning systems	Reactor design and process monitoring
Computational cell factory engineering	Minimal cells	Cell heterogenity
Process models	Expansion of the genetic code	Stress-tolerant production organisms

Top50 innovations: Field Innovation areas, solutions to challenges

Sustainable exploitation of novel feedstocks	Contributions to sustainable agriculture	Efficient and sustainable industrial production and products with minimised environmental impact
Novel feedstocks	Crop improvement targeting genome and epigenome	Resource- and energy efficient bioprocesses
Using side and waste streams	de novo domestication	Carbon-neutral bioprocesses
Supply and pretreatment of novel feedstocks	Asexual reproduction of seeds	CO_2-based chemicals
	Increasing and maintaining soil fertility	Climate-gas mitigation of microbial activities
	Novel farming concepts	Biodegradable plastics
	Novel protein sources	Plastic degrading enzymes
Bio-based intermediates, materials and product groups	Health and well-being	
Smart drop-ins	Health-promoting ingredients	
Dedicated bio-based chemicals	Novel antimicrobial agents	
Bio-based materials	Probiotic sanitation strategies	
Bio-functional materials	Veterinary DNA vaccines	
Novel algae products		

Top 50 innovations – maturity level 2020 and 2030 - Examples

Innovation	Lab scale	Application-oriented R&D, pilot	Scale up demonstration	Fully implemented, market	Broad use
Expansion of the genetic code	2020	2030			
Minimal cells					
Microbial Electrosynthesis					
Lab-on-a-chip					
New enzymes					
Engineering microbial consortia					
Reactor design and process monitoring					
Novel antimicrobial agents					
Novel farming concepts					
Process models					
-omics technologies					
Biodegradable plastics					

Top 50 innovations - factsheet example

01 Screening biodiversity

INNOVATION DESCRIPTION

In order to detect novel organisms, variants of biomolecules, biomaterials and metabolic pathways with interesting properties fast and efficiently, novel sources of biodiversity are sampled and screened with advanced technologies, using various detection methods and machine and deep learning algorithms. Novel sources are e.g. marine environments, microbiota, endosymbionts, in silico bioprospecting of databases. Technologies comprise e.g. high-throughput screening, cell-free expression systems, microfluidics. Detection methods are e.g. fluorescence activated cell sorting, mass spectrometry, nuclear magnetic resonance, colorimetric assays.

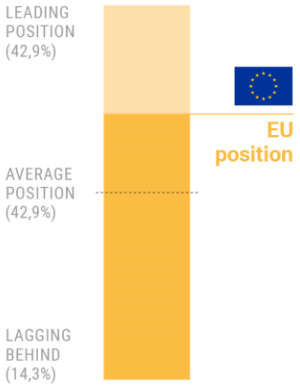
ILLUSTRATIVE EXAMPLE

Advanced high-throughput screening strategies are applied to discover e.g. new enzymes which can convert a given chemical substance: Microfluidic chips are used to generate thousands of droplets of picoliter volume per second. Each droplet functions as a reaction chamber and contains an enzyme variant and substrates. If an enzyme variant can convert the substrate, this is indicated by fluorescence or colour of the reaction product. Fluorescing or coloured droplets are sorted, and the enzyme contained in each coloured droplet is characterised further. More than 100 million enzyme variants can be screened per day in this way.

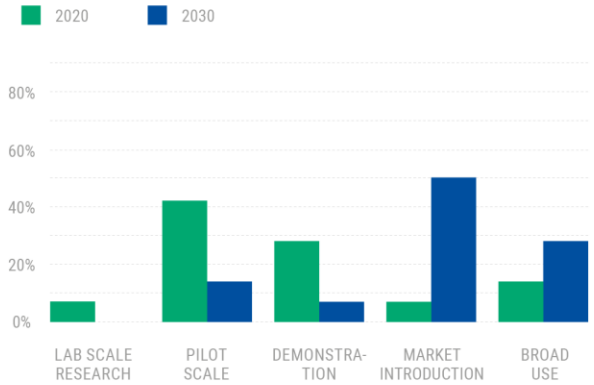
PRIORITY ISSUES

R&D in interdisciplinary cooperation is required to develop novel detection methods, not relying on fluorescence or colour, to implement screening systems with real-life selection conditions, and to use machine and deep learning. Especially sampling of extreme environments requires costly expeditions and equipment.

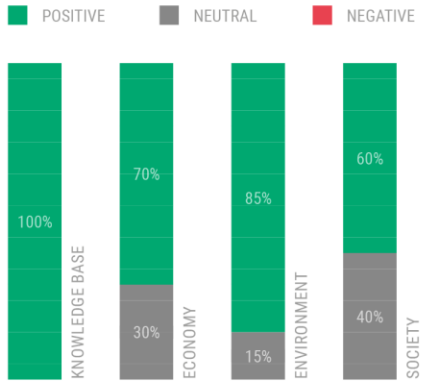
INTERNATIONAL COMPARISON



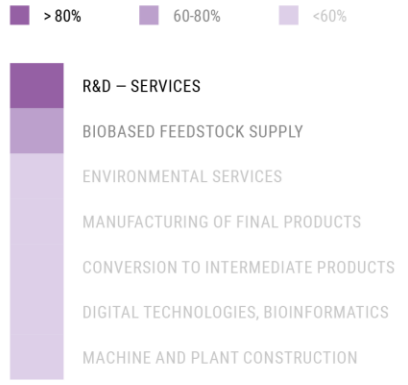
MATURITY LEVEL 2020/2030



EXPECTED IMPACT



IMPACT ON INDUSTRIAL SECTORS



CONTRIBUTION TO SDGs

REFERENCES

Ngara, Tanyaradzwa Rodgers; Zhang, Houjin (2018): Recent Advances in Function-based Metagenomic Screening. In Genomics, proteomics & bioinformatics 16 (6), pp. 405–415. DOI: 10.1016/j.gpb.2018.01.002. | Zeng, Weizhu; Guo, Likun; Xu, Sha; Chen, Jian; Zhou, Jingwen (2020): High-Throughput Screening Technology in Industrial Biotechnology. In Trends in biotechnology. DOI: 10.1016/j.tibtech.2020.01.001

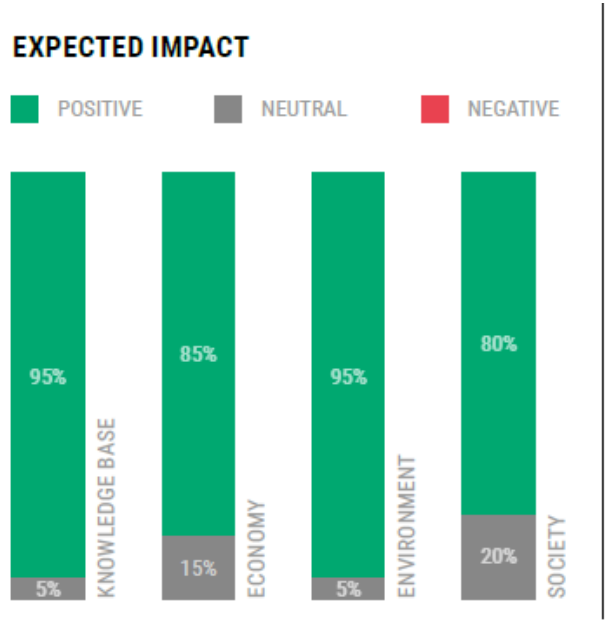
Increasing and maintaining soil fertility

What's the innovation about?
Novel approaches for maintaining and improving soil fertility

- target the **biological diversity** (soil microbiomes, plant diversity),
- **crop cultivation techniques** (i.e. focus on root growth) and
- **biological strategies for pest control**.

farmmanagement.pro

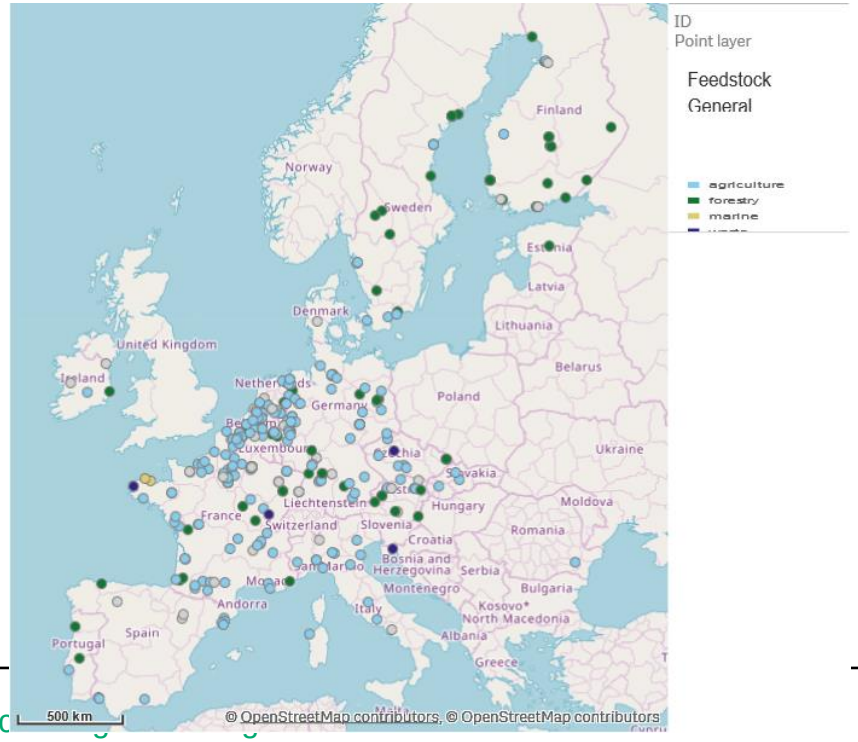
What's the impact?
maintaining robustness and stability of soils as adaptable ecosystems with respect to carbon, nitrogen, phosphorus and water cycle



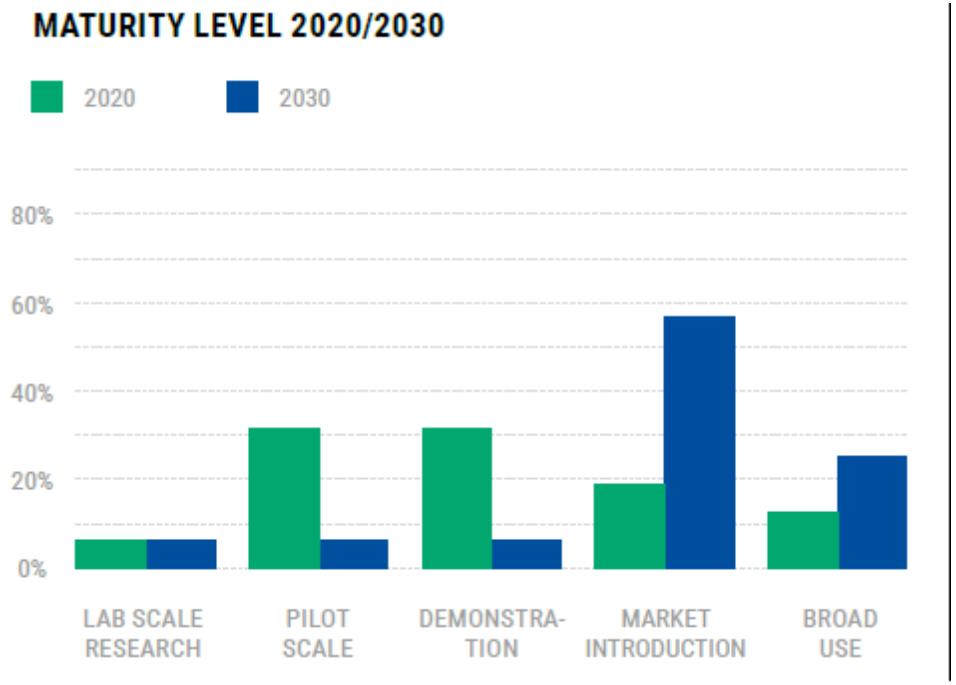
Optimising biorefineries

What's the innovation about?
Pretreatment, conversion, and downstream processing become fully integrated and are optimised, in order to convert biomass efficiently at a large scale

https://www.horizons-mag.ch/2018/06/05/
biorefineries-for-a-future-without-oil/



What's the impact?
zero waste
compete with the fossil-based industry



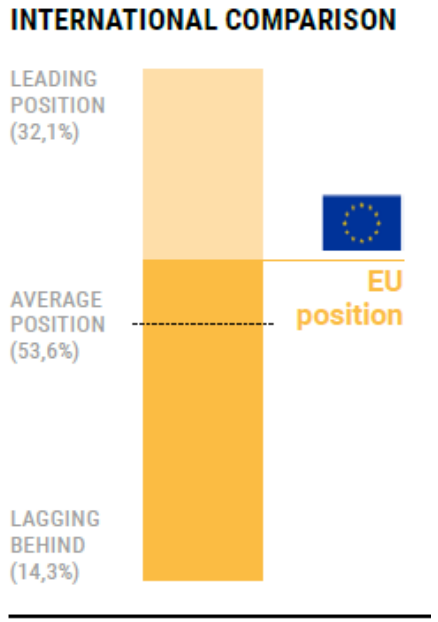
https://datam.jrc.ec.europa.eu/datam/mashup/CHEMICAL_BIOREFINERIES_EU/index.html

Bio-functional materials

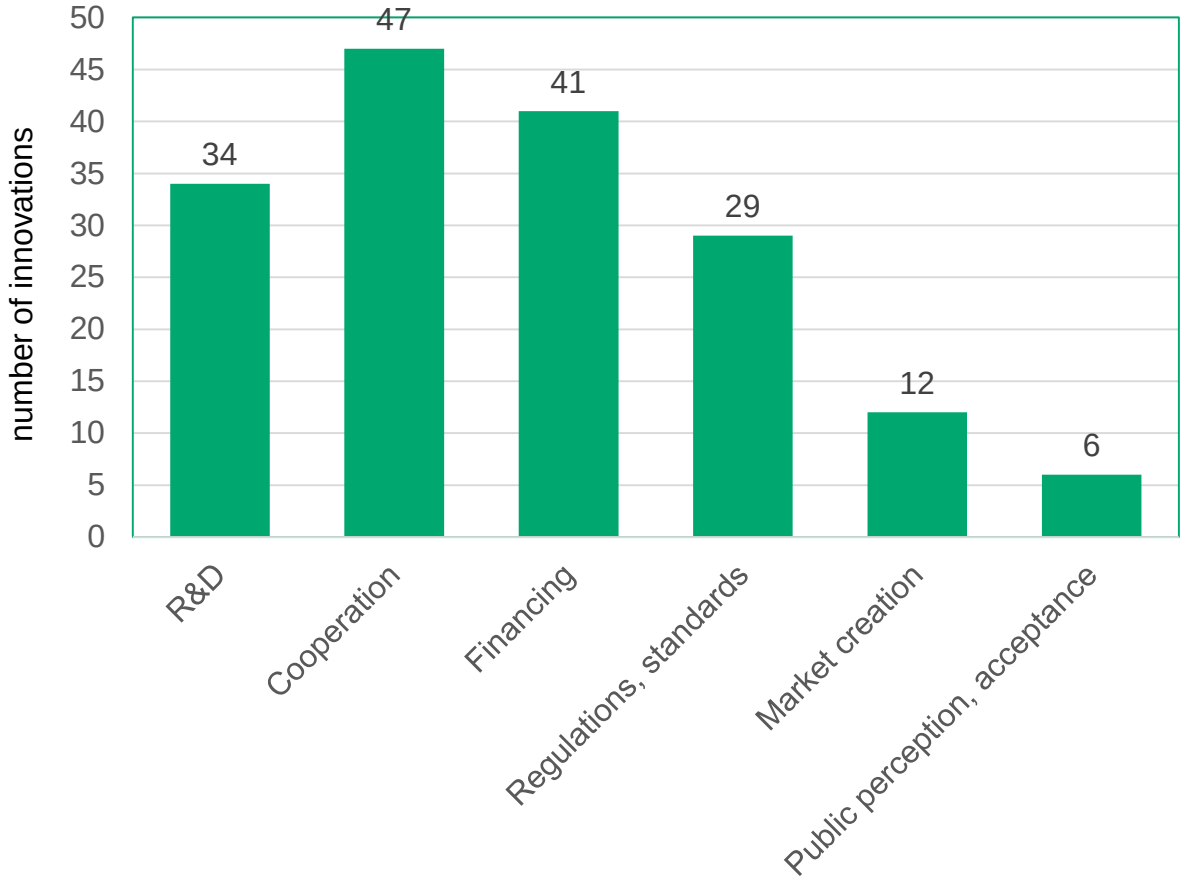
What's the innovation about?
bio-based materials ...

- with new functionalities
- which change their properties depending on the environmental conditions, by integrating active biomolecules e.g. enzymes, cells, antibodies, biosensors into the material,

What's the impact?
better surface properties, molecular recognition, temperature responsiveness, healing generation



Priority issues to be addressed to overcome existing hurdles



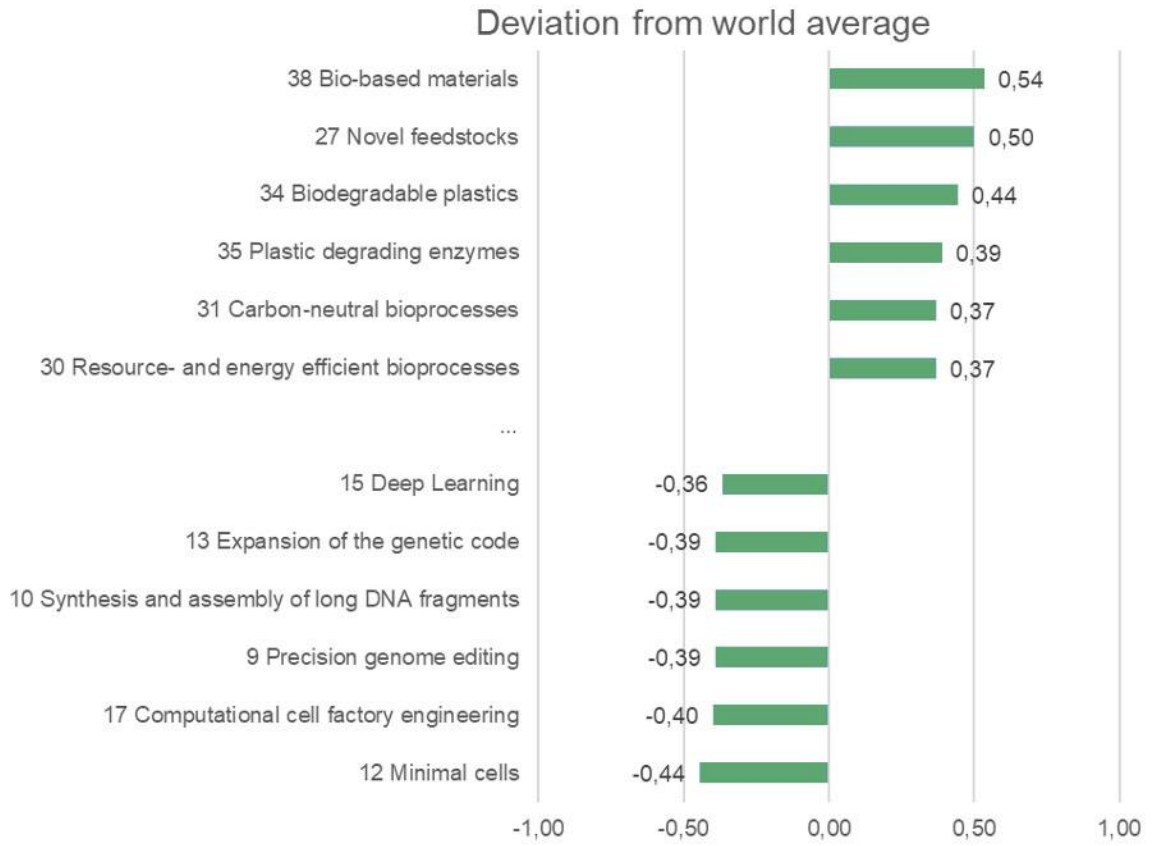
- **R&D, cooperation, innovation financing most important**
- **R&D** more important in **cross-cutting** enabling technologies
- **Financing, regulations, market creation** more important in **applications/solutions**

Source: EU-wide online expert survey on top50 innovations, 3 answers per innovation possible

Top 50 innovations: EU position in international comparison

top50 innovations in which EU is clearly leading/clearly lagging behind

- EU **performs well in most innovations** according to EU-wide online expert survey, patent & publiaction analysis and interviews
- EU **leading** in **environmentally beneficial or sustainable solutions (+)**
  - Enzymes
  - Novel feedstocks and bioprocess engineering
  - Bio-based processes and products
- **EU lagging behind (-)** in
  - Digital technologies
  - Genome editing
  - Synthetic biology
  - partly agricultural technologies innovations



Source: EU-wide online expert survey on top50 innovations

Role and Status of Central and Eastern European countries in bio/life sciences

- Central and Eastern European (CEE) countries have made massive progress in the development of their bio-based sectors over the past decade and have the potential for a significant role in the bioeconomy
- Important initiatives for the bioeconomy development in CEE (BioEast) and harmonization across Europe (European Bioeconomy Policy Forum (EBPF)) exist
- Still, development in CEE lacks somewhat behind Western European countries
  - CEE countries only receive 7% of the available EU contribution of Horizon 2020 funding related to top 50-innovations, of which 59% is part of a few big Flagship projects
  - Most CEE countries have not yet bioeconomy strategies and (as in many other countries) more coherent alignment to other policies is an important issue

→ study propose different actions, e.g. increased funding for establishing or upgrading technologies, infrastructures and clusters in CEE countries as well as actions to greater harmonization of bioeconomy-relevant policies across Europe

Portfolio of top50 innovations – Conclusions

- Portfolio of top50 bio-based innovations represents important developments and innovation needs for a successful transition towards a sustainable bioeconomy and for achieving impacts in SDGs

- Portfolio is no 1:1 blueprint for R&D&I support programmes
  - Prioritization required depending on e.g. specific strategic goals, strengths and weaknesses, R&D&I capacities, economic sector focus of Member States
  - Need to transform the "default" portfolio of top50 bio-based innovations into tailor-made actions plans and roadmaps

  ➡ BIOEAST has implemented relevant actions, such as the “BIOEAST Foresight Exercise“

- Needs of innovation call for comprehensive R&D&I support programmes which comprise a broad tool box of instruments

Thank you

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Study available via
http://www.biobased-innovations.eu/