Development of the marketplace of biodegradable packaging in connection with green transformation of enterprises in Poland:

DUO-BIO-PS

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- Challenge 4

CHALLENGE MOTIVATION

- Regulatory perspective: **EU Green Deal (2019)**
  - Circular Economy Action Plan (2015)
  - Plastics Strategy (2018)
  - Packaging & Packaging Waste Directive (review 2022)
  - **Single Use Plastics Directive (2018)**
  - **European Policy for Biodegradable Plastics**

- Market perspective for bioplastics (biobased & bopdegradable
  - 1% of the plastics global market
  - Asian countries
  - Growth: x3, x4 in 5 years?

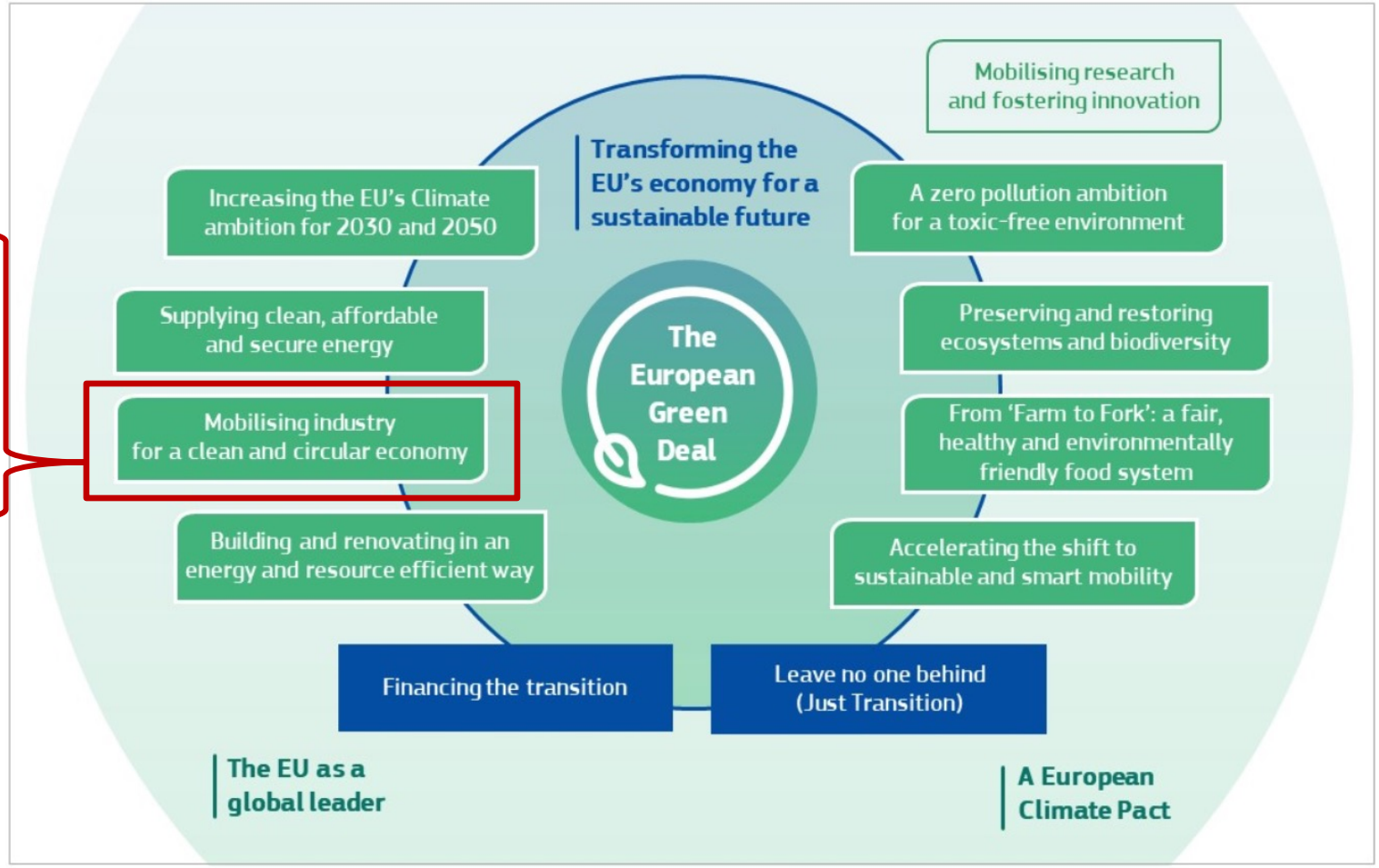


Figure: The European Green Deal, COM/2019/640

CHALLENGE: GOALS & PROJECT STEPS

How we might effect on an improvement of the marketplace of biodegradable packaging in connection with green transformation of enterprises?

State of the art in bioplastics → Dynamics of the market → State of the art in bio-PS → Outcomes/products: scenarios & business strategies for DUO-BIO-PS

Outcomes/products:

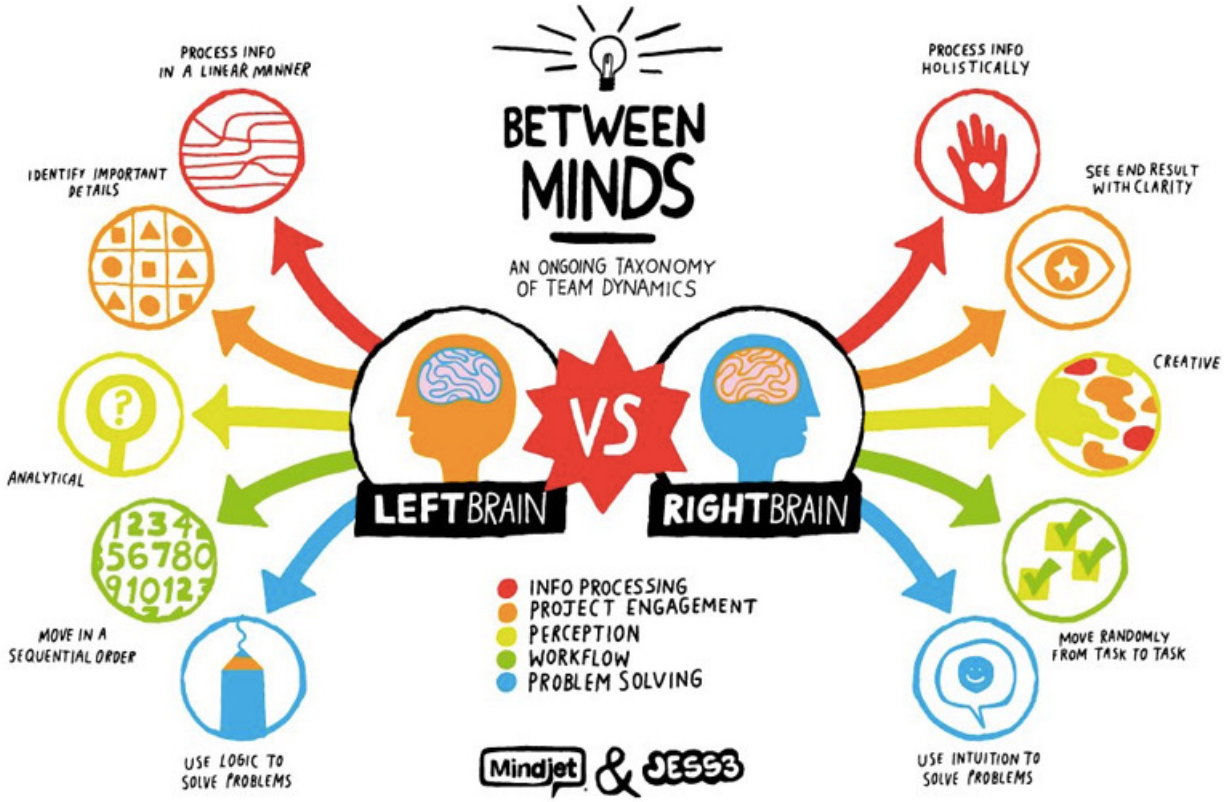
Scenarios & business strategies

INNOVATION!

for biodegradable food packaging in Poland: **DUO-BIO-PS**

with reference to the Synthos green strategy - EVERGREEN

METHODOLOGY & TOOLS



- Resources: state of the art research, weight of evidence
  - scientific literature, reports, official EU documents, market data
  - opinions & posiitons of various stakeholders
  - our own knowledge & experience
- Tools
  - **brainstorming !**
  - SWOT analysis
  - business strategies models scenarios
  - discussions with Tutors
- Cooperation with Synthos Company
  - regular contacts with coaches
  - round table discussion
  - company resources (EVERGREEN strategy)

Figure: https://www.deskmag.com/en/coworking-tools-tips/the-art-of-brainstorming-549#galery

STATE OF THE ART:
BIODEGRADABLE PLASTICS IN POLAND - DOMESTIC SUPPLIERS

- Food
  - categories: dry, non-fatty food, single use applications (dishes, cyutlery), secondary packaging
  - materials: biomaterials: cellulose, starch, bran, sugar cane, **polymers: PLA**
- Cosmetics
  - R&D & pilot phase only
  - oily products (lipsticks, creams)
  - material: PLA





- Conclusions
  - PLA - the only widely available bioplastic (biodegradable)
  - No PS as bioplastic (bio-based or biodegradable)

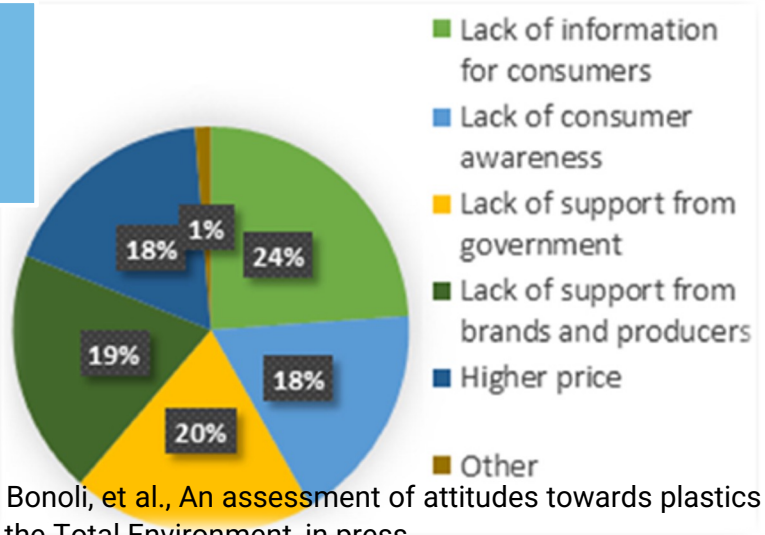
STATE OF THE ART

SOCIAL ASPECTS

Advantages for the society:

- faster elimination of waste
- new jobs
- new reseach

Consumer concerns:



Source: W.L. Filho, A.L. Salvia, A. Bonoli, et al., An assessment of attitudes towards plastics and bioplastics in Europe, Science of the Total Environment, in press

TECHNOLOGICAL ASPECTS

- Barier properties of biodegradable and bio-based plastics too weak
- Cost of biodegradable plastics manufacturing > double
- Biodegradable plastics require tightly controlled waste management
- Investments needed in the infrastructure
- Without support - biodegradable plastics could end up in landfills

STATE OF THE ART:

ENVIRONMENTAL ASPECTS

- The variability of results in the environmental assessment
- Bio-plastics reduce GHG
- Reduced use of fossil fuels
- Biodegradability of various polymers differ
- Land availability & competition with food crops

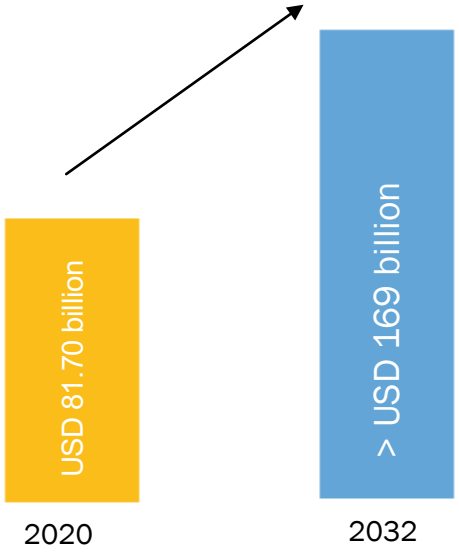
MARKET TRENDS = SUMMARY

paradigm shift towards achieving a ‘zero waste’ economy	recyclability, reusability and biodegradability are rated highly by consumers across the world
positive expectations regarding the future of bioplastics as replacement	lowering costs = main driver for wide=scale adoption
circular sourcing: biowaste frim biorafinery	bio-positive story-telling

DYNAMICS OF THE MARKET

Market growth will **accelerate** at a **CAGR** of cover

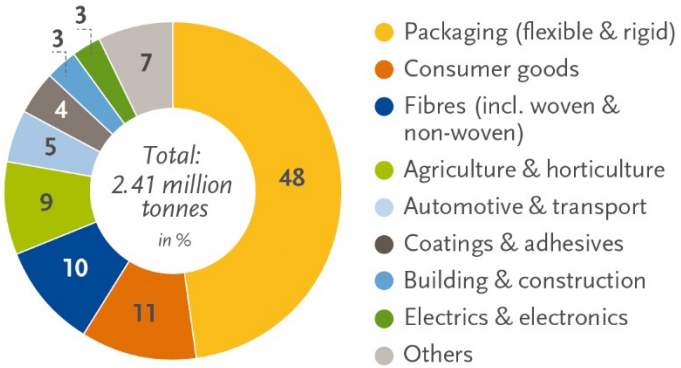
6,8%



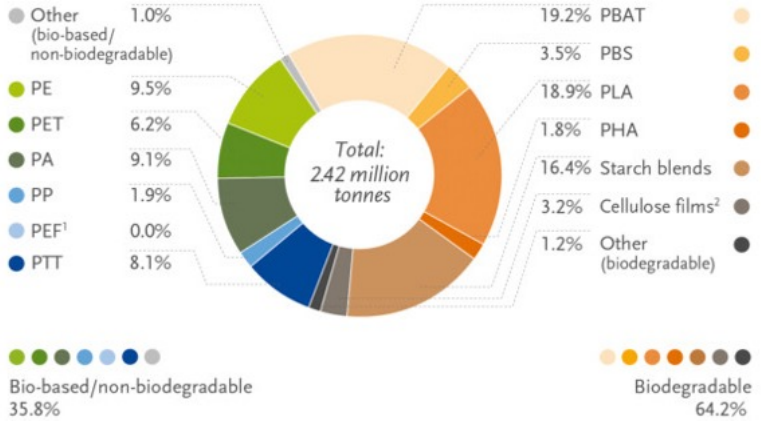
Global production capacities of bioplastics in 2021

Source: https://www.european-bioplastics.org/market/applications-sectors/

Region



Market segment



Material type

SWOT ANALYSIS FOR BIODEGRADABLE PLASTICS

TECHNOLOGICAL, ECOLOGICAL, ECONOMIC, SOCIAL AND MARKET ASPECTS

STRENGHTS

- **Good image, public perception** of biodegradable materials
- Bio-plastics are today the **fastest growing market**
- **Huge interests** in sustainable processes = hugh investment in innovations

WEAKNESESS

- **Small market** in comparison to standard plastics materials
- **Distrust** for biodegradable plastics from the industry and some consumers
  - labelling, sorting rules, greenwashing, bariers in classical recycling
- **Weak barrier properties** of most biodegradable plastics

OPPORTUNITIES

- Great pool for **innovation**
- Big potential for **growth**
- Creation of new **workplaces** and new industry, new disciplines
- Great chance to overcome the problem of some non-recyclable packaging

THREATS

- Competition from quickly developing recycling technologies
- Only non-recyclable packaging allowed as targeted use of biodegradable plastics

= barriers to expand the market

STATE OF THE ART IN BIO-PS

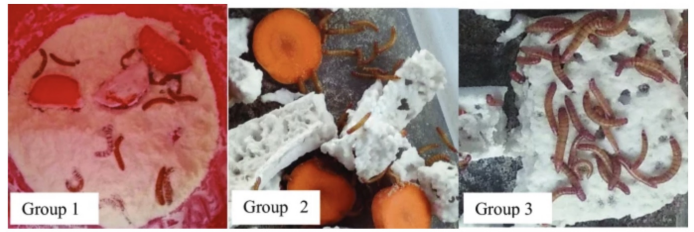
- The production of bio-based polystyrene is in its initial stage → only a laboratory scale of this type of production has been tested.
- The basic material for the production of styrene is ferulic acid. Its source is the possibility of using natural renewable resources (various types of plants).

BUT!
The ferulic acid source should be changed. According to EU legislation, it is prohibited to use food as a source for non-food production.

Different research directions

microbial degradation

degradation by superworms



The larvae of *T. molitor* (mealworms) reared in the presence of corn flour (Group 1), polystyrene and carrots (Group 2) and polystyrene only (Group 3)

STATE OF THE ART: SUMMARY & RECOMMENDATION

Polystyrene: „difficult" polymer
- difficult recyclability
- ban in the SUP directive
- negative public perception

May be:
- bio-based
- biodegradable

DUO-BIO-PS → innovation → answer to the Challenge

STATE OF THE ART IN BIO-PS

duo bio-PS → biobase and biodegradation

The production of duo-bio polystyrene is a project that can be **performed** in the perspective of 5 years in the research and laboratory tests phase.

The implementation of such an innovative material will certainly allow Synthos to stand out on the market and join the group of innovative green enterprises.

SHORT, MEDIUM AND LONG-TERM BUSINESS STRATEGIES

Development of business plans for biodegradable food packaging in Poland

- **PLA:** technology concept formulated and experimental proof of concept
- **duo-bio PS:** state-of-the-art research; basic research and technology concept formulated

1 year

- **PLA:** technology validated in lab, technology validated and demonstrated in industrially relevant environment
- **duo-bio PS:** experimental proof of concept and technology validated in lab

3 years

- **PLA:** system prototype demonstration in operational environment, system complete and qualified and system proven in operational environment
- **duo-bio PS:** technology validated and demonstrated in industrially relevant environment

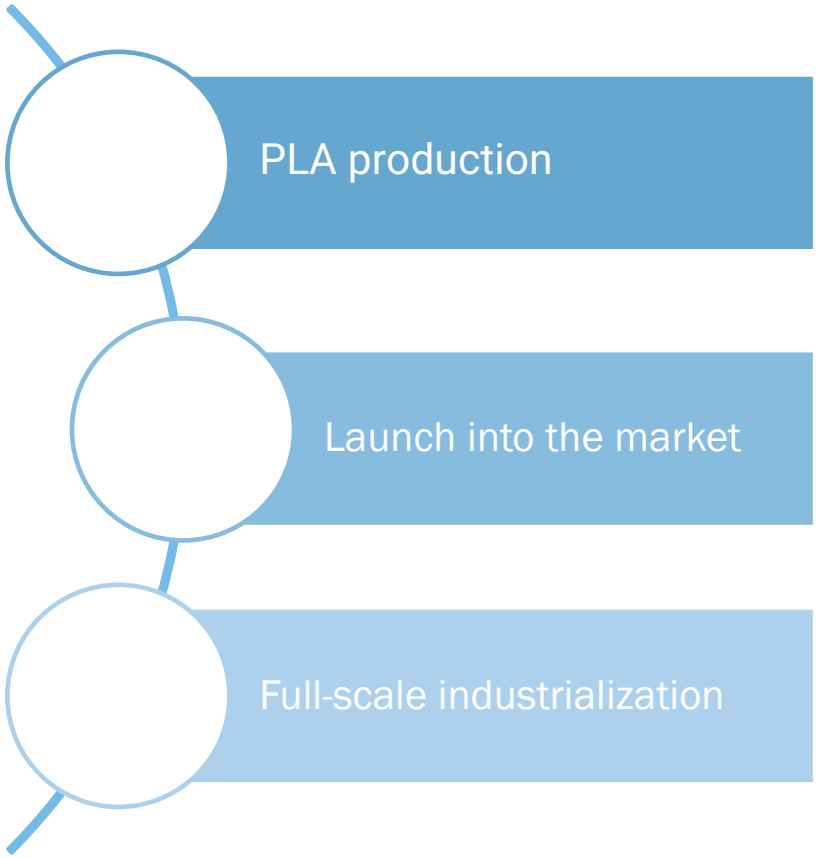
5 years

- **duo-bio PS:** system prototype demonstration in operational environment, system complete and qualified and system proven in operational environment

8 years

OUTCOMES/PRODUCTS: SCENARIOS & BUSINESS STRATEGIES FOR PLA

SCENARIO 1: PLA



- Design of the entire production process with an emphasis on the "cradle to cradle" concept.
- Create the most efficient process in terms of media consumption, greenhouse gas emissions and time consumption.
- Ensuring compliance with food regulations

- Cooperation with 1 or 2 market players.
- Creation of a waste collection system.
- Establishing cooperation with recyclers.
- Environmental impact analysis and assessment.
- Research for innovative applications (e.g. cosmetic products).

- Full-scale market launch.
- Expand your production with different kinds of applications and different kinds of packaging.
- Continuous development and improvement of the efficiency of processes.

OUTCOMES/PRODUCTS: SCENARIOS & BUSINESS STRATEGIES FOR DUO-BIO-PS

SCENARIO 2: Duo-bio-polystyrene

Bio-PS production

- Production of polystyrene is based on decarboxylation and polymerization processes. Their design and way of working is well-known on the conventional PS production based on petroleum sources.
- Through the production process of bio-polystyrene we received 2 types of PS: poly(vinylguaiacol) or poly(vinyl catechol) and it depends on used additives.
- Propose to produce expanded bio-based polystyrene for food-packaging single-use products.

Semi-industry scale of duo-bio -PS

- Cooperation with a box-diet supplier. The supplier of the diet boxes will be a company that collects used boxes from customers on a daily basis.
- The biodegradation process may be based on living organisms: tenebrio molitors. These superbugs have an ensimatic system that allows them to depolymerize the PS.
- Process waste containing death worms - making them safe and easy to manage.
- Development of technology for the isolation of the enzyme system.
- Depending on what substances or material we will receive after the biodegradation process, the next stages will be design.

Industrial scale of duo-bio -PS:

- Full industrialization and its scale will be based on the results obtained on a semi-industrial scale.
- Further research in this direction

NEXT STEP?