Novel packaging films and textiles with tailored end of life and performance based on bio-based copolymers and coatings.

D.7.5 Final report on Sustainable Business Models and Value Chains including Consumer Perception aspects

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Acronyms

AB	Advisory Board
B2B	Business to Business
B2C	Business to Consumer
BBI-JU	Bio-Based Industries Joint Undertaking
CA	Consortium Agreement
CBE-JU	Circular Bio-based Europe Joint Undertaking
CO2	Carbon Dioxide
D	Deliverable
E&D	Exploitation and Dissemination
EC	European Commission
EoL	End of Life
EU	European Union
FA	Fatty Acid
FAWVB	Fatty Acids Water Vapour Barrier
H2020	Horizon 2020
IB	Industrial Biotechnology
IOT	Internet Of Things
IPR	Intellectual Property Rights
IR	Infra-Red

KER	Key Exploitable Results
KPI	Key Performance Indicator
LCA	Life Cycle Analysis
LCC	Life Cycle Cost
NIR	Near Infra-Red
OA	Open Access
PBSA	Poly(butylene succinate-co-adipate)
PCT	Polycyclohexylenedimethylene terephthalate
PLA	Polylactic Acid
PVC	Polyvinyl chloride
ROP	Ring Opening Polymerization
SaaS	Software as a Service
s-LCA	Social life Cycle Analysis
SME	Small and Medium Enterprise
UVP	Unique Value Proposition
WP	Work Package
WPI	Whey Protein Isolate

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Executive summary

The aim of this deliverable is to provide the details on how the project's results will be used in commercial exploitation activities, for training purposes, for further research activities as well as for standardisation activities. It also specifies in detail for each result the business model, the value proposition and potential revenue stream. A consumer perception analysis is also included together with a market analysis focused on biobased packaging, mono and multilayer film and trays, textile primary and secondary packaging markets. Other sources of coverage have been considered in order to advance the TRL after the end of the project and a financial analysis is provided in section 7.

1. INTRODUCTION

The aim of D7.5 is to develop a comprehensive report including a series of case studies, showcasing successes and failures in each area, and discussing suitable ones for BIOnTOP taking into account the perception in the value chain down to consumers.

The document consists of 7 Sections, starting from the analysis of the market needs and opportunities in EU in the bioplastic sector; a focus on the 3 BIOnTOP key market applications has been developed, defining market trends and use case analysis. In Section 3 BIOnTOP products and solutions have been analyzed starting from the tools and methodologies learned through the Horizon Results Booster PDES-C[1] and BPD[2] services.

Consumers are the key actors of BIOnTOP applications, thus an analysis of their needs and perception was carried out, in Section 4 the main results have been reported. In Sections 5 a focus on Sustainable Business and Revenues Models is included. In Section 6 an overview of potential funds to further develop and commercialize the developed application is included. In Section 7 some Financial projections are reported. Considering D7.5 is a public deliverable and in order to avoid to disclose sensitive information Sections 5, 6 and 7 include a brief overview and not a detailed analysis on costs and projections. In any case the data inserted in this deliverable are enough to promote BIOnTOP results among potential und-users paving the way for a further development and a final commercialization of the products developed within the project.

[1] https://www.horizonresultsbooster.eu/ServicePacks/Details/6

[2] https://www.horizonresultsbooster.eu/ServicePacks/Details/7

2. NEEDS AND MARKET OPPORTUNITIES

Currently, bioplastics still represent less than one percent of the more than 390 million tonnes of plastic produced annually*. After stagnating in 2020, mainly due to Covid-19, the overall global plastic production has been increasing again since 2021. This development is driven by rising demand combined with the emergence of more sophisticated applications and products.

According to the latest market data compiled by European Bioplastics in cooperation with the nova-Institute, global bioplastics production capacities are set to increase from around 2.2 million tonnes in 2022 to approximately 6.3 million tonnes in 2027.

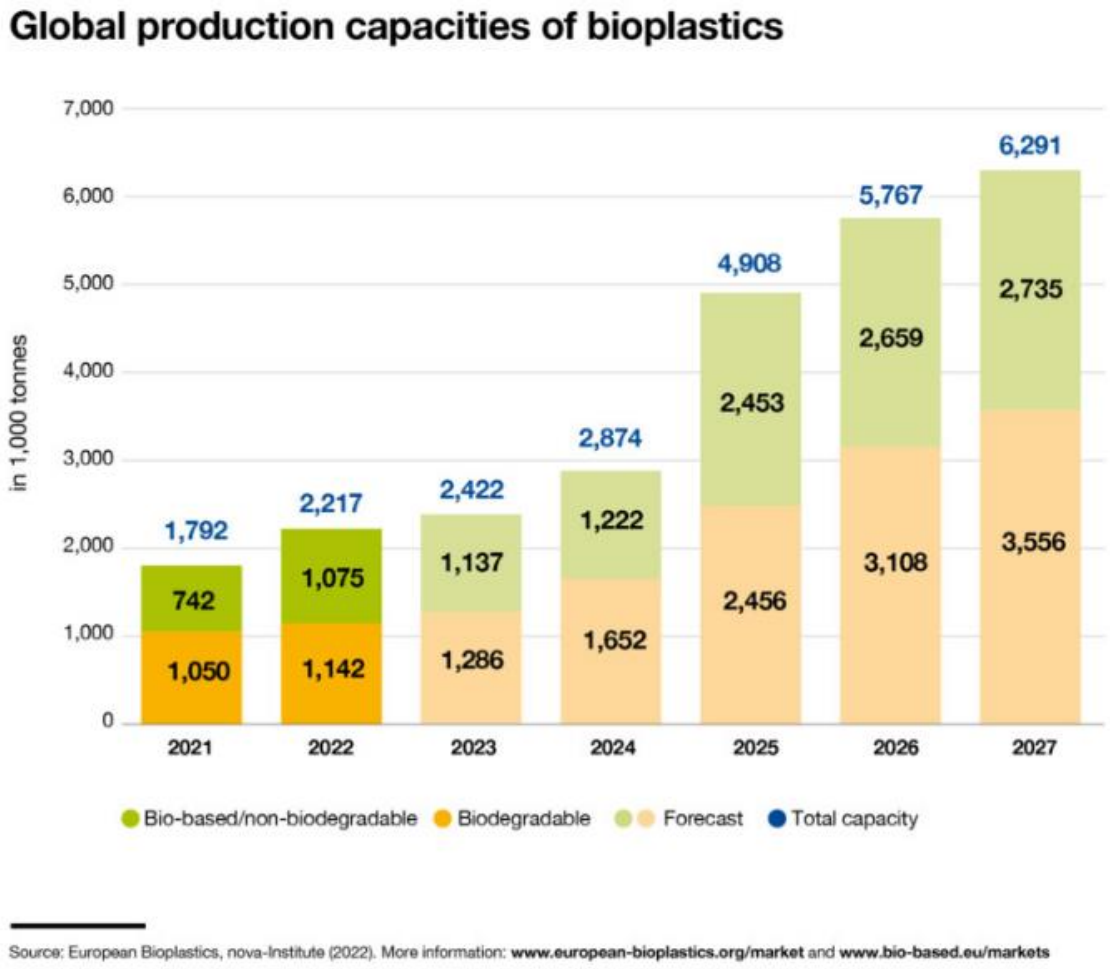

Figure 1:Global production capacities of bioplastics[3]

Bioplastic alternatives exist for almost every conventional plastic material and corresponding application. Due to a strong development of polymers, such as PHA (polyhydroxyalkanoates), polylactic acid (PLA), PAs (polyamides) as well as a steady growth of Polypropylene (PP), the production capacities will continue to increase significantly and diversify within the next 5 years.

[3] https://docs.european-bioplastics.org/publications/market_data/2022/Report_Bioplastics_Market_Data_2022_short_version.pdf

Currently, biodegradable plastics altogether, including PLA, PHA, starch blends and others, account for more than 51 percent (over 1.1 million tonnes) of the global bioplastics production capacities. The production of biodegradable plastics is expected to increase to over 3.5 million in 2027 due to a strong development of polymers, such as polylactic acids (PLAs) and PHA (polyhydroxyalkanoates).

Biobased, non-biodegradable plastics altogether make up for more than 48% (almost 1.1 million tonnes) of the global bioplastics production capacities. These also include drop-in solutions like biobased PE (polyethylene) and biobased PET (polyethylene terephthalate), as well as biobased PA (polyamides). Their relative share is predicted to further decrease to about 44% in 2027. However, in absolute numbers the production capacities for biobased polymers are still going to increase over the next five years to more than 2.7 million tonnes. While production capacities for biobased PET stagnate, the main drivers for the growth are Polypropylene (PP), polyamide (PA), and polyethylene (PE).

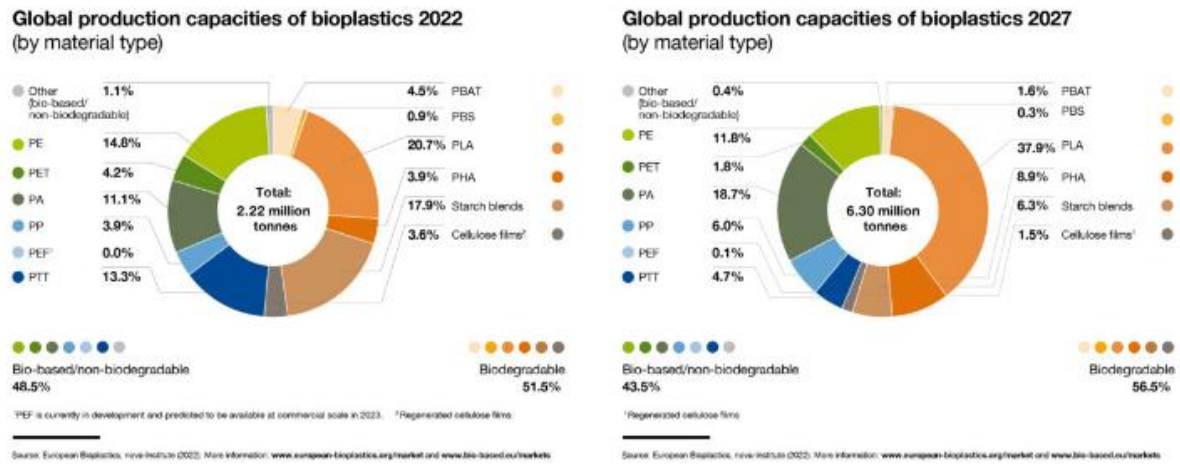

Figure 2: Global production capacities of bioplastics in 2022 (by material type)[4]

Bioplastics are used in an increasing number of markets, from packaging, catering products, consumer electronics, automotive, agriculture/horticulture, and toys to textiles and several other segments. Packaging remains the largest market segment for bioplastics with 48% (almost 1.1 million tonnes) of the total bioplastics market in 2022. However, the portfolio of applications continues to diversify. Segments, such as automotives & transport or building & construction, remain on the rise with growing capacities of functional polymers.

[4] https://docs.european-bioplastics.org/publications/market_data/2022/Report_Bioplastics_Market_Data_2022_short_version.pdf

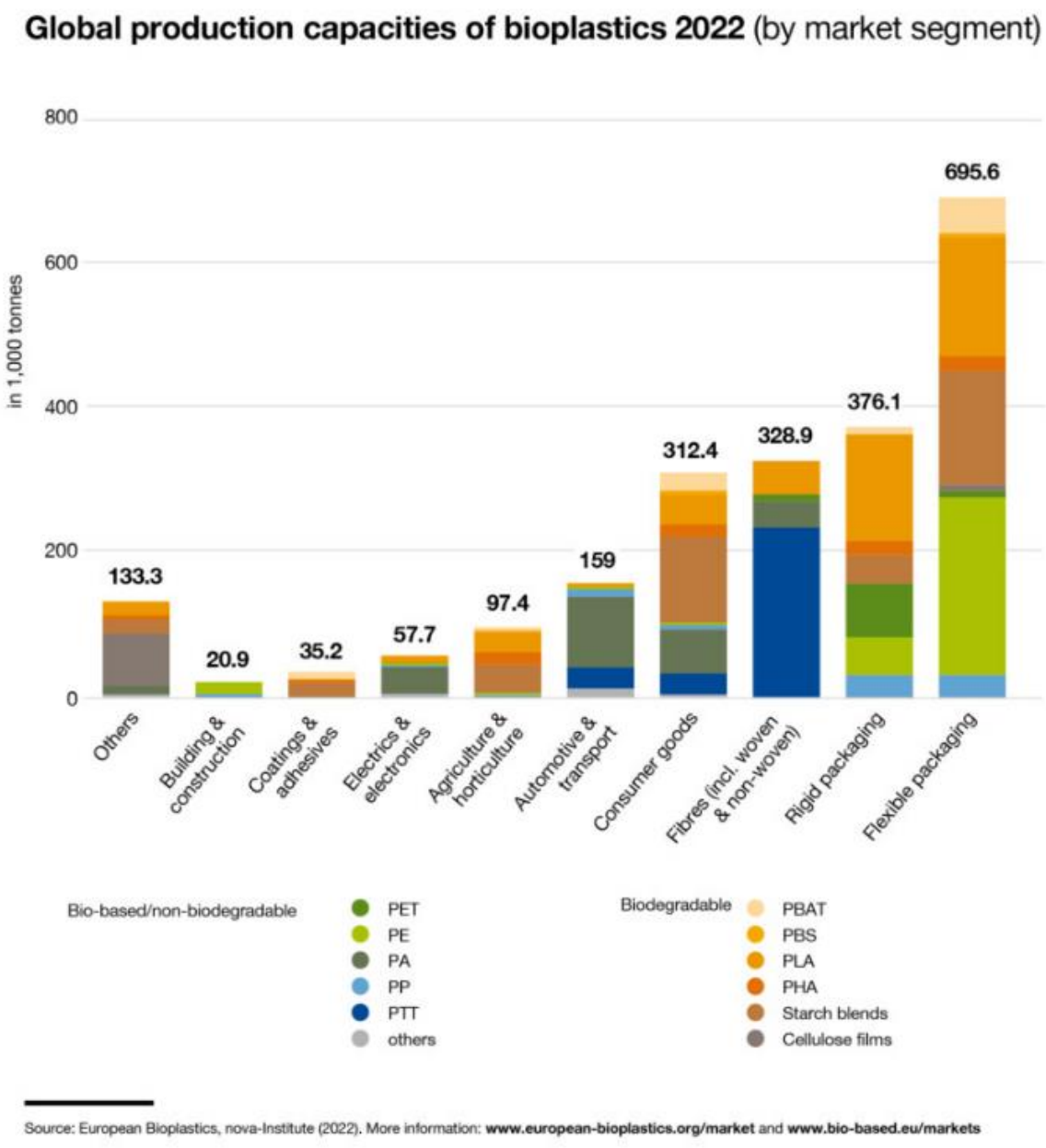

Figure 3: Global production capacities of bioplastics in 2022 (by market)[5]

With a view to regional capacity development, Asia further strengthened its position as major production hub with more than 41 percent of bioplastics currently being produced in the region. Presently, just over a quarter of the production capacity is still located in Europe. However, Europe's share and that off other world regions will significantly decrease within the next five years. In contrast, Asia's production capacities are predicted to increase to almost 63 percent by 2027.

[5] https://docs.european-bioplastics.org/publications/market_data/2022/Report_Bioplastics_Market_Data_2022_short_version.pdf

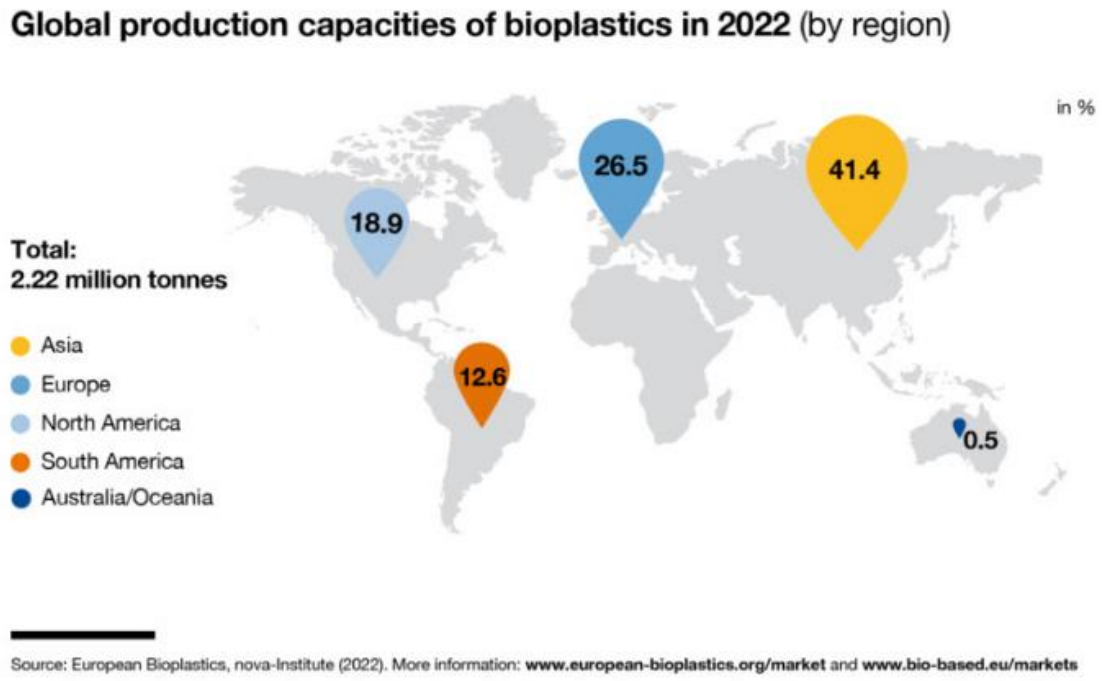

Figure 4: Global production capacities of bioplastics in 2022 (by region)

The land used to grow the renewable feedstock for the production of bioplastics is estimated to be 0.8 million hectares in 2022 and continues to account for only 0.015 percent of the global agricultural area of 5 billion hectares. Alongside the estimated significant growth of global bioplastics production in the next five years, the land use share for bioplastics will increase to, however, still below 0.06%. This clearly shows that there is no competition between the renewable feedstock for food, feed, and the production of bioplastics.

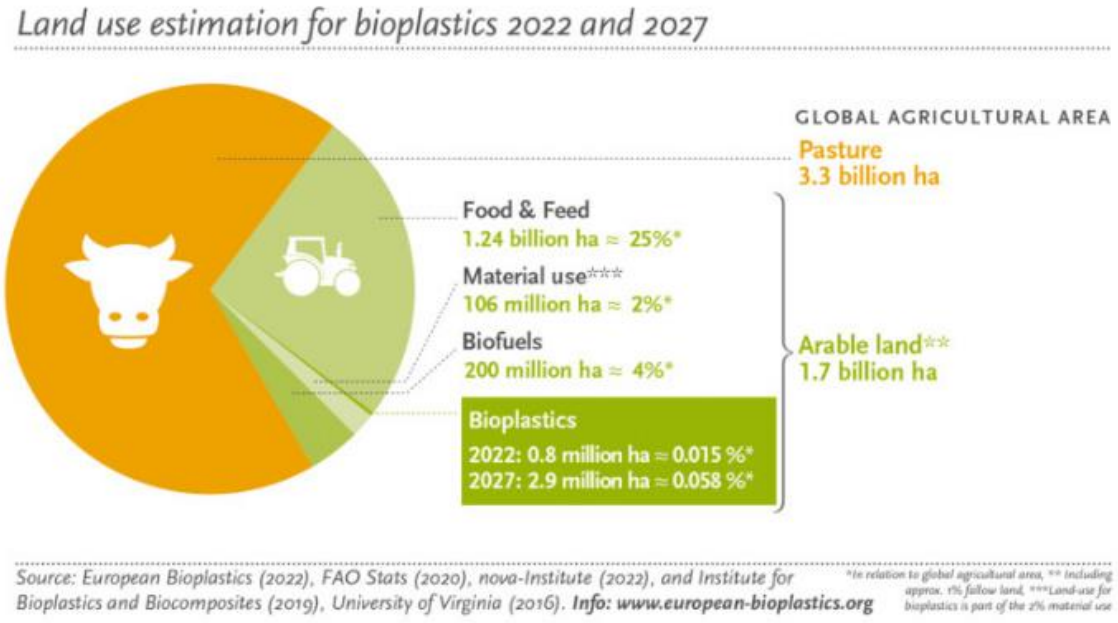

Figure 5: Land use estimation for bioplastics 2022 and 2027

2.1. Bio-based packaging

There is still a high demand for packaging made from bioplastics to be used for wrapping organic food as well as for premium and branded products with particular requirements. In 2022, global production capacities of bioplastics amounted to about 2.22 million tonnes with 48% (1.07 million tonnes) of the volume destined for the packaging market – the biggest market segment within the bioplastics industry. Rigid bioplastics applications are available for cosmetics packaging of creams and lipsticks as well as beverage bottles and many more. Materials, such as PLA, bio-PE or bio-PET are used in this section. Several well-known brands, such as Volvic or Heinz use bio-PET for bottles of all sizes containing drinks and other fluids, while Coca-Cola signed a cooperation to test the use of bottles made from PEF. Coca-Cola also introduced the "100 percent Plant-based Bottle" into the market. Procter & Gamble resorts to bio-PE to package some of its cosmetic products. As a potentially mechanically recyclable material, PLA is also gaining pace in the rigid packaging market.

Biodegradability is a feature often sought when it comes to food packaging for perishables. Flexible packaging solutions, such as films and trays are particularly suitable for fresh produce, such as fruit and vegetables, as they enable longer shelf life. The requirements for food packaging are as divers and numerous as there are different types of food. Today, packaging materials and processes are extremely sophisticated and easily adaptable to meet specific application and preservation needs. When it comes to protecting food and prolonging shelf life, the performance of bioplastics packaging is comparable to that of existing conventional packaging and sometimes even better. By continuing to improve barrier properties like antimicrobial coating and other aspects, the bioplastics industry will be able to achieve better preservation of food products than current packaging very soon.

For almost every conventional plastic material and application there is a bioplastic alternative available on the market that has the same properties and potentially offers additional advantages.

2.2. Mono and multilayer Films and trays

Also referred to as co-extruded films, because of the co-extrusion process used during manufacturing, multilayer films can be comprised of between three – 12 layers. These barriers play a critical role in preserving the items inside, which is why multilayer film is used heavily in the packaging of food, FMCG and medical items. This structure protects goods and preserves shelf-life by controlling the transmission and concentration of moisture, UV, oxygen, and gasses and providing mechanical and physical properties like puncture, tear and heat resistance. The multilayer multimaterial structures fulfil functionalities, where monomaterial has limitations. The thermoplastic layers in these films commonly consist of plastics such as: PE, PP, EVOH, PA, PET. PE is traditionally the most cost-effective component, and therefore the most widely used. Ironically, it is also suitable for kerbside recycling, making it easier for the public to dispose of in a way that guarantees its re-entry into the supply chain – IF it was being used in a monolayer and monomaterial film. In mechanical recycling, recycling these multimaterial structures can be rather difficult due to the varying melting temperatures of the polymers and their different mechanical properties. Thus, this material stream is considered in multiple cases non-recyclable (or very difficult to recycle) via mechanical recycling and only recyclable in chemical recycling stream. When layered with PA (in a PE/PA polyethene/polyamide composition) or EVOH for example it is inherently challenging to reprocess and be used in the manufacturing of new products - limiting the recyclability of flexible films. More brands and retailers are striving to meet consumer and legislative demand. The pressure

is on when it comes to creating packaging that the consumer can easily recycle, and of course, in some countries – recycling infrastructure proves to be a further hindrance. The negative perception of plastic has led to around 26% of brands trying to reduce plastic use, while 60% are looking to emphasise recycling and the inclusion of a high volume of recycled plastic content. The final 14% are looking at innovative ways to promote systemic behavioural change with strategies that include partnering with environmental advocacy and academic sustainability groups, incentivising consumers to recycle and partner with suppliers to reduce consumption.

There is still much education required when it comes to the public perception of plastic.

The challenges that brands face come down to meeting legislative and consumer demand for sustainable, recyclable packaging whilst maintaining the quality of the product. Brands are also facing other pressures such as changing consumer preferences, e-commerce and costs. For this reason, those responsible for packaging are having to explore several avenues, experiment with packaging designs and rethinking their supply chains, finding partners that can supply reliable volumes of recycled material to keep up with manufacturing. There is also the argument around the trade-off between recyclable packaging, food waste and carbon footprint.

The use of multilayer film and the potential switch to monolayer/monomaterial structure is complex balance between weight, functionality and recyclability, but it's also encouraging to see brands, retailers, supply chains and converters increasing their conversations around the subject and really starting to address it head-on.

Many packaging teams for retail brands are now clearly defining the materials they will and won't accept from brands and manufacturers[6].

2.3. Textile primary and secondary packaging

Packaging textiles or Packtech include all textile packing materials for industrial, agricultural, and other goods. One of the important uses of textiles is the manufacturing of bags and sacks, traditionally from cotton, flax and jute but increasingly from polypropylene. It consists of synthetic bags used for industrial packaging and jute sacks used for packing food grains. Packaging is a long established application for textiles. Packtech is the largest end-use. Bags, sacks, flexible and wrappings for textile bales and carpets are used in one hand; however, on the other hand, it includes lightweight nonwovens used as durable papers, tea bags and other food and industrial product wrappings. Armoring, cords, belts are also used as packaging textiles.

The global textile packaging market is projected to grow at a constant compound annual growth rate (CAGR) of 6.2% between 2022 and 2025, reaching USD 222.4 billion by 2025.

Based on product type, the textile packaging market is segmented into Polyolefin Woven Sacks (excluding FIBC), FIBC, Leno bags, Wrapping fabric, Jute Hessian and Sacks (including Food grade jute bags), Tea-bags (filter paper), Soft luggage products (TT component). Woven sacks (excluding FIBC) account for around 50% of the technical textile consumption under Packtech followed by Jute hessian and sacks (including Food grade jute bags) with around 30% share. FIBC and wrapping fabrics

6 https://www.mckinsey.com/capabilities/sustainability/our-insights/starting-at-the-source-sustainability-in-supply-chains

account for around 20% of the total usage. Usage of technical textiles in soft luggage products, leno bags and tea-bags is less than 5% of the total usage in packaging textiles.

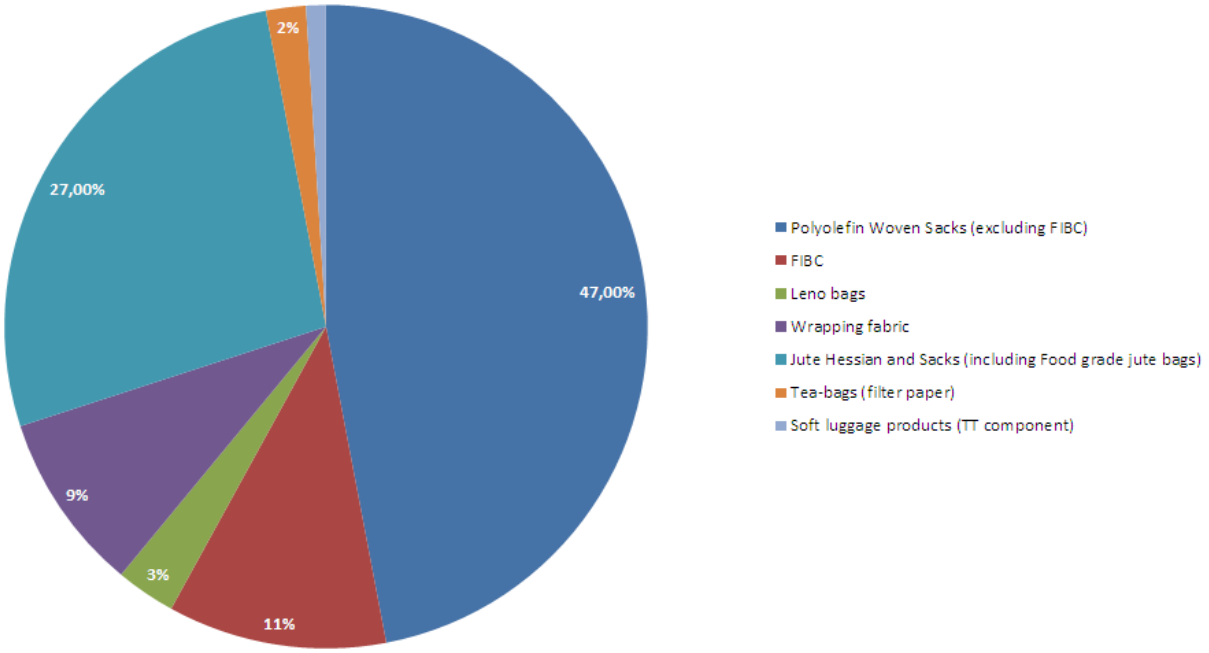

Figure 6: Textile packaging market – product type

To get a sense of the global size of the packtech market, let's take a closer look at the growth of some of the best packtech materials. For example, polypropylene woven sacks brought in approximately USD 3.75 billion in global market value in 2022 and is projected to reach approximately USD 5.6 billion in 2032 at a CAGR of 4.1%. At the same time, the worldwide FIBC market is projected to reach a value of USD 7.1 billion in the projected period of 2022 to 2032, with a CAGR of 5.3%.

In other words, the total market value for both of the top two packtech materials alone is expected to exceed $12 billion within 10 years from now. To put this figure into perspective, the estimated global market size of bags and plastic bags by 2027 is around USD 22.9 billion, while the paper bag is also projected to reach around USD 7.9 billion in 2032.

3. PRODUCTS, SOLUTIONS, BENEFITS AND TECHNOLOGY

BIOnTOP has delivered novel bio-based biodegradable packaging based on versatile copolymers and coatings that optimally preserve the packed products but also primary resources, considering the packaging is based on significantly >85% renewable resources, partly produced from by-product biomass and recyclable. The materials developed is biodegradable in home composting conditions but also recyclable for multiple use secondary packaging.

n this Section BIOnTOP innovations are described based on the key characteristics of sustainable business models, derived from the stakeholder theory[7] and also referred to as the three principles[8] of

[7] http://stakeholdertheory.org

sustainable business or the "Triple P"[9]: i) Environmental friendly; ii socially responsible; iii) economically successful.

1. Environmental friendly: the concept is completed based on the impact business activities and business decisions have on the environment. BIOnTOP is fully in line with this principle considering that for each products developed alternative energy sources were founded, reducing carbon footprint, getting rid of plastic bags, and using sustainable materials. Furthermore, the production of more responsible and environmental friendly products within BIOnTP influence the entire supply chain, pushing suppliers to act more environmentally responsible too.

All due considered BIOnTOP can be considered "environmentally sustainable" as it preserves natural capital and environmental resources.

2. Social responsibility: this point concerns the way companies work with their employees but also with other internal and external stakeholders. A socially sustainable business cares about its employees' welfare, maintaining a connection with its workforce and stakeholders going beyond just a business relationship.

Also in this sense, BIOnTOP is fully aligned with the social responsibility principle.

3. Economically successful: the economic pillar is at the bottom-line of every business, profit is the key of any business as companies has to make profit to remain sustainable. But each business has to be based on the circular economy principle, tackling global challenges like climate change, biodiversity loss, waste, and pollution. Climate change, global pollution, resource extinction, loss of biodiversity, and global pandemics (COVID-19) arises, companies need to find ways to manage planet resources in a more sustainable way.

Today, the global production causes a lot of damage to the environment; releasing more than 10 million tonnes of CO2 into the atmosphere every day; cutting down more than 42 million trees per day; producing 1 million tonnes of plastic a day, of which 32.000 tonnes end up in the ocean every day; causing the extinction of more than 150 species per day.

In this sense the use of BIOnTOP applications contributes in a concrete way to the creation of a sustainable global economy.

BIOnTOP consortium has focused its sustainable business model on the 11 KERs using the tools and methodologies learned through the Horizon Results Booster PDES-C and BPD services provided by the European Commission. Sustainability is the key of BIOnTOP success.

[8] https://ecocation.org/three-pillars-of-a-sustainable-business/

[9] https://ecocation.org/sustainable-business-models/

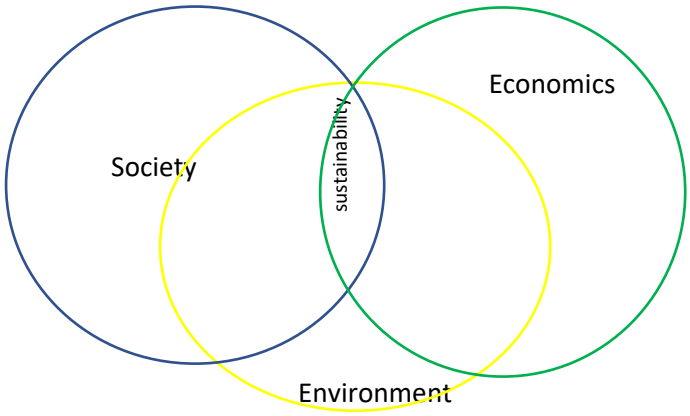

Figure 7: The Triple [10]Bottom Line

The following are the BionTop Key Exploitable Results:

- Copolymers synthesis route
- Compounds formulations
- FA grafting
- Process to allow FA combination with whey coating
- Fibres coating
- Monitoring system for materials & Predictive models and derived app for biodegradation kinetics on BIONTOP
- Secondary packaging
- Films & trays packaging and coated laminates
- Processability of novel biopolymer formulations into textiles
- Process to obtain nets
- Specific biodegradable formulations for textiles

In section 5 a deep overview of each KER is presented in the form of the Business Model Canvas.

4. CONSUMER PERCEPTION ASPECTS

In order to ensure the sustained alignment of BIOnTOP to market real needs and to help decrease the time-to-market of the proposed solutions, Movimento Consumatori has been appointed to analyse consumer perception on bio-based packaging, identifying awareness, attitudes and willingness to buy.

[10] https://online.hbs.edu/blog/post/what-is-the-triple-bottom-line

This research results and the recommendations proposed were drawn from a survey – 3.303 responses collected in n.8 European countries (Germany, France, Italy, Spain, Netherlands, Belgium, Greece, Malta) [Quantitative data]– and n.3 focus groups focused on consumer associations, food-chain industry companies and institutions [Qualitative data].

The study's results examined the following areas:

Awareness and knowledge – The research proved that consumers had a lack of knowledge regarding bio-based products that cannot be easy identified in the market. Although low awareness of bioplastics characteristics was identified, the study verifies positive consumer perceptions that were so positive they wished for more incisive legislative regulations to support it at global or, at least, European level.

Association and connotation – According to awareness and knowledge analysis, even if the European consumers associate bioplastic with an environmentally friendly choice, they also raised some doubts related to the economic (expensive) and social (land consumption) impact connected to bioplastics.

Information and label – Data shows that consumers have more interest in factual advice that maximizes the utility of the selected product. Moreover, the research demonstrated that more information could be provided, mainly in relation to recycling procedures, and that consumers complain about packaging information that is unclear, especially around End of Life (EoL) treatment.

Buying decision and willingness to pay – Buying decisions are strictly connected with the ability to recognize bioplastics. The consumer's difficulties in verifying the nature of product/packaging purchased represents a barrier on market development. Therefore, even if European consumers perceive bioplastic as an environmental-friendly choice, they do not recognize it as such at point of purchase. Furthermore, the study points out that consumer purchasing choices are based not only on environmental concerns but also on social and economic judgements.

Quantitative Data. The data was collected from two different sources. Approximately 1.300 questionnaires came from the proposal and stimulus work carried out by the associations and bodies that are partners in the project and with the support of the European Consumers Union (ECU), the official stakeholder of the BIOnTop project. This data was analysed to check consistency with main demographic variables like sex, age and education, which were compared to official statistics about the populations studied. To maintain consistent representation for the most populous countries in Europe, a random sample was added with approximately 2.000 responses collected from structured panels involving agencies active in the various countries; respondents were identified through quota sampling that took into account sex, age and educational qualification (UNESCO 2013). Both data sets collected were subjected to a merging procedure to combine them into a dataset of 3.303 cases. The overall sample is considered suitable for representing key European countries with reference to Germany, France, Italy, Spain, the Netherlands, Belgium, Greece, and Malta. Considering the population distribution at the level of the European countries, we consider the sample as being consistent in terms of representing the European populations for these nations.

The questionnaire was divided into four sections: i) awareness and knowledge; ii) associations and connotations; iii) info and labels; and iv) buying preferences and willingness to pay. MC allocated the

largest number of questions to the section on consumer decisions regarding the purchase of products with bioplastics packaging. In the first section, an attempt was made to investigate how much the concept of 'bioplastics' was known among the interviewees and what normative drives were preferred by national and European institutions. In the section on associations, a few questions were introduced to understand how the label 'bioplastics' is associated with other ecological issues through the technique of semantic differential. In the third section, the focus was on labels and the information present on product packaging. The way people approach information was explored, particularly whether they are really interested in the information on the packaging or only in the contents of the packaging. This section also identified some of the labels that are most frequently found on bioplastics packaging to try to understand whether they are understood correctly by consumers. Finally, in the fourth section respondents were asked to express their projections with respect to the purchase of products packaged with bioplastics materials, particularly whether there was a different preference for purchase among seven types of everyday products. The questionnaire closed with a series of questions for social profiling of respondents. The elaborations were realized with SPSS statistics software.

Qualitative Data. The first action planned was a focus group aimed at consumer associations in four European countries. A second focus group involved large-scale Italian distribution and production companies. Finally, a third focus group was planned to involve public bodies and institutions related to the field of recycling like municipalities of big Italian towns and a multi-stakeholder Italian consortium. Unfortunately, due to the restrictions imposed by the pandemic and the difficulty of scheduling a single meeting, we changed the research design from a focus group methodology to individual semi-structured interviews. This choice helped us to have a more specific in-depth exploration of the topic understanding several different contexts.

In the first focus group, we tried to explore the perception and role that consumers might have in the transition to bioplastics. In the second group, the companies involved expressed their point of view with respect to the complexity of managing the distribution chain, especially in the food sector, in view of a massive use of bioplastics. In the third group, with the administrators of the municipalities and the Italian consortium of bioplastics, we addressed the issues of changing consumer habits when the latter must commit to the disposal of urban waste by differentiating, recycling, composting and reusing the objects purchased.

The interviews included three sections. The first was intended to allow for a positioning of the interviewees with respect to bioplastics; the second was more oriented towards grasping the challenges and opportunities on the topic from the first quantitative results that emerged; and finally, the third section aimed at better understanding consumer behaviour with respect to ecological transition.

According to MC research, several considerations could be made:

The first consideration is that a lack of bio-based technology knowledge is the most important barrier for bioplastics adoption. Therefore, consumer associations, in partnership with producers and retailers, could play an important role in leading this green transition process from traditional plastics to bioplastics. The second point is that experts use the term 'bioplastics' in different ways (i.e. institutions point out the EoL treatment aspects, whereas manufacturers push compostability characteristics). The third consideration involves the stakeholder differences regarding the

relationship between fossil-based and bio-based plastics. Thus, even though some doubts remain, whereas the municipalities and consumer associations favour a "greener" plastic; bioplastics producers are more "comfortable" with considering bioplastics as a tool that can contribute to a more sustainable economy but that cannot completely substitute fossil-based plastics. It is worth noting that, at least in the short term, producers' best-case scenario is a relatively small market confined to food packaging and delivery, while consumer associations have less concerns regarding more widespread use of bioplastics packaging. Those limits are also visible through the quantitative analysis. Bioplastics is a term recognized by about 2 out of 3 people and its meaning is blurred, meaning that people do not properly understand this material. Therefore, consumers must grapple with a complex product. Meanwhile, all key informants, each with their own line of reasoning, considered consumers as key players who need to be more involved in green transition, to achieve faster tangible outcomes.

Therefore, the challenge is to unlock consumers' potential through measures that empower, support and enable every consumer to play an active role in the green transition, as stated by the New Consumer Agenda (European Commission 2020B).

Data confirms that many adults – mostly those over 56 and the more educated – believe in the benefits that bioplastics can offer in protecting the environment. These people are on the wealthy side of society, but despite this, about 4 in 10 people identify cost, misuse of bioplastics and the risk of monocultures for raw material production as the main concerns in systematic bioplastics adoption.

The consumer associations point out that even though consumer choices are based on ethical aspects, cost is still the most important factor in purchasing decisions. With the notable exception of consumers inclined to organic products, most purchases are based on the cost of the product being low. From this perspective it is not surprising that consumer associations, which have limited possibilities to promote cost-cutting at production sites, favour the intervention of political institutions in supporting bioplastics, making its alternatives less convenient or banning them.
For institutions, citizens are the hardest actors to align to an efficient waste management procedure, considering both the impact of imperfect waste separation in the end-of-life cycle and the limited leverage institutions have on them.
However, for both consumer associations and institutions, communication is the key to ensure an increased awareness, both when deciding what to buy and how to dispose of packaging. It should be noted, however, that communication here has different implications and distinctive features. Consumer associations consider communication necessary to promote a change in consumption style through a broad cultural change. Institutions, on the contrary, envision communication as having a more normative and procedural dimension. Data collected from customers confirms that they are convinced (8 in 10 people declared that they "strongly agree" or "agree") that laws should ensure mandatory regulation about bioplastics. These laws should be enacted at global (57%) and European (28%) level at least. At the same time, about 60% of the respondents recognised a role for consumer associations and individual citizens in supporting bottom-up pressure to adopt bioplastics.
Generally, consumers associated bioplastics with positive terms such as less pollution (63%), compostability (59%), and sustainability (59%). However, half of respondents associated bioplastics

with increased costs, while there was concern about the possible increase in land consumption to produce them, although at the same time bioplastics are associate with trust and safety by consumers.

Communication is by far the most relevant theme for all the stakeholders. All participants shared a concern about raising consumers' awareness regarding bioplastics. We could identify two main communication issues to be addressed. First, communication should be aimed at increasing the desirability of bioplastics and stimulating the demand from the consumer side. Consumers need to be informed about the distinctive features of bioplastics to be able to identify and distinguish them from other similar materials. Such knowledge is one of the keys to promoting its adoption in a market where consumers are increasingly ethically driven in their purchasing decisions. Such communication could be aimed at the general public through dedicated campaigns and reinforced through detailed information regarding on each product's labels. Research data shows that attention to labels is selective and, in general, the most salient information for consumers is the expiry date of the product (34%). The second most sought-after information concerns the product's properties (24%) – only 1 in 10 said they were concerned about the marks on packaging for recycling or information about chemical additives. Unfortunately, the presence of Internet links for further information did not seem to be of interest to consumers interviewed (only 3% were interested).

Moreover, bioplastics should be well presented and communicated to allow people to know how to deal with them. Bioplastics should not just be easily identifiable but its production should also be traceable to reassure green consumers that each step of the packaging process has avoided harm to the environment. To this end, the analysis reveals the need to align the interests of retailers and bioplastics producers. The former stresses the impossibility of shouldering the full costs of communication without the help of the latter or increasing the costs of the products, which will decrease their desirability in the eyes of consumers.

Secondly, as stressed by institutional actors, communication is needed to ensure consumer compliance with correct waste disposal given its significant impact on the overall waste management system and the costs for both producers and consumers. With respect to the communication aimed at suggesting a preference for bioplastics over alternatives beyond marketing, informing citizens about waste separation is harder and more procedural and probably requires a dedicated information programme.

There are a few certifying bodies that attest to the compostability of bioplastics products. Some are uncommon and their lack of recognition among consumers can lead to confusion.

Only 4 in 10 consumer respondents correctly interpreted the "TUV-Home" label and 3 in 10 the "TUV-Industrial" label. Overall, more than a third did not know what these labels meant, which suggests how significantly complex the practice of waste disposal is.

Some stakeholders suggested adopting a single logo for bioplastics products – directing the consumer to the correct disposal method could eliminate ambiguities and make the products immediately recognisable. An initiative to pursue this objective should be taken at EU level since products travel across countries. The future logo should clearly identify bioplastics and display, in a simple way, the correct EoL treatment.

Logos and brands should help to disambiguate which among the bioplastics are biodegradable since this single piece of information is the most relevant when it comes to consumers separating household waste. The lack of clear and homogeneous policies across the EU and within single

countries is a major barrier for the take-up of bioplastics. For example, 36% of respondents reported that the main limitation to the correct disposal of waste is insufficient information on the product packaging and 3 in 10 respondents said that it was local regulations that were most problematic in helping consumers dispose of product packaging correctly.
This means that despite the lack of leverage stakeholders have in steering European or national policies, a step forward in aligning different systems is needed to allow the widespread adoption of bioplastics. For example, in the Italian case, the waste management system controlled at municipality level constitutes an obstacle to the standardized procedures needed to manage bioplastics waste in households. Besides the lack of consistency in waste management, EU regulations are considered an obligatory point of passage to ensure promotion of bioplastics and to make them the preferred choice for consumers by either penalizing or banning alternatives.
Industry has specific requirements regarding packaging. Rapid changes in terms of consumer preferences and retailers pose additional complexity. The bioplastics manufacturers association (and similar organizations) plays a role in facilitating the connections with industry and small producers, but it is still not well known. This is an issue especially for small producers, which need to invest heavily to find a bioplastic product in the market that is tailored to their needs.
The research's quantitative and qualitative data confirms that the transition from traditional plastics to bioplastics should take place without additional costs for consumers. Consumers are very price conscious at the time of purchase: 1 in 2 stated that cost is the main lever on which purchasing decisions are based. Even those who would accept an increase in price in the short-term would do so in the hope that this would make it easier to lower costs in the future.

On the positive side, consumers are very "environmentally oriented", with around 60% supporting an interest in conscious purchasing. Respondents stated that they were "very" or "somewhat" encouraged to buy bioplastic products precisely because they do not have an impact on the environment (86%).

However, just a third of consumers declared that organic origins and the possibility of recycling the packaging were among the reasons for choosing to buy a product. This share is lower in the case of bioplastic products. Despite the desire to buy products made of bioplastics reported by 8 in 10 people, only 1 in 3 admitted to recognizing such products.

Interest in paying more for bioplastics sat at around 10% at most, especially among older people and those with high levels of education and managerial jobs.

However, work with stakeholders has shown that the process does not have to be 'linear'. It is in everyone's interest to create a smooth transition to bioplastics without them becoming the "solution" and the replacement material for any traditional plastic product. The possibility of maintaining the goal of reuse and avoidance of single-use products by consumers and local authorities should be safeguarded, while at the same time encouraging agreed developments between producers and disposal consortia to ensure that an already functioning supply chain is not jeopardized.

5. BUSINESS AND REVENUE MODEL

To contribute to the sustainability plan and to exploitation activities, it is important to further focus on the problems the novel solutions are addressing, who are the ones who feel this problems the most (the users of the solution, the target group of dissemination activities, your “customers”), the unique value proposition (what makes the novel solution much better than current ones, the pivot for messages to be used for the messages to be delivered during dissemination) and to identify how to reach customers/users out (use mode and distribution channels). It is also important to identify the costs of providing our target groups with the novel solution how to monitor progresses and how to cover costs incurred (sustainability).

The Lean Canvas is a tool that can help in these crucial activities. It is a powerful tool that has been used by consortia to further develop the characterization of their KERs and finalise the exploitation/business plan for the KERs.

Here Canvas for each KER is presented:

- **Copolymers synthesis route**

<table>
<tr>
<td rowspan="2">Problem

1)

Traditional synthetic routes of copolymers are more expensive because they last longer times and therefore they require of more energy consumption. This leads to more expensive products and increase their carbon footprint.

Alternative Solutions

Synthesis of bio-(co)polymers by conventional methods.</td>
<td>Solutions

The innovative synthetic route leads to higher yield of production and so it is more economical, less energy consumption and lower carbon footprint.</td>
<td rowspan="2">Unique Value proposition

3)

MORE SUSTAINABLE ROUTE FOR THE SYNTHESIS OF 100 % BIOSOURCED PLA COPOLYMERS TO BE USED AS ADITIVES FOR BIOPLASTICS</td>
<td>Unfair Advantage

Trade secret

Patent pending</td>
<td rowspan="2">Customer segment

2)

Manufactures of PLA / biopolymers (blends)

Manufacturers of additives for bioplastics

Compounders of bioplastics

Early Adopters

Manufacturers of additives and bio-(co)polymers</td>
</tr>
<tr>
<td>Key Metrics

6)

Number of licenses

Annual income from royalties</td>
<td>Channels

5)

• Licence agreement with big companies
• Technical Workshop with selected customers</td>
</tr>
<tr>
<td colspan="3">Cost structure (when solution is ready for the market)

8)

Cost of licences negotiations</td>
<td colspan="2">Revenue Streams (after 6 months and 3 years)

9)

Royalties (0 after 6 months; 500.000 EUR after 3 years)</td>
</tr>
</table>

- **Compounds formulations**

Problem **1)** Top 3 problems	**Solutions** **6)** Top 3 features	**Unique Value proposition** **5)** Why you are different and worth buying.	**Unfair Advantage** **7)** Can it be easily copied or brought?	**Customer segment** **2)** Who are they?
• Many compounds for packaging applications have focused on recyclability, and some products have been formulated to be industrially compostable, but there are only a few home compostable solutions. • Consumers make choice based on packaging • Consumers want to be active in reducing waste and often have a garden (they need soil improvement). • Policy regulations – require more % of compostable products • Multilayer trays are currently	• It is home compostable • It is fully biobased • It contains natural fillers as biomass by-products fibres from food and agricultural industry waste • Show good recyclability	Our compound formulations help food and non-food companies that would like to sell the products packed in sustainable packaging by attracting the customers interested in environment protection by offering packaging made from competitive price recyclable material that fits to the existing production lines and ready to be composted at home unlike existing packaging having similar properties.	The new materials can be somehow copied but it takes time to know how to process the new materials and this know-how is already developed in the project. The decision on know-how protection to be made.	Customers: 1. Large distributors and companies that sell packaging products. 2. Food and non-food companies that would like to use home compostable packaging **3)** **Early adopters** Early adopters: EMSUR-COEXPAN (Project partner INNOTECH) TIPA Compostable Packaging

not recycled and producers/institutions pay for their disposal/incineration **4)** **Existing alternatives to address the same problems** • Home-compostable solutions with lower biobased content (no carbon neutrality) • Paper or starch, but often with insufficient barrier to gases properties	**Key Metrics** **9)** Key aspects/activities you need to measure for a feedback • # customers contacted • # contracts signed • Amount sold (kgs/tons) • # license agreements		**Channels** **8)** How you contact your customers/early adopters Directly selling the compound by PLANET. Licensing to other companies.	(acquired Bio4pack)

Cost structure **11)** Prototyping HR costs, Eng. costs, MFG costs, marketing costs etc. Estimate costs for each "cost-entity" Estimate costs after seed stage 6 months and 3 years. IPR contribution of INSTM and AIMPLAS Raw materials costs: 3.4 €/kg Production costs: 1 €/kg Marketing costs 0.2 €/kg Test samples costs Legal costs	**Revenue Streams** **10)** The different revenue streams How each stream generates revenue Estimation of how much each stream will generate Estimation of revenue at seed stage 6 months and 3 years. Direct sales by PLANET: 50000€ after 6 months and 700000 after 3 years. Licensing

Table 1: Compounds formulations BM Canvas

- **FA grafting**

Problem **1)** Materials that are water sensitive. Hydrophilic material that loose their function in the presence of high relative humidity. Materials that swell upon contact with water. **Alternative solution** **4)** Lamination with a water repellant plastic layer.	**Solutions** **4)** The fatty acid grafting technology is a process upscaled to pilot scale in which fatty acids are covalently attached onto a material surface e.g., biopolymer, paper-based material. The fatty acid grafting technology does not need solvents, is extremely material efficient and forms a nanoscale hydrophobic layer.	**Unique Value proposition** **3)** Through fatty acid grafting a **nanoscale hydrophobic effect** can be built without changing the surface of a product. **Material reduction:** The fatty acid layer is very thin (compared to e.g., plastic layer alternatives) and commony does not interfere recycling processes as other multilayers are not possible for mechanical recycling (chance of a **novel end-of life**). The fatty acid layer is **biobased** and **biodegradable**.	**Unfair Advantage** **7)** There was a patent on this technology which already expired. It is still a technology which is new and innovative.	**Customer segment** **2)** B2C and B2B sales focus on different target customers: a) Packaging companies b) Packaging users: food / cosmetic / pharmaceutical companies **Early adopters** Research institutes that upscale the process for a specific material to large scale. Companies that offer sustainable products such as more sustainable packaging or textiles. Printing companies as the technology is able to be used via gravure printing

	Key Metrics **6)** Number of requests to optimize the fatty acid grafting technology for their purpose.		**Channels** **5) B2B:** Printing/Packaging companies that can adopt the fatty acid grafting technology with their machines and product manufacturers that purchase the packaging material from the printing/packaging company. **Fairs, workshops, advertising campaign, magazines:** To present the possibilities and advantages of this technology to product manufacturers.	techniques. Paperproducing industry that have a need to hydrophobize their paper in an environmentally friendly way.

Cost structure

8)

Estimated cost	**6 months**
Staff (engineers, project managers, and administrative staff), R&D costs for industrial scale upscaling	200k€
Cost of raw materials	5k€
Depreciation cost of potentially required machines and components	5-100k€
Costs for life cycle assessment of new product versus old material	10k€
Sales & marketing costs (advertisement of new potentially more sustainable material)	50k€

Revenue Streams

9)

Printing/packaging industry: Direct sales of the product

Packaging users: food / cosmetic / pharma-ceutical companies: Cheaper packaging, potentially reduced costs for waste disposal for their end-consumers

Table 2: FA grafting BM Canvas

- **Process to allow FA combination with whey coating**

Problem **1)** Multilayer packaging are necessary to sufficiently protect sensitive products such as slides cheese or sausage. Multilayer packaging are mostly made of several fossil plastic layers that are commonly not possible to be mechanically recycelt. End-of life of multilayer packaging is incineration or landfilling. Alternative solution **4)** Alternatives are fossil-	**Solutions** **4)** Substitution of fossil-based non-biodegradable packaging by biobased multilayers made of whey protein layer (oxygen barrier layer) and fatty acids (protection layer towards water and water vapor) that are sufficient to protect the packaged product.	**Unique Value proposition** **3)** Both layers (whey protein and fatty acid) are biobased and biodegradable. The layers can be coated onto a substrate e.g. PLA and provide a biobased multilayer with new end of life (mechanical recycling for subtrate e.g. PLA films for industrial or PLA/PBSA films for home-composting conditions). Whey is a by-product of the cheese manufacturing industry and thus a potential sustainable raw material. Fatty acids onto whey protein coating is essential as the whey protein is sensitive towards water/water vapor.	**Unfair Advantage** **7)** The whey protein coating was patented WO2013014493A1. The combination with the fatty acids is new and innovative.	**Customer segment** **2)** B2C and B2B sales focus on different target customers: c) Packaging companies d) Packaging users: food / cosmetic / pharma-ceutical companies manufacturing oxygen sensitive products **Early adopters** Companies or packaging producers (e.g. in Europe) that need to change their packaging based on regulatory demands to lead to more circular packaging while maintatining their function in protecting the packaged good.

based, expensive, synthetic oxygen barrier layer e.g. EVOH or other fossil-based multilayers.	**Key Metrics** **6)** Number of manufacturers using the bio-based multilayer packaging made from whey protein and fatty acids to package there products.		**Channels** **5)** **B2B:** Technical workshops between packaging company that can produce the whey protein layer and fatty acid grafting and food product manufacturers. **B2C**: Fair, articles in magazine, press ect.	

<table>
<tr>
<td>Cost structure

8)

<table>
<tr><th>Estimated cost</th><th>6 month</th><th>3 years</th></tr>
<tr><td>Staff (engineers, project managers, and administrative staff), R&D costs for industrial (product individual) scale upscaling</td><td>200k€</td><td>If the scale up to industrial scale is set up (estimate 6-12 months) the running costs within the next 3 years are potentially not very high.</td></tr>
<tr><td>Cost of raw materials</td><td>10k€</td><td></td></tr>
<tr><td>Depreciation cost of potentially required machines and components</td><td>5-100k€</td><td></td></tr>
<tr><td>Sales & marketing costs (advertisement of new potentially more sustainable material)</td><td>50k€</td><td></td></tr>
</table>
</td>
<td>Revenue Streams

9)

Packaging industry: Direct sales of the new biobased multilayer film/packaging which is supposed to be cheaper compared to fossil-based multilayers obtaining an oxygen barrier layers such as EVOH.

Packaging users: food / cosmetic / pharmaceutical companies: Cheaper packaging, potentially reduced costs for waste disposal for their end-consumers</td>
</tr>
</table>

Table 3: Process to allow FA combination with whey coating BM Canvas

- **Fibres coating**

<table>
<tr>
<td>1. Problem

1) Need to replace coatings with sustainable alternatives due to pressure from clients and regulation

1. Avoid use of traditional materials such as PVC, PO, PU
2. Switch to solvent free coating approaches

Alternative Solutions

• Materials which are either biobased or biodegradable
• Usually require new techniques</td>
<td>4. Solutions

Top 3 features

1. Biobased and biodegradable
2. Solvent free
3. Relatively cheap and easy to produce

6. Key Metrics

• companies investigating the possible use of the solution
• companies using the solution
• Amount of product sold</td>
<td>3. Unique Value proposition

• Biobased coating
• Solvent free
• Waterborne
• Biodegradable
• Free of harmful chemicals
• Compatible with standard equipment</td>
<td>7. Unfair Advantage

• Patented solution
• Alternatives either are not applicable using wet coating techniques or are expensive due to the complex production method

5. Channels
• Exhibitions and fairs
• CTB channels such as newsletter and socials
• Publications
• CTB connections and consulting activities</td>
<td>2. Customer segment

Target customers

• Distributors of coating solutions
• Companies looking to replace their current coatings with sustainable solutions

Early Adopters
• SMEs interested in breaching into new segments or expanding their product range. (Their demand should show the potential to e.g. large distributors of coating solutions)</td>
</tr>
<tr>
<td colspan="3">8. Cost structure (when solution is ready for the market)

<table>
<tr><th>Cost</th><th>6 months</th><th>3 years</th></tr>
<tr><td>Material</td><td>50k€</td><td>200k€</td></tr>
<tr><td>Manufacturing overhead (indirect material)</td><td>5k€</td><td>10k€</td></tr>
<tr><td>Manufacturing overhead (indirect labor)</td><td>10k€</td><td>20k€</td></tr>
<tr><td>Manufacturing overhead (other)</td><td>5k€</td><td>10k€</td></tr>
</table>
</td>
<td colspan="2">9. Revenue Streams (after 6 months and 3 years)

For Centexbel: Possible licensing of patent (can also be a €0 revenue if done free)

For distributor:

First 6M: 50k€

• 3y: heavily depending on implementation and success: 200k€</td>
</tr>
</table>

Table 4: Fibres coating BM Canvas

- **Monitoring system for materials & Predictive models and derived app for biodegradation kinetics on BIONTOP**

Problem **1)** Top 3 problems His main problem Which job has to accomplish What and why? With the (1) increasing concerns about the environmental impact of plastic waste, companies are seeking ways to reduce their environmental footprint (2) and improve their sustainability practices (3). **4)** **Existing alternatives to address the same problems** While different models, such as BIOWIN, BESS, METABOL,	**Solutions** **4)** Top 3 features Based on the VP (why it is better than others) Use MVP to test assumptions Remember: the first sentence should clarify what it does, how it does it. By developing a system that can effectively monitor and sort plastic waste from packaging (e.g., black plastics problem, dirtiness), we can help businesses to achieve these goals while also (1) reducing costs and (2) improving operational efficiency of current sorting solutions. This system can also (3) assist governments in achieving their environmental targets by improving the management of plastic waste in their territories. Ultimately, we are addressing the need for more sustainable waste management practices in the industrial sector.	**Unique Value proposition** **3)** Why you are different and worth buying (How you help customer doing his job, accomplish his mission Improve his position …. better than others. Provide Explain how you differentiate from alternative solutions and thus the uniqueness of your solution. Provide numbers to the performance of your solutions (see earlier explanation). (1) in-line integration into manufacturing lines or for at-line use and along the value chain & chemometric models development maintenance (2) What we can measure: identification of materials (eg. new bioplastics), thickness of coatings or multilayer films,	**Unfair Advantage** **7)** Can it be easily copied or brought? What is the customer retaining costs? Acquisition costs Switching costs See the earlier explanation for clarification. …. We will offer a demo or trial which can help them see the value of our solution first-hand and make it easier for them to make a buying decision	**Customer segment** **2)** Who are they? Distinguish between users and customers (customers buy, users "use") Split into vertical segments Pick the strongest customer segment Remember geographic location, Industry and connection to the problem. The intended market & customers are: recycling waste companies, bioplastic material producers and biological processors for treatment of waste polluted with plastics at international level. **Early adopters** Remember geographic location, Industry and connection to problem. + why are they early adopters?

etc. exist for the prediction of the biodegradation of organic compounds (chemicals), no model is available for the prediction of the biodegradation of polymers. On the sorting side, all the used identification techniques require a pre-calibration which has to be developed for innovative materials, for which the right identification approach has to be proposed both to allow its subsequent recycling but also allow industry acceptance for new biopolymers in the main stream of currently recycled materials.	**Key Metrics** **6)** Key aspects/activities you need to measure for a feedback The inputs will be descriptive variables of the plastic (e.g. mechanical and chemical properties), the compost (e.g. chemical/biological composition) and the results of biodegradation testing over time (CO2 emission or some other measure vs time) of different combinations of compost and bioplastic materials. For a new compost/bioplastic combination, the system will be able to predict (with a given confidence factor) the KPIs. The system will use artificial intelligence data processing techniques to find the historical case (for which results are known) which best matches a new case. This will potentiate empirical testing by biomaterial researchers, as it will indicate the most promising material/compost combinations, thus reducing the number of evaluation experiments required.	micro-nanoparticles from liquid/solids (eg. microplastics), texturized surfaces, atomic element composition, foreign bodies, etc.) (3) IOT Wireless sensor Networks (4) Software development (a Platform to integrate Monitoring + Data analytics) & (5) Machine Learning, Deep Learning & Data fusion for augmented IR and model predictive control	**Channels** **5)** How you contact your customers/early adopters, How you deliver value How you promote value We will explain them that our full monitoring system or specific chemometrics package is designed to be installed in existing recycling plants and provide real-time information about the composition of incoming waste materials, allowing for precise sorting of bioplastics. This system offers a range of benefits, including reduced waste and improved yield, as well as increased efficiency and cost savings for their operations. We understand that waste management professionals are always looking for new and innovative solutions to improve our processes and meet the needs of their customers. In this manner, with our advanced technology, we believe that we can help them achieve these goals and make a positive impact on the environment. We would be	What is your relation to these etc. IRIS Marketing Department will approach early adopters internationally to introduce them to our innovative solution for improving the efficiency of recycling plants through the sorting of new bioplastics. As early adopters in the field, we believe that they will be particularly interested in the potential of this technology to revolutionize waste management practices and reduce the environmental impact of plastic waste.

			delighted to connect with them to discuss how our technology can benefit their business and help them achieve their sustainability goals.	

Cost structure **8)** Prototyping HR costs, Eng. costs, MFG costs, marketing costs etc. Estimate costs for each “cost-entity” Estimate costs after seed stage 6 months and 3 years. The size and the values will be customized according to the accuracy the costumer aims to achieve (eg. More units of monitoring at line will increase the accuracy and reduce the price). The post project exploitation strategy of IRIS will be to use all the foreground knowledge and prototypes for offering new B2B services to clients, such strategy will ensure that all the prototypes and technology built and developed will be able to be offered to new clients after the project end	**Revenue Streams** **9)** The different revenue streams How each stream generates revenue Estimation of how much each stream will generate Estimation of revenue at seed stage 6 months and 3 years. We will craft a targeted message that speaks directly to their needs and priorities by highlighting the benefits of our technology and how it can help them achieve their sustainability goals and improve their waste management processes.

- **Secondary packaging**

Problem 1)	**Solutions**	**Unique Value proposition**	**Unfair Advantage**	**Customer segment**
1) High impact of conventional secondary packaging on the environment and more demanding legislation regarding it. 1. No biocontent in the material increases its environmental impact in the production phase.	4) **Top 3 features** 1. Completely recyclable - films can be produced with 100% recycled material retaining all of their properties 2. High biocontent 3. Low environmental impact	3) Easy to process films that retain 100% their properties when recycled and have lower environmental impact than the fossil based counterparts.	7) • Know-how of processing novel material • Optimized production that lowers the cost of final product	2) Target customers Plastic converters and packaging companies that further modify the received films into their desired shape. There are many small and big companies in the Europe.

2. Limited mechanical recycling due to loss of properties (down to 50% of mechanical strength compared to original material) and available waste 3. End of life is either landfilling or incineration (only around 30% of material is recycled) of which both have high impact on the environment **Alternative Solutions** Increase of recycled content in the products. Reduction of material through decrease in packaging weight in turn, lowering its impact. Biobased alternatives with clear end of life scenarios and lower environmental impact.	**Key Metrics** 6) Key activities you measure • Amount of product sold • Number of customers • Number of complaints		**Channels** 5) Path to customers • Exhibition and Fair • Commercial agreement • Distribution of film demonstrators through already existing channels	**Early Adopters** Small and medium sized companies that can quickly test and switch to new type of materials.

Cost structure (when solution is ready for the market)

8)

Cost	6 month	3 years
Direct Labor	60k€	500k€
Material	270k€	3.2M€
Manufacturing overhead (indirect material)	20k€	300k€
Manufacturing overhead (indirect labor)	10k€	80k€
Manufacturing overhead (other)	50k€	100k€

Revenue Streams (after 6 months and 3 years)

9)

1) Sale of polymer films

6 months → 580 k€

3 years → 5.9M€

- **Films & trays packaging and coated laminates**

Problem 1)	**Solutions**	**Unique Value proposition**	**Unfair Advantage**	**Customer segment**
1) The current PLA-based packagings are industrial compost, and they have low barriers to O2 and moisture. 2) If a barrier is added, this layer is normally fossil-based and non-compostable, so the final packaging is not as sustainable	4) **Top 3 features** 1. Food contact approved 2. Home compostable 3. Medium-high barrier to O2 and moisture	3) If all the goals of the project are achieved, the outcome of this project would be a material that could be home composted, or recycled, not giving rise to any environmental concern. Additionally, the fact that it's based on biomass is reducing the impact in terms of CO2 footprint.	7) • Current packaging materials, based on traditional plastics, have a fine-tuned engineering that has resulted in very efficient products and processes. This is very difficult to replace.	2) Target customers Food producers in general. Specific markets: cheese, wet wipes, produce, coffee. **Early Adopters**

<table>
<tr>
<td>as initially designed.

Alternative Solutions

A re-design of the PLA matrix can be developed to make it home compostable. Additionally, bio-based and compostable coatings can be applied in order to increase the level of barrier</td>
<td>Key Metrics

6)

Key activities to measure

• ARCHA will perform the migration tests to check food approval.
• University of Pisa are performing the compostability of the material.
• AIMPLAS and INNOTECH are measuring the barrier properties.</td>
<td></td>
<td>Channels

5)

Path to customers

• Some customers are part of the consortium.
• Fairs and exhibitions
• Leaflets, online media</td>
<td>The material resulted from this project won’t probably work at the final customers, so the main beneficiaries of this material will be tech centres and converters that should rework on it to get the final packaging material.</td>
</tr>
<tr>
<td colspan="3">Cost structure (when solution is ready for the market)

8) N.A.</td>
<td colspan="2">Revenue Streams (after 6 months and 3 years)

9)

Revenues in our case would come through:

- Incorporating this development to our product portfolio and selling it to current or new customers

- Selling a licence to other converters to produce this product in other markets or geographies different for ours</td>
</tr>
</table>

Table 5: Films & trays packaging and coated laminates BM Canvas

- **Process to obtain nets**

<table>
<tr><td rowspan="2">Problem 1)

Processability into nets of the new compounds developed in the project.

Alternative Solutions

Using already known compounds that are not home compostable or organically recyclable to obtain biobased or not-biobased nets.</td><td>Solutions

Correct process parameters

Processable with actual machines of the company</td><td rowspan="2">Unique Value proposition

The obtained know how will allow to produce biobased nets from the home compostable and organically recyclable compound under the correct parameters.</td><td>Unfair Advantage

Being the first to work with the new compounds for obtaining nets.
Confidential know-how – Industrial secret.</td><td rowspan="2">Customer segment

Internal use

Early Adopters

Own company</td></tr>
<tr><td>Key Metrics

Number of products in which the company applies the know-how.

Sales of new products produced under the achieves know-how.</td><td>Channels

Application in new products of the company.</td></tr>
<tr><td colspan="2">Cost structure (when solution is ready for the market)

Depending on final nets product</td><td colspan="3">Revenue Streams (after 6 months and 3 years)

Depending on final nets sales</td></tr>
</table>

Table 6: Process to obtain nets BM Canvas

- **Specific biodegradable formulations for textiles & Processability of novel biopolymer formulations into textiles**

Problem **1)** Customers and some governments demand for tea bags to be home compostable. Current solution for woven tea bags was "only" industrially compostable **Alternative solution** **4)** Alternatives that reach home composability are as far as we know not commercial yet in a woven tea bag. There are currently no home compostable	**Solutions** **4)** 1. Home compostable 2. Transparent 3. (close to) Drop in material	**Unique Value proposition** **3)** Home compostable nets for tea bags offer clients the possibility to produce home compostable tea bags (current solutions are only industrially compostable) while retaining the properties of the classical tea bag: food contact, transparency, etc	**Unfair Advantage** **7)** • Trade secret and processing experience • Home compostability	**Customer segment** **2)** Target customers Teabag producers/converters **Early adopters** Current customers making teabags using industrially compostable nets. Project partner Sioen is currently developing this onto industrial scale to start producing the fabric for these home compostable woven tea bags.

<table>
<tr>
<td>woven tea bags on the market, only industrially compostable.
Other home compostable alternatives are either nonwovens or paper alternatives but these lack the transparency typical for woven tea bags. Most of these are also not drop in as they are not thermoplastic.</td>
<td>Key Metrics
6)
- Sales of nets in linear (kilo)meters

- # of new customers</td>
<td></td>
<td>Channels
5)
Path to customers
• Exhibition and Fair
• Contacts with original customers that purchased industrially compostable nets.</td>
<td></td>
</tr>
<tr>
<td colspan="3">Cost structure
8)
<table><tr><th>Estimated cost</th><th>6 months</th><th>3 years</th></tr><tr><td>Direct Labor + Material</td><td>90 k€</td><td>1.080 k€</td></tr><tr><td>Overhead (indirect labor + material + other)</td><td>5 k€</td><td>5 k€</td></tr><tr><td>Total</td><td>95 k€</td><td>1.085 k€</td></tr></table></td>
<td colspan="2">Revenue Streams
9)
Estimated sales of nets per month:
• 6M: 120 k€
• 3Y: 1.2 M€</td>
</tr>
</table>

Table 7: Specific biodegradable formulations for textiles BM Canvas & Processability of novel biopolymer formulations into textiles

6. Analysis on further funds to advance the TRLs

- **HORIZON EUROPE**[11]: the EU's key funding programme for research and innovation with a budget of €95.5 billion. It tackles climate change, helps to achieve the UN's Sustainable Development Goals and boosts the EU's competitiveness and growth. The programme facilitates collaboration and strengthens the impact of research and innovation in developing, supporting and implementing EU policies while tackling global challenges. It supports creating and better dispersing of excellent knowledge and technologies. It creates jobs, fully engages the EU's talent pool, boosts economic growth, promotes industrial competitiveness and optimises investment impact within a strengthened European Research Area. Legal entities from the EU and associated countries can participate.

- **CBE-JU**[12]: CBE JU is a €2 billion partnership between the European Union and the Bio-based Industries Consortium (BIC) that funds projects advancing competitive circular bio-based industries under Horizon Europe, the EU's research and innovation programme. CBE JU is the legal and universal successor of BBI JU. In this framework the most suitable funds are those related to the Innovation Action in order to raise BIOnTOP TRLs up to 9.

- **Interregional Innovation Investment**[13]: The Interregional innovation investments instrument as part of the European Regional and Development Fund (ERDF) aims at supporting interregional innovation projects in their commercialisation and scale-up phases giving them the tools to overcome regulatory and other barriers and bring their project to investment level. The agency will implement two call strands: i) Financial and advisory support for investments in interregional innovation projects; ii) Financial and advisory support to the development of value chains in less developed regions. The I3 Instrument work programme aims at promoting innovation through Smart Specialisation and interregional collaboration. The I3 Instrument supports stronger interregional cooperation in investments and makes sustainable connections by linking regional ecosystems in shared smart specialisation areas vital to accelerate market uptake of research results and stimulate innovation.

- **Cascade fundings**: Cascade Funding, also known as Financial Support for Third Parties (FSTP), is a European Commission mechanism to distribute public funding in order to assist beneficiaries, such as start-ups, scale-ups, SME and/or mid-caps, in the uptake or development of digital innovation.

  This funding method aims at simplifying the administrative procedures, creating a light, SME-friendly application scheme, by allowing that some EU-funded projects may issue, in turn, open calls for further funding.

  This scheme is based on the model of Erasmus students and was first introduced by the European Commission in Horizon 2020, the Framework Programme for Research and

[11] https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en

[12] https://www.cbe.europa.eu/

[13] https://eismea.ec.europa.eu/programmes/interregional-innovation-investments-i3-instrument_en

Innovation (2014-2020). It will be used also in the new Horizon Europe Framework Programme for Research and Innovation (2021-2027).

More information and open calls available here: https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/competitive-calls

7. FINANCIAL ANALYSIS

In order to investigate the economic and commercial viability and perform a financial analysis, the results of the LCC studies conducted by OWS in the frame of task Task 4.1 Life cycle sustainability assessment have been used.

See deliverable D4.2 for more details of the Life cycle cost assessment. The conclusions of the Life cycle cost assessment in deliverable D4.2 are that most biontop demonstrators had higher Life Cycle Costs than their reference systems and that the costs of the production phase represented at least 78% of the total life cycle costs. The coated biontop tea bag textiles had lower costs across the total life cycle, but the production costs were comparable to the combined production costs of PET-tea bags and LDPE secondary packaging. Copolymer production, when required for the demonstrator, was the major cost contributor because of its high electricity consumption, although the drying processes during compound production were important cost contributors. However, cutting the electricity costs alone was found not sufficient to bring the life cycle costs to the same level of the reference systems. Also, the biopolymer costs should decrease. It should be noted that the costs of the end-of-life waste treatments were found to be more important for the reference systems than for the biontop systems. While generally speaking composting has a lower cost than incineration, and incineration has a lower cost than recycling, the observed Life cycle costs of the biontop demonstrators were much more affected by the very high production costs, rather than by the decreased costs at the end-of-life, unless the end-of-life strategy allowed closed loop recycling, thereby effectively decreasing the production costs. Note that this effect of recycling would decrease if the production costs themselves decrease as a result from production optimization. An interesting case is given by the tea bag textiles, of which the uncoated tea bag textiles resulted already in similar (although higher) life cycle costs as the reference system and the coated tea bag textiles resulted in comparable or lower life cycle costs than the reference system. This case is especially driven by the costs at the end-of-life, because of the relatively high cost and low energy recovery when incinerating tea bags containing tea. It should also be remembered that in the future further cost reductions of the biontop demonstrators are expected because biopolymer production is in the process of optimization. In addition, the current Life cycle cost was performed with the recent relatively high prices for averaged European non-household grid electricity. When in the future more European electricity is produced within Europe by using sustainable non-fossil technologies, future electricity unit prices may decrease and become less sensitive to price fluctuations. Because the major cost contributor for most of the demonstrators was electricity consumption at the copolymer and compound production phase, a 40% reduction of current obtained life cycle costs might be possible. However, in order to obtain similar production costs of fossil-based polymers and plastics, also the costs of biopolymer production must decrease.

CONCLUSIONS

BIOnTOP is a high impact project that contributes to the improvement of the bioeconomy in Europe. As shown in the paragraphs above it delivers cost competitive packaging solutions that can be mechanically recycled or industrially/domestically composted combining different approaches to tailor the bioplastic biodegradation. In this way, the sustainability from cradle to cradle of several new bio-based high-volume applications is maximised.

All the activities carried out during the project allow to say that the proposed solutions are all commercially viable in practice. BIOnTOP significantly contributes to the KPIs set out in the overall BBI-JU roadmap and more specifically to the expected impacts in the topic BBI.2018.SO3.R10-Develop bio-based packaging products that are biodegradable/ compostable and/or recyclable, packaging products that are biodegradable/ compostable and/or recyclable. BIOnTOP furthermore contributes to social and environmental impacts in terms of pollution and consumer health.

The consortium will analyse all the available potential funds to advance the TRLs of such promising applications in order to start the commercialization phase in the next few years.