D.T1.1.6 – REPORT ON MARKET AND ECONOMIC FEASIBILITY ANALYSIS TO REACH MARKET APPLICABILITY

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1. Introduction

Over their short "life" after their discovery in the first half of the 20th century plastics have become an essential material basis for human life. They are found in virtually all sectors where their use brings huge benefits. On the other hand, plastics are polluting our soil and water and represent a threat to our health and our planet.

Packaging is a significant use of plastics as well as other materials. Packaging has become an essential commodity in the modern life, but due to its dispersed use and a very short time in which it end as waste, it is a major resource sink and a major environmental threat. Packaging is increasingly composed of several materials that complement each other to provide better service. Paper and cardboard represented 41 % of all packaging waste generated (by weight) in the EU-28 in 2016 (about 35,4 million tonnes). The increasingly common combinations of paper and plastics are emerging as a limit for advances in waste management that will ultimately lead to environmental effects. For example, the appearance of plastic stickies and microplastics in recycled paper has become a concern in paper recycling.

The current state-of-play is largely still based on concepts developed before the advent of modern environmental standards, current waste management practices and concepts of efficiency in resource use. These relatively recent concepts are now translated into policies and concrete measures that are now influencing all sectors of life. This is a profound transition that requires social and technical changes, new attitudes and new technologies. Changes in packaging are only one small area in this transition, but one that has the potential to touch every citizen, contribute to a reduction of environmental burdens and add an important practical contribution to meeting new policy standards.

The changes required in the specific field need to mobilize synergies between business and research in the area of combined paper-bioplastics packaging design, production and recycling in Central Europe. These linkages are not sufficiently established due to lack of awareness in the paper and converting sector about new bioplastics materials, a strongly separated focus on plastics or paper in clusters and branch organizations, the lack of a common innovation strategy within a clear European and national legal and economic context and the lack of dedicated tools to support SME's as well as larger companies to introduce new paper-plastics packaging solutions.

Advances in biodegradable packaging offer a solution, but more producers need to be aware of the availability of more sustainable packaging that still retains all functional benefits as current conventional packaging. The BIOCOMPACK-CE project is aiming to develop tools to share knowledge in paper and bioplastics, to improve the technology and to help companies understand their packaging options.

The purpose of this document is to encourage stakeholders in the paper-plastic packaging value chain and to offer support to those interested in a transition to more sustainable solutions. The present report describes the framework and a plethora of aspects that influence the decision to transition to new solutions that should be considered when entering in new business opportunities. The content is organized to help them implement solutions answering to regional challenges in the fields of paper-bioplastics packaging innovations. At the same time we would like to influence the policy-makers when making choices for their strategic planning. The ultimate goal that we are aiming for is to build a cohesive group among actors in the biocomposite packaging value chain.

2. Feasibility

A Feasibility study deals with a broad multitude of aspects that influence a business development and is used to support a business decision-making process. Feasibility, in a narrow definition, may be considered as a likelihood of successfully bringing options to real life. For the purpose of this study the option we consider bringing to life are environmentally advantageous solutions in paper-plastic multimaterial packaging and other products. Real life is viable production and use of biocomposite multimaterial products. Finally, we add can the regional focus of Central Europe that defines the focus of this study as well as the Biocompack-CE project, but the concepts explored are in no way limited to the region.

Feasibility = likelihood of bringing option to life

Option = products made from paper/plastic composite
Life = viable market performance

2.1. Background conditions

When considering feasibility there are a number of background factors - conditions that need to be considered. For the selected application those most relevant are:

- Environmental benefits
- Resources
- Economic conditions
- Use and demand
- Lessons learned /best practices
- Policy

The importance of these factors does not necessary follow in this order but all will play a role in establishing the feasibility of a sustainable product such as paper-plastic biocomposite packaging.

Environmental benefits of a product one considers putting on the market will include an evaluation of *reduced environmental burdens* which can be in different categories such as pollution reduction, emissions reduction (e.g. CO2 equivalent) or various specific measures.
The reduced burdens are directly linked to *Resource efficiency* – the amount of resources such as raw materials, water, energy use, their type and source. Resource efficiency is strong linked to the practices of the circular economy that forsees an efficient (low) resource use as well as reuse that lowers the demand of inputs per product unit. Reuse is strongly linked to waste treatment including recycling as well as waste collection organization, but is ultimately also dependent on product design.
Safety is an additional aspect to look at. A safe product will not exert significant environmental burdens even if handled in a suboptimal way.
A direct measure of environmental aspects are results from a Life cycle analysis (LCA). These are not always available and can easily surpass the capacity of a fledgling business, but simplified measures if conducted in a thorough and honest manner and keeping to life cycle thinking can also offer useful insights.

Resources must be available for a business development. Limiting the scope to Central Europe and the application one can list regional paper and plastic production and the converting industry, knowledge related to these activities, logistics, markets and consumers, the innovation system as well as existing waste management options. This combines the physical resources (materials and industrial capacity) as well as soft resources trained personnel and knowledge support. Markets may be local or external so waste management capacity linked to the market should be considered. For example, targeting a market without composting facilities and a collection of organic waste with compostable products will likely be a failed attempt.

Economic conditions are a key factor in business activities and expansion. The broader economic conditions that may be growing or declining and may differ by sector country or region are the background to more specific factors such as the economic capacity for investment in a company or in the broader economy. The structure of the relevant industry (e.g. paper, plastic, trading, engineering etc.) is highly relevant. Purchasing power and its trend will define opportunities in the markets as will public support measures for sustainable development. The later may be defined in different terms such as reduction of energy use, renewable energy support, carbon neutrality goals, circular economy development etc.

The **Demand** for new sustainable products is crucial. New, sustainable products demand a high level of awareness spread through the society. This is normally fueled by NGOs and media. Alternatively, awareness can be pushed by companies however this is a difficult and demanding task normally not at the core of a business. Demand can also be significantly influenced or even defined through regulatory requirements or restrictions. This can be achieved by specifications of materials that are allowed in certain uses or in a softer way through preferential treatment of certain solutions/products through fees. A typical and relevant example are packaging fees that distinguish between materials or uses.
Markets and their characteristics are key for demand. These can be domestic markets or export markets that can be reached directly by sales of the product or indirectly with a product (such as packaging) sold there via another product.

Business decisions are made in the context of **existing knowledge and experiences**. Knowledge acquisition, lessons learnt and best practices all shape the context and support decisions. Typical methods to acquire and assess such prior knowledge is through projects done with domestic or international partners. An analysis of market trends especially in lead markets where successful practices can be observed as examples of best practices. The acquisition of practices may also be done between sectors with appropriate adjustments. Not only successes but also failures must be considered when looking for best examples and cases from which lessons may be learnt.

Finally, the **policy** context and its effect on the business option should be understood. Policy is a very important factor in defining future business opportunities for sustainable solutions. The current - exiting policy framework defines the existing market conditions whereas expected policy will define the conditions in the future. It is important to understand the predictable future trends especially when entering innovative and long-term business developments. This relates to all level of policy and regulation that follows: international, national as well as regional or local. Due to its nature local policy can change faster than national policy but can define market conditions to the same extent. For example, city regulation can easily set higher standards than national regulation but can define a sufficient market to start operations. The same may apply to industry, sectoral or even company policy that may be voluntary or obligatory. Policy at these lower levels is often faster, more innovative and ambitious than at higher political levels and will be passed by bodies that do not follow demanding and often slow and unpredictable procedures as for example national parliaments responsible for national legislation.

All these factors described above must be considered in the decision-making process regarding business decisions. Most of these factors however are **external** – outside a particular company and are beyond the influence of a business actor. There are of course important **internal** factors as well that will define feasibility of a business move. These factors such as financial standing, available internal knowledge, staff, space etc. will not be described here as these are normally well understood by the company management.

2.2 Strategy

Feasibility will also depend on a strategy taken and its implementation. The background analysis outlined above and the specific assessment of the business actor and the development option under consideration should lead to a strategy with a high probability of success.

Strategy should define discrete options regarding the market, context and knowledge.

A market decision should define the overall fundamental nature of the development in terms of market lead or creation and time frame. The fundamental question is whether the development will follow demand in the market and how well established the competition may be, or will it attempt to create demand which will have less established competition but may be riskier and more demanding. Especially with highly innovative products and services we can also act on anticipated demand that we expect to appear in the future. A lead time will offer more possibilities for trials, prototypes and market preparation but will bring results in a longer period.

A decision also must be made regarding the market that we wish to enter. This may be commodity or niche both with specifics in competition, size and requirements.

Also technology options: using existing technology or newly acquired technology should be made as they influence investment, productivity and the time range. When planning to put products on the market these must be understood in terms of end-of-life options possible, available and targeted. For paper/plastic multimaterial composites it is important to understand if recycling or composting for example are the preferred options. In term of market the value chain should be understood including all parts and what position /role in it we will assume. The value chain and role will largely define growth and development options as well as risks, limitations and exposures.

To complete the strategy views, the knowledge position must be defined. What knowledge must be obtained and where can it be found? Through staff hiring, consultants, from academic sources or through organizations/associations or partners/suppliers. And in addition, what support options for knowledge acquisition should be explored. For example, projects, institutions, support programs can be serve as options.

The desired change to new sustainable products can occur through many routes but a thorough understanding of the conditions that shape the business landscape for a specific development option should be understood and an appropriate strategy should be formed that has a high degree of probable success. a guided process as developed within the Biocompack-CE project should help to assess such factors and assist the decision-making process. Still, it is important to understand that each development route will be special and different but the key will be the wish to change.

3. European Policy Frame

3.1. European Green Deal

The European Green Deal[1] (EGD) plays a driving role in the policy agenda for the new European Commission that clearly directs the innovation and development efforts into a sustainable future for Europe and seeks a leading global role for Europe. Climate change is the top priority of the policy that proposes to make the territory of the European Union climate-neutral by 2050. Although EGD and S3 are not comparable initiatives, the S3 process by its impact on effective governance, principles of stakeholder involvement, its bases in entrepreneurial discovery and transparency has a great potential to substantially contribute to the EGD. A recent policy analysis[2] proposes that EGD should be conceived as a reallocation mechanism, fostering investment shifts and labour substitution in key economic sectors, while supporting the most vulnerable segments of society throughout the decarbonisation process.

Early-stage EGD policy documents and the proposed Roadmap[3] of the Commission directly address actions in the domain of plastics, namely under 1) *Industrial strategy for a clean and circular economy*: Circular Economy Action Plan, including a sustainable products initiative and particular focus on resource intense sectors such as, construction, electronics textiles and plastics, on which first action is scheduled for March 2020, and 2) pollution under the action: *Towards a zero-pollution ambition for a toxic free environment*, the task Zero pollution action plan for water, air and soil (action planned for 2021) can be understood to cover the challenge of plastic and microplastic pollution.

Plastics have become a major public and policy concern which is illustrated by the frequency of media reports about plastics as well as the policy documents and measures that specifically focus on plastics. Concerns about plastics include two main aspects that significantly differ from other materials: **circularity and pollution**.[4]

3.2. Circular Economy

Change mind set from linear to circular approach. Develop different value chain = reuse some materials to reach CE

A circular economy is a systemic approach to economic development designed to benefit businesses, society, and the environment. In contrast to the 'take-make-waste' linear model, a circular economy is regenerative by design and aims to gradually decouple growth from the consumption of finite resources. After defining what an economy actually is, this learning path explores the nuances of the concept of a circular economy, including the difference between biological and technical materials, the different

[1] The European Green Deal, Dec 11, 2019 https://ec.europa.eu/info/sites/info/files/european-green-deal-communication_en.pdf

[2] Grégory Claeys, Simone Tagliapietra and Georg Zachmann: How to make the European Green Deal work, Bruegel, Policy Contribution Issue n °13, November 2019 https://bruegel.org/wp-content/uploads/2019/11/PC-13_2019-151119.pdf

[3] European Green Deal: Roadmap - key actions, Dec 11, 2019 https://ec.europa.eu/info/sites/info/files/european-green-deal-communication-annex-roadmap_en.pdf

[4] Fighting Plastic Pollution, European Parlament, 2020 https://www.europarl.europa.eu/news/en/headlines/priorities/fighting-plastic-pollution

opportunities that exist to keep materials and products in use, and the history of the idea. Finally, the benefits of shifting from a linear to a circular economy are highlighted.(copy/paste https://www.ellenmacarthurfoundation.org/explore/the-circular-economy-in-detail)

Despite efforts to improve waste management efficiency circularity – the circular use of plastics, remains a challenge. Currently only 30 % of waste plastics are recycled while 39 % are incinerated and 31 % landfilled[5]. This represents a poor use of resources, a loss of value and business opportunity and is directly linked to pollution. Combined with the projected growth in plastics use the challenge will gain importance in the future. The circular economy is an important European policy that was introduced in 2015 within the *EU Action Plan for the Circular Economy*[6] which should help stimulate Europe's transition towards a circular economy, boost global competitiveness, foster sustainable economic growth and generate new jobs.

The action plan established a concrete and ambitious program of actions, with measures covering the whole cycle: from production and consumption to waste management and development of markets for secondary raw materials and a revised legislative proposal on waste. The principles of a circular economy and efforts to "close the loop" is included in the revised legislative framework on waste that entered into force in 2018. It sets clear targets for reduction of waste and establish an ambitious and credible long-term path for waste management and recycling with specific targets for every major material type. The implementation of the Action plan could be seen by the inclusion of circularity-related topics (e.g. recycling) in EU sponsored R&D programs.

3.3. Plastic Strategy

A crucial policy development specifically targeting plastics is the *European Strategy for Plastics in a Circular Economy*[7] ("Plastic Strategy") The strategy set goals, principles and concrete measures to improve management of plastic materials with a focus on waste management improvements and reduced pollution.

A direct outcome of the strategy is the enactment of a new directive restricting use of single-use plastics.[8] A number of measures under preparation address improving harmonization and traceability of recycled plastics which aims to improve safety of recycled plastic materials and a growth in market demand for recycled plastics.

The Strategy recognizes the problem of the considerable plastic contribution to marine litter and the problem of microplastics. It outlines specific actions to deal with marine litter: actions to tackle sea-based sources of marine litter, and actions to monitor and curb marine litter more effectively.

[5] Factsheet about the Plastic Strategy: https://ec.europa.eu/environment/circular-economy/pdf/pan-european-factsheet.pdf

[6] Closing the loop - An EU action plan for the Circular Economy (2015) https://eur-lex.europa.eu/resource.html?uri=cellar:8a8ef5e8-99a0-11e5-b3b7-01aa75ed71a1.0012.02/DOC_1&format=PDF

[7] A European Strategy for Plastics in a Circular Economy (2018) https://eur-lex.europa.eu/resource.html?uri=cellar:2df5d1d2-fac7-11e7-b8f5-01aa75ed71a1.0001.02/DOC_1&format=PDF

[8] Directive 2019/904 on the reduction of the impact of certain plastic products on the environment https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019L0904

3.4. Smart Specialization Strategy

The fully-fledged introduction of the **Smart specialization strategy (S3)**[9] concept into the European territorial development policy was a unique territorial development initiative that significantly surpassed any such procesesses in past both in scope and principles applied. Characteristic for S3 is the »place based« strategy that allows regions and EU member states to define their own development agenda based on their unique priorities and identified strengths.

Formally the Smart Specialisation Strategies are defined as integrated, place-based economic transformation agendas that focus on policy support and investments on key national/regional priorities. They encourage a broad stakeholders involvement, while taking into account local strengths, competitive advantages and potential for excellence.[10]

S3 is an outward-looking policy instrument that seeks to overcome sectoral and national limitations to seek cross-cutting synergies and efficiencies as well as broader, mutual support across the entire S3 process. This approach is supported both by substantial dedicated funds and a sufficiently long time-frame that supports significant progress to be made.[11] [12] As such, the S3 innovation policy is expected to play a crucial role in the promotion of the European economy and its independent leading role in the world.

Macro regional strategies and European **Territorial Cooperation Programmes**, also known as interreg have integrated the smart specialisation development in their work plans facilitating cooperation among regions and countries. Cooperation in S3 at the macro-regional level helps explore whether and how S3 priorities envisaged in national and regional strategies differentiate, or are complementary to, their neighbouring countries/regions. It also leads to the creation of strategic linkages to tackle common challenges when engaging in joint S3 initiatives.[13]

3.5.- UN Sustainable Development Goals (SDG)

Another important driver (not of EU origin, but with full EU support) in the industry today are Sustainable Development Goals (SDGs) that are at the heart of the UN's 2030 Agenda, adopted in September 2015. The European Treaties has sustainable development firmly anchored in their European policy for a long time and these goals have given a new impetus to global efforts for achieving sustainable development. The EU is fully committed to playing an active role to maximize progress towards the Sustainable Development Goals.

[9] Smart Specialization Platform, What is Smart Specialization? https://s3platform.jrc.ec.europa.eu/what-is-smart-specialisation-

[10] Dominique Foray and Xabier Goenaga: The goals of Smart Specialisation, JRC-IPTS S3 Policy Brief Series No. 01/2013 ftp://139.191.159.82/pub/EURdoc/JRC82213.pdf

[11] European Regional Development Fund (ERDF) https://ec.europa.eu/regional_policy/en/funding/erdf/

[12] European structural and investment funds, Data: https://cohesiondata.ec.europa.eu/

[13] S3 cooperation in the frame of the EU Macro-Regional Strategies: https://s3platform.jrc.ec.europa.eu/eu-macro-regional-strategies

Eurostat is regularly preparing reports to monitor progress towards the SDGs in an EU context. The analysis in their publication builds on the EU SDG indicator set, developed in cooperation with a large number of stakeholders. The indicator set comprises around 100 indicators and is structured along the 17 SDGs. For each SDG, it focuses on aspects which are relevant from an EU perspective. The monitoring report provides a statistical presentation of trends relating to the SDGs in the EU over the past five years ('short-term') and, when sufficient data are available, over the past 15 years ('long-term'). The indicator trends are described on the basis of a set of specific quantitative rules. More detailed information is available at Eurostat webpage. https://ec.europa.eu/eurostat/en/web/sdi/overview

Contribution to the SDGs is imperative for any sustainable business. In the case of the biocomposites packaging especially contribution to the SDG 9 'Industry, innovation and infrastructure', SDG 12 'Responsible consumption and production' and SDG 13 'Climate action' should be made.

4. Market condition

4.1. Trends

Packaging market is highly affected by leading economic and demographic trends. Europe being the second largest regional packaging market accounting for around 25% of global packaging market value in 2017, valued at €195.2 billion in 2018 and is forecast to grow to € 214.0 billion in 2023 according to new Smithers Pira publication – The European Packaging Competitive Landscape: Strategic Forecasts to 2023.

4.1.1. - Economic/demographic trends

- Growing number of people living longer and/or living alone
- economic growth
- population growth
- urbanization
- ageing population
- single-person household

4.2. Situation by PPs countries & global

Central Europe is a very specific region in terms of paper/plastic biocomposites as it covers the traditionally innovative broader alpine area as well as straddling the historic and wealth divide between western and Eastern Europe. The countries represented in BIOCOMPACK-CE include Italy – a founding member state representing Western Europe on one side of the spectrum and Croatia the most recent member state from south-eastern Europe on the other. Italy is home to one of the largest bioplastics producers (Novamont), has a large and extended composting industry, a very innovative industry and is a European frontrunner in terms of legislative measures supporting sustainable packaging. On the other hand Croatia due to its relatively recent entry into the EU is lagging in waste management organization and infrastructure as well as innovation in packaging sustainability. For example, Croatia is still experimenting with only several municipalities collecting organic waste and a very modest extent of composting facilities. Other countries in the project: Poland, Slovenia, Slovakia and Hungary can be placed into the "space" between these two extremes, each with specific strengths and weaknesses.

Croatia

Croatia joined the EU most recently among countries participating in the project. It is therefore still upgrading its waste management system to align it fully with EU requirements. A shortcoming most relevant to the topic of sustainable biocomposite packaging is the lack of separate collection for organic waste. This is collected only in several counties on a semi-experimental basis. This is a serious impediment for a potential uptake of compostable packaging. In line with the collection situation biological waste treatment capacity – especially composting facilities are also insufficient.

In Croatia, there are two major companies at the market that produce biodegradable films and foils, EcoCortec in Beli Manastir and Weltplast in Odra / Zagreb. In its production program, Eco Cortec offers products based on three types of biodegradable polymers – PLA, PHA and fossil-based biodegradable polymer, while Weltplast works with BASF biodegradable polymers. EcoCortec and University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture have been involved in the CIP Eco-innovation project, funded by the European Union – MarineClean (Marine debris removal and preventing further litter entry), with the scope of developing plastic packaging material, degradable in seawater.

Hungary

In Hungary, with the aim to produce PLA,6 years ago Nitrokémia Zrt. planned to set up a bio-refinery in its factory site, in Balatonfűzfő within a Hungarian-Chinese joint venture. The capacity was planned for 80.000 tons per year and the costs of investment was budgeted for HUF 40 million. However, the project has not been implemented yet. On the other hand there are global players as Burger King Magyarország open for environmentally friendly products on the domestic market. Coated paper cups are currently purchased from abroad. The operator of Burger King Magyarország has provided their forecasted demand of paper cups by 2018 that means about 10 million pieces of paper cups. On average a paper cup weights 14 g and a 7-9% PLA coating might be applied, that means 1,12 g/cup on average. The annual PLA usage by Burger King, in case of coating 9,5 million pieces of paper cups means approx. 10,6 tons of PLA.

Ugrinpack is a small innovative producer of laminated compostable papers and cups. They are a leading producer of products made from paper/plastic biocomposite materials. Their products are used by fast food chains and have been also used during large public events.

Profikomp (https://www.profikomp.hu/en/) is a leading provider of composting facilities.

Italy

Italy is among the leaders in the EU in sustainable material and product production and use. It has one of the largest European production capacities for biodegradable plastics and a very extensive composting capacity. It is also an important market for compostable and multimaterial compostable packaging and other products. Italy can therefore serve as an example for a successful introduction of such products in production and use, as well as for infrastructural development.

In Italy the multi-material cellulose-based packaging represents approximately only 3-4 % of the total paper based packaging produced in the country. This calculation takes into account rigid multi-material products such as milk containers as well an estimation of the share of flexible multi-material packaging made of paper/plastic. Multimaterial papers and products are the production domain of the paper value chain. Plastics converters do not produce such products. So the most important industry for this sector is the paper industry. Besides beverage cartons, multimaterial products are mainly used in flexible packaging, especially in retail (e.g. large quantities of windowed paper bags) and for food stuffs where they serve to display, protect and preserve the product. Other less specific and very varied products are also packaged in combined materials (pharmaceuticals, batteries ...). Products mainly consist of laminated or extruded plastic polymers on papers for print, packaging or other products and of packaging and other products with added barriers, windows, plastic envelopes etc.

Poland

In Poland, it is difficult to talk about a market for products made of biodegradable plastics or packaging made from the bioplastics market and biocomposites before 2016. There are numerous marketing activities aimed at showing the advantages of this type of products, mainly in the ecological aspect, but their sale rate is still very modest. However, three companies have biocomposite products in their offer, though they are not widely used yet and have a small share in the packaging market. On the Polish market there are products from this group made of paper (paper, cardboard or cardboard), laminated with NatureFlex cellulose film (paper plates, various types of cardboard boxes). In addition to aqueous glue and paints, they consist entirely of cellulose-derived materials.

On the other hand, Poland has a very strong scientific base of Universities and specialized research institutions involved in basic and applied research focused on sustainable materials such as composites and plastics. Together with the large market Poland has great capacity for impact as well as significant industrial/business development.

Slovakia

In Slovakia the company PANARA a.s. entered into bioplastics area since 2006 with the goal to develop biodegradable- bio based blends for different types of plastic processing. Strong partnership with Slovak university of technology escalated into common excellent and unique Centre called CEPOMA (Center for Applied Research of environmentally friendly polymeric materials) which is technological and technical base for research and development activities connected with new biodegradable and bio based blends. Presently there is no bioplastic production, however, the company PANARA s.r.o. will realize in 2018 the construction of production units of these materials in the SR with an initial capacity of 1.2 kt/year and after running the production unit plans to expand production capacity to a minimum of 40 kt/year.

Slovenia

Slovenia is another specific case in the project defined by a small but developed market, an efficient waste management system and a relatively high awareness. The small economy does not possess plastic production but has a very extensive converting sector. Slovenia, due to its size is likely to have issues to assemble a complete "national" value chain and is likely to link with partners in other countries.

In Slovenia There is no market developed for the paper-bioplastic packaging products yet, nevertheless, it has a good potential to develop as demand for such products is rising. All the players involved in the value chain of the paper-bioplastic packaging are already well represented, the only question is, how and when they will get started with new products business and trading.

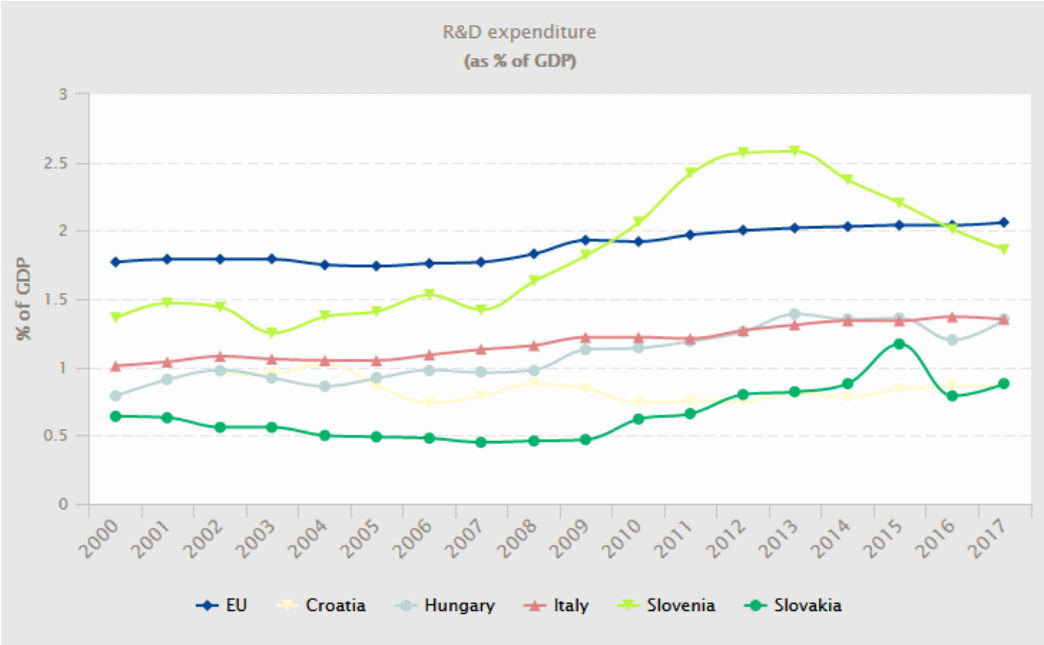

Figure 1. Investments in R&D in countries represented in Biocompack-CE project. Source:Eurostat

4.3. Situation by relevant sector

Biocomposites

Biocomposites that combine paper and plastics are not recognized as a separate material or product group. As a consequence they are not represented in available statistical data. This is a result of the relatively small quantities produced and used. These combined materials are also not commonly treated separately in the frame of packaging or packaging waste. Therefore it is difficult to obtain reliable data on the extent of their use, especially in markets that are still at an early stage of development.

There is a huge potential for the growth of the biocomposites. That is why it is important to establish a good value chain in the biocomposites that at the moment do not exist yet.

Paper industry

Paper industry is well developed in all countries, however only in Italy there are few advanced paper recycling mills with the possibility to treat efficiently multi-material paper-based composites.

The potential of the paper/bioplastic biocomposite sector depends primarily on the paper and bioplastic sectors. The paper sector is larger and more widely spread in the region. Due to the nature of the paper industry, its large-scale technology and historic development it is dominated by relatively few large companies, in many cases parts of multinational companies. The paper industry in Central Europe builds on a long paper production tradition and a relatively abundant regional resource base. Wood as the main resource for cellulose fiber and pulp is the most abundant renewable resource in the region. In principle paper is a commodity, although the sector is divided into many smaller niches with production of specialty paper types. Due to specialization these can reach higher prices and market availability constrains can also exist. Recent reports (2018) from the packaging sector show that paper and especially special types is in growing demand so that availability of quantities for growth is limited. All project countries have a strong domestic paper production industry in large scale commodity paper types. The proximity, established trade links and common market conditions (within the EU) mean that the region has a relative self-sufficiency in terms of paper.

The paper and board packaging sector is currently in a much better situation compared to plastic in terms of recyclability. A figure of around 80% is estimated for Western European countries such as Italy, Germany and UK, although this is even higher in both Austria and Belgium, at nearer to 90%. Lower rates are apparent in Eastern Europe, owing to a lack of adequate recycling infrastructure.

Plastics sector

The situation in the plastics sector is significantly different. Commodity plastics are sourced globally and very limited production is available in the region. The situation is further complicated by the number of different plastic types that are used in combination with paper. Leading are polyolefins (polyethylenes of different densities and polypropylene) followed by polyesters (PET) although other types are also used in smaller quantities. Bioplastics, be it bio-based or biodegradable, are niche materials that represent and estimated 2% of the overall plastics market. As a consequence bioplastic production, especially in biodegradable plastics is fragmented among smaller producers mainly focused on

compounding of specialty grades and not basic polymer production. The region has one of the most important bioplastics producers in Italy (Novamont). This is an important factor in the broad use of bioplastics in Italy which is felt in plastic products such as carrier bags as well as in paper/plastic composites.

In terms of recyclability and recycled content within its products is the plastics packaging sector likely to face the greatest pressure. At present, the industry is making greater efforts to increase the recyclability of plastics packaging, in line with consumer and regulatory demands. Recycling rates, however, are lagging for flexible plastics in many parts of the world, although this situation may change given the growing emphasis on the circular economy.

Converting and packaging sector

Both the converting and packaging production sectors are strongly developed in the Central European region. They need to cater to very demanding and technologically advanced markets both domestic and foreign (European) so they cover a very broad range of products and technologies. Of special interest is the capacity for combined paper/plastics packaging products which is present in all countries of the region. The packaging sector involves both large as well as a number of small companies.

Flexible packaging

Multicomponent packaging composed of paper and plastics is strongly linked to flexible packaging and beverage cartons. Flexible packaging recycling in general is a problem in current recycling schemes due to the dispersion of the packaging (small sizes) and a great variety of materials and material combinations. Examples are metalized plastics and multilayer barrier composites. The issue is addressed by the CEFLEX (Circular economy for flexible packaging) association: www.ceflex.eu The association aims to improve the sustainability of flexible packaging. One key envisioned measure are improvements in design and material selection.

In general, Central European economies are characterized by a focus on exports and a strong involvement in the broader European market. In part this is due to specialization in niche products by a number of companies and the fact that several domestic markets are relatively small so that large scale production quickly exceeds them.

Products made of paper/plastics are normally predominately composed of paper therefore their recycling in the paper industry shall represent a priority to pursue to reduce the impact on their end of life.

In the new legislation context the replacement of conventional plastic products with multimaterials based on paper and bioplastics may represent a substantial advantage due to (i) increase of renewable material, (ii) increase of recycling options. As a matter of fact, besides the recyclability in the paper industry, the organic recycling represents a good option if paper is combined with biodegradable bioplastics particularly for packaging products got in contact with wet and grease foodstuff.

4.4. Best practices

Novamont, Italy (www.novamont.com)

Novamont is a leading Italian chemicals and material producer with plants in several countries. It is one of the largest producers of biodegradable plastics. Novamont was an early entrant in the area of biodegradable plastics. It is famous for its line of Mater-bi materials. Initially these were based on thermoplastic starch but the line now includes a broad range of materials and grades. Novamont has been instrumental in the fast development of Italian compostable plastics use as well as the development of numerous applications of compostable plastics in products that are now in wide use.

Ecozema, Italy (www.ecozema.com)

Ecozema is a producer of compostable cutlery, serving products and bags. It uses materials such as Mater-bi, polylactic acid (PLA), cellulose pulp, wood and plastic grades for film blowing. Ecozema is an early adopter and has become one of the most important producers in its area.

Evegreen, Slovenia (www.bioplasticpot.com , www.evegreen.eu)

Evegreen create advanced, eco-friendly products for a sustainable future. Through relentless research & development, our products are pushing the limits of bio-degradable polymers - at high quality, amazing performance and truly low costs. Their main innovative product are 100% Biodegradable plant pots. Using it you don't need to worry about contaminating your soil with plastic. In fact, you don't even need to worry about adding fertilizer because Evegreen rice husk pots break down as organic fertilizer.

BIOTREM, Poland (www.biotrem.pl)

Biotrem is an innovative Polish producer of serving plates and cutlery made of edible wheat bran and small amounts of polylactic acid (PLA). The products were developed in active cooperation with the Polish R&D sector. The products are easily compostable (within 30 days) and are distinct in their composition. The relatively large production is largely exported into European markets.

Ugrinpack, Hungary (www.ugrinpack.eu)

Is a SME producing compostable laminated papers for food packaging and compostable laminated paper cups. It has a growing customer base. Ugrinpack products are typical food contact uses of paper/plastic biocomposites.

5. Key Challenges / Operational Requirements

5.1. High relative costs

One of the most important reasons for relatively slow adaptation of biocomposite packaging is still relatively high cost of biopolymers and bioplastics compared to conventional plastics, on average depending on the type from 2 to 5 times. Furthermore, the use of bioplastics in combination with paper to achieve greater functionalities (barrier, transparency) leads to increase costs in comparison to mono-materials. On the other hand, with respect to multimaterials paper/plastic only a relatively small percentage of the material needs to be replaced lowering the cost gap. In terms of volumes, the present small niche market does not allow sufficient returns, therefore widening the market is one of the greatest challenge that can only be achieved putting in place different support actions. In this regards local communities, public authorities and large companies/retailers may play an important role by supporting GPP, CSR and favoring sustainable packaging by lowering environmental fees based on easy recyclability of sustainable packaging.

Bioplastic is still distinctively more expensive than conventional plastic. But with improved technologies and increased business the price will become more and more competitive. On the other side this difference can be compensated with better environmental impact and gain other more positive effects.

With reaching economy of scale the biocomposites will gain better price competitiveness.

According to European bioplastics the global bioplastics production capacity is set to increase from around 2.11 million tonnes in 2019 to approximately 2.43 million tonnes in 2024. Presented on a diagram below.

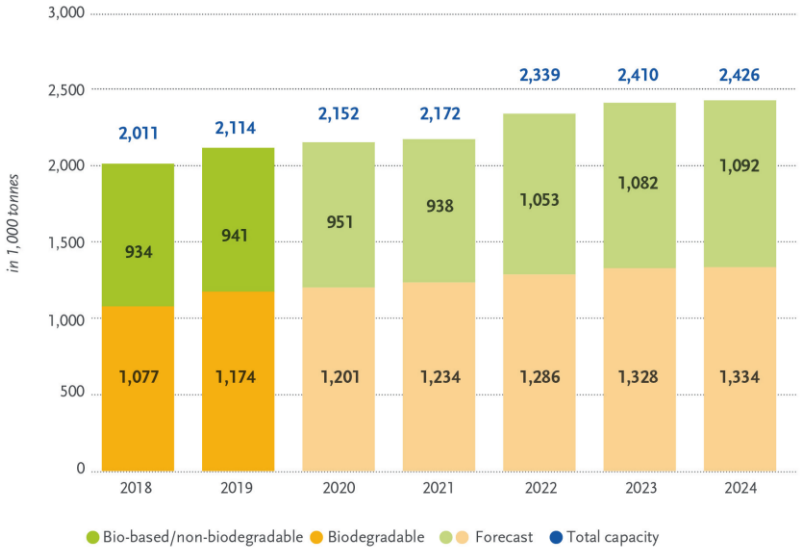

Fig.2 Time development of bioplastics production. source: European Bioplastics

5.2. Management/availability of raw materials

Unpredictability of oil prices encourages market players to look for alternatives, made of raw materials that have a price that is easier to forecast. Biodegradable packaging market drivers include the focus on sustainable materials used by brand owners and retail companies, as well as availability of new capacities to boost supply and the development of bio-based solutions.

Another of key challenges for production of bioplastic packaging is economy of scale. How to reach it through overcoming challenges (limited processability, insufficient properties, using food for products). Reconstruction of the value chain is needed. Ensuring consistent supply of good-quality raw materials. Inventing more environmental friendly materials, so we will depend less on fossil raw materials. There are several research and innovation going on in this field in order to come to the solution that will overcome obstacles. Despite gaining increasing attention the gap in knowledge on the behavior and the potentialities of the complex biodegradable materials, especially used in food packaging where numerous factors need to be taken into account, is still present. Several reviews on biocomposites have been published (4. Satyanarayana, K. G.; Arizaga, G. G. C.; Wypych, F. Prog. Polym. Sci. 2009, 34, 982.; 9. Faruk, O.; Bledzki, A.; Fink, H. P.; Sain, M. Prog. Polym. Sci. 2012, 37, 1552.; 10. Bledzki, A. K.; Gassan, J. Prog. Polym. Sci. 1999, 24, 221.; 11. Yu, L.; Dean, K.; Li, L. Prog. Polym. Sci. 2006, 31, 576.; 12. La Mantia, F. P.; Morreale, M. Compos. Part A 2011, 42, 579.; 13. John, M. J.; Sabu Thomas, S. Carbohydr. Polym. 2008, 71, 343.; 14. Wahit, M. U.; Akos, N. I.; Laftah, W. A. Polym. Compos. 2012, 33, 1045.; 15. Satyanarayana, K. G.; Sukumaran, K.; Mukherjee, P. S.; Pavithran, C.; Pillai, S. G. K. Cement Concrete Compos. 1990, 12, 117.; 16. Najafi, S. K. Waste Manage. 2013, 33, 1898.), but they are still lacking the exploration of potential application of biocomposites. different types of raw materials (lignin, waste) to different bioplastic product types. Legislation (example Italy with biodegradable bags see below) or subsidies can help making biocomposites more economically viable. On the other side biocomposite are environmentally more acceptable, they contribute to reduction of greenhouse gas emission and they build positive green image for the product and company. Fossil fuel-based raw materials are not everlasting and will eventually need to be replaced by biobased materials. Materials are a source of innovations, so there is a great urge for development of new materials.

In the process the company should define what are the most important characteristics materials, the footprint at the beginning of productions or at the end of life, ideally both. There is no more room for negligence in case of sustainability. Another question that is important is if the product needs to be made out of composites or can it be made out of mono-material. Since in theory all materials are recyclable, but most materials that end up as product packaging (bottles, sachets, cups, bags, shells) are too contaminated with food waste, dyes, inks, glues, labels, and layers of mixed materials to ever be actually recycled. Thousands of types of packaging and variations of materials, all ending up in one giant recycling bin and are presenting burden for waste management instead of valuable materials. It is too hard to clean, too costly to separate, not enough of a market for the cleaned, sorted plastics to pay for the prior processes and then we same to the easiest and more cheaper solution to rather use virgin plastic. But this model is not sustainable anymore, the pressure is coming from all sides. The time for a new model has arrived. There are basically bioplastics alternatives for almost every conventional plastic material and corresponding application available. According to European Bioplastics will the production capacities of bioplastics continue to diversify within the next 5 years, with further commercially availability of bioplastics materials.

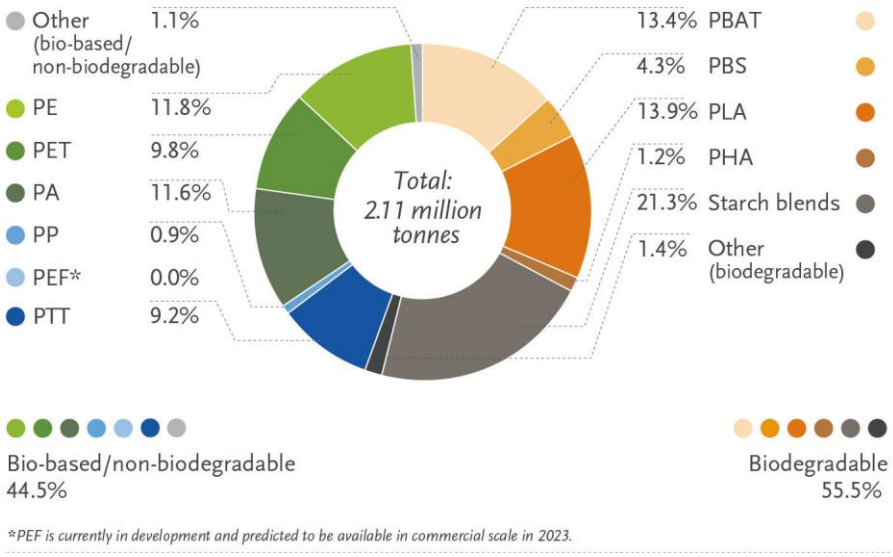

Fig. 3 Global production capacities of bioplastics 2019 (by material type)

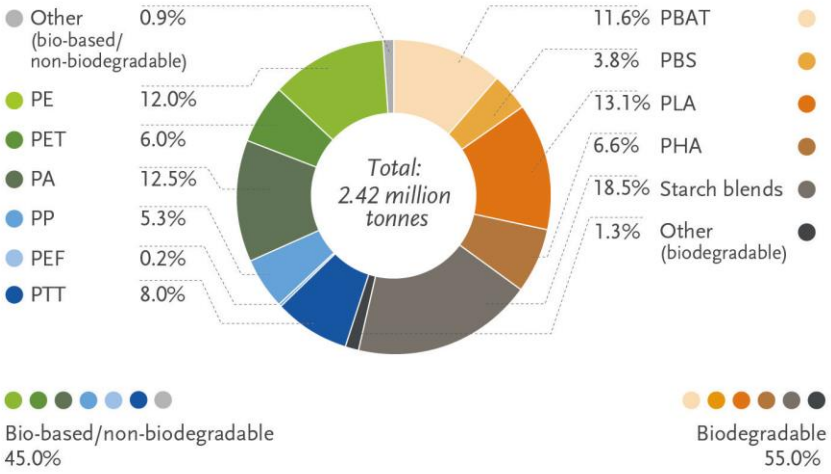

Fig. 4 Global production capacities of bioplastics 2024 (by material type)
Source: European Bioplastics (2019) www.european-biplastics.org

5.3. Technology availability/ Competing technologies/Machinery needed

There are several technologies already existing on the market for producing biocomposites. With some bioplastics same technologies can be used as with conventional one, in other cases some adjustments and innovative approaches are needed.

Existing technologies are extrusion coating, lamination, extrusion with lamination, rod coating. Each presenting and overcoming a particular limitation. Depending what type of materials you use and what

is the purpose of your product you can find appropriate technology. Things to be considered when choosing particular technology are first and utmost what material you are using, its specifications, what capacity, temperature, size, thickness. You cannot forget about using right adhesives and post treatment. In case of printing you need to have in mind the type of the printing and make sure about using proper inks or be within the allowed percentage of it within the whole product.

Main challenge here is how to overcome technology limitations that are preventing large-scale commercialization of biocomposite packaging. Investments into the R&D and innovation are essential for finding better solutions to overcome bottle necks to further development of the Innovation system. In Europe there is a broad range of mechanisms helping with investments at all levels of development. Innovative production technologies, value chain organization and increased market share will reduce overall cost of biocomposite products and the gap in comparison to conventional plastics.

Table 3.1 Bioplastics for packaging technology developments to 2022

	Technology developments to 2022
Bioplastics directly extracted from biomass	Research being undertaken to determine possible development of biopolymers from organic waste streams
Bioplastics produced directly by natural/GM organisms	PHA deficits are being improved by compounding with PBS or PLA New PHA production process from carbon capture
Bioplastics synthesised from bio-derived monomers	Performance-enhancing additives and processing aids Higher barrier PLA films Higher temperature PLA films
Biodegradable polymers synthesised from petrochemicals	Development of blends with higher renewable content
Non-biodegradable produced from renewable resources	Development of bio-derived PE, PP, PET and succinic acid Introduction of polyethylene furanoate (PEF) on horizon to challenge PET

Source: Smithers Pira

Based on the new report of the World Economic Forum Bioplastics for a Circular Economy is number 1 emerging technology out of 10 for 2019.

Fig 5.: Top 10 Emerging Technologies 2019
Source: World Economic Forum

5.4. Consumers' perceptions/market demand

Consumers are still not willing to pay more for "greener solutions" They do demand them, but when it comes to price, still not willing to pay more.

Consumer – e.g. purchasing and consumption behavior, concerns over sustainability and other environmental matters, etc.; changing grocery shopping patterns
- sustainability concerns
- online shopping
- on-to-go (OTG) consumption

Consumers are more and more environmentally aware which reflects in changing their consumption habits with demanding more sustainable "green" solutions. On the other side they feel overwhelmed with flood of information and different materials. They do not feel competent to differ which materials are good or bad and how to treat them when becoming waste. Sometimes the reason lay in misleading information, other times in lacking of information. There is still a fundamental misunderstanding of terms like biodegradable, compostable, bio-based, etc. present, not only among consumers (general public), but also wider (other stakeholders in the value chain, e.g. converters, retailers) .

All these confusions are not favorable for the wider development of biocomposite market. There is a need to address them through clear and sound communication among all the actors in the value chain. In order to come up with common and transparent solutions (standards, certification, labelling).

Consumers want a simple, official and trustworthy label that will help them identifying the right materials.

Growing sustainable packaging demand for food and beverages applications is a significant driver for market development.

5.5. Recycling infrastructure/Waste Management

- Improve selection and sorting of multimaterials.
- Support the development of composting infrastructures in CE
- Support the development of advanced material recycling plants for t

• Biodegradability of plastics is linked to the standard EN 13432 for industrial composting that was introduced in 2000 and applies to packaging.

• Additionally, the EU Plastics Strategy 2018 also acknowledges that industrial compostable products have value for separate collection of bio-waste and facilitate organic recycling (composting). Consequently, they shall be treated in a corresponding facility and shall produce high quality compost / soil improvers according to circular economy principles

"It is necessary to clearly distinguish between the different degradation pathways and so make the appropriate waste route obvious to the consumer/final user."

Be aware of the best method of disposal as industrial composting facilities are not the same as natural degradation.

Precondition for biocomposting packaging market is development of an industrial composting infrastructure that is still limited in the EU.

First step is creating the conditions for an effective recycling of these new products in the paper industry or composting plants as function of the type of product and infrastructures present in the specific region/country.

Material recycling shall be the priority for non-food packaging and food packaging intended to get in contact with dry food or liquid containers easy to empty. Depending on design and available infrastructures multimaterial packaging must be separate or sorted. Multimaterials intended to get in contact with grease or wet foodstuff may be developed for organic recycling due to the fact that containers are not easy to clean and often drags food along with the pack. Organic recycling is particularly convenient in specific contexts where food residues are likely to be present and certified products can be ensured by the organizers. Some examples are available in school and company cantinas or food service at large commercial centres/private parks/large events.

Table 3: Waste treatment, 2016
(% of total)

	Recovery			Disposal	
	Recycling	Backfilling	Energy recovery	Landfill and other	Incineration without energy recovery
EU-28	37,8	9,9	5,6	45,7	1,0
Croatia	47,2	4,0	1,0	47,8	0,0
Italy	78,9	0,1	4,0	14,2	2,7
Hungary	54,1	3,7	7,4	34,2	0,6
Poland	46,2	22,2	3,3	28,0	0,4
Slovenia	60,2	27,2	4,8	6,9	0,8
Slovakia	40,0	4,7	7,0	47,8	0,5

(*) This designation is without prejudice to positions on status, and is in line with UNSCR 1244/1999 and the ICJ Opinion on the Kosovo Declaration of Independence.
Source: Eurostat (online data code: env_wastrt)

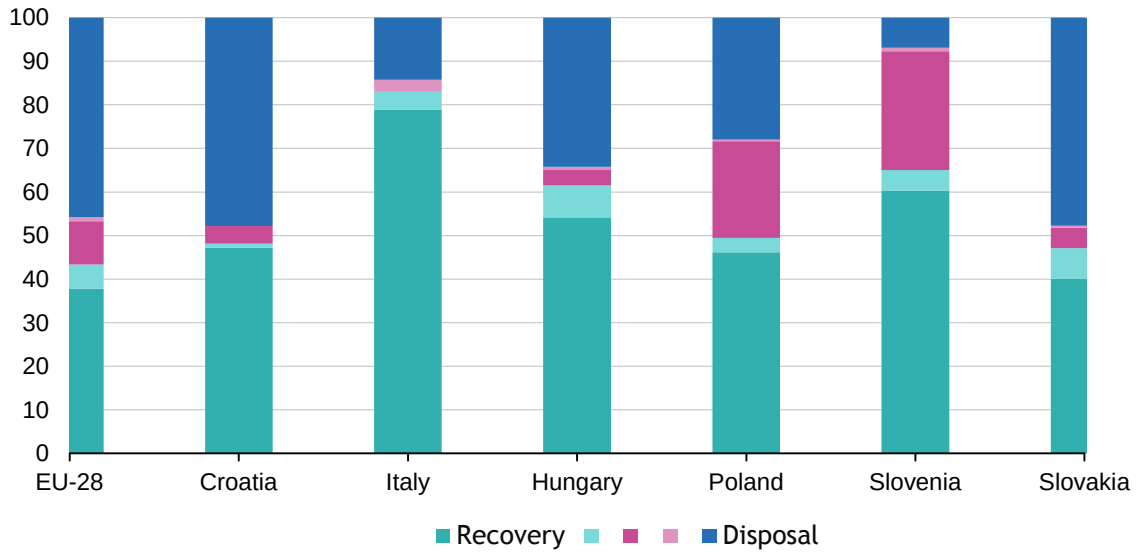

Fig 6. Waste management practices in countries participating in project Source: Eurostat

5.6. Framework conditions(regulations, legislations, etc)

Sustainability issues are having a profound effect on regulatory activity. Economic instruments such as pricing, taxes and levies using for plastic packaging proved as very effective in reducing the consumption of such packaging and paved the way for a more viable development of biocmposite packaging. Regulations can play a great role in motivating development of more biocomposite packaging. In this field, Europe appears to be at the forefront of much of the current regulatory activity via legislation.

- ### The Packaging Waste Directive

  EU first introduced measures aimed at limiting packaging waste in the early 1980s, it was not until the 1990s that to some extent harmonization was defined in Directive 94/62/CE, aimed at reducing the impact of packaging and packaging waste on the environment.

  The Directive was amended in 2004 to provide criteria aimed at clarifying the definition of the term ‘packaging’, as well as increasing targets for the recovery and recycling of packaging waste. Several more amendments have taken place since then, most recently in April 2015. The main aim of this amendment was to reduce consumption of lightweight plastic carrier bags across the EU region. Member states were given the option of ensuring annual consumption levels did not exceed certain levels stipulated by the Directive, or to adopt measures ensuring that lightweight plastic carrier bags are not provided free of charge at the point of sale of goods or products, or a combination of the two.

  Recently, in May 2018, the EC adopted new waste management rules (852/2108/EU), which set down legally binding recycling targets for the EU28 region. These included targets for both 2025 and 2030, as part of the Council’s aim of moving towards a more circular economy (see table below)

TABLE 3.1 New EU recycling targets for packaging materials, 2025–30 (%)		
	By 2025	By 2030
All packaging	65%	70%
Plastic	50%	55%
Wood	25%	30%
Glass	70%	75%
Paper and cardboard	75%	85%
Ferrous metals	70%	80%
Aluminium	50%	60%

Source: European Commission

TABLE 3.1 New EU recycling targets for packaging materials, 2025–30 (%)

- **SUP Directive -> 2nd July 2019 came in to force**

Plastic strategy seeks an overall improvement of management of plastics including packaging with particular attention given to reducing obstacles for recycling. Even more recently an EU directive proposal was published that concerns itself with single use products and possible methods for lowering their use. This motion is now under discussion with the outcome still unknown but it also covers packaging items and is in principle looking into products with extremely short life times – a characteristic of a large portion of packaging. In this context also multimaterials packaging may find the best solutions to merge functionality, recovery and recycling options.

- **Extended Producer Responsibility (EPR) scheme -> lower the price**

Another important driving force would be the propagation and impact of the EPR system at EU level. Extended Producer Responsibility (EPR) involves the extension of a producers' financial and/or physical responsibility for its product to the post-consumer stage of the product's life cycle. EPR is a good policy approach for prevention and better management of waste. EPR policies should be preferred when there are illegal waste disposal problems and/or when poorly functioning secondary raw material markets exist. EPR policies do stimulate producers to change the design and resource input to products, too. EPR can be an important stimulus in the establishment of a recycling-oriented society. EPR not only changes the allocation of responsibility but can stimulate the sharing of responsibility and costs across the product chain.

- **REACH**

(https://ec.europa.eu/environment/chemicals/reach/reach_en.htm)

REACH (EC 1907/2006) aims to improve the protection of human health and the environment through the better and earlier identification of the intrinsic properties of chemical substances. This is done by the four processes of REACH, namely the registration, evaluation, authorisation and restriction of chemicals. REACH also aims to enhance innovation and competitiveness of the EU chemicals industry.

"No data no market": the REACH Regulation places responsibility on industry to manage the risks from chemicals and to provide safety information on the substances. Manufacturers and

importers are required to gather information on the properties of their chemical substances, which will allow their safe handling, and to register the information in a central database in the European Chemicals Agency (ECHA) in Helsinki. The Agency is the central point in the REACH system: it manages the databases necessary to operate the system, co-ordinates the in-depth evaluation of suspicious chemicals and is building up a public database in which consumers and professionals can find hazard information.

The Regulation also calls for the progressive substitution of the most dangerous chemicals (referred to as "substances of very high concern") when suitable alternatives have been identified.

One of the main reasons for developing and adopting the REACH Regulation was that a large number of substances have been manufactured and placed on the market in Europe for many years, sometimes in very high amounts, and yet there is insufficient information on the hazards that they pose to human health and the environment. There is a need to fill these information gaps to ensure that industry is able to assess hazards and risks of the substances, and to identify and implement the risk management measures to protect humans and the environment.

Having entered into force in 2007, REACH provisions are being phased-in over 11 years. Companies can find explanations of REACH on the DG GROWTH (Internal Market, Industry, Entrepreneurship and SMEs) or ECHA websites, and can contact national helpdesks.

The EU REACH Regulation (Regulation (EC) 1907/2006) entered into force on June 1st, 2007 and deals with the Registration, Evaluation, Authorisation and Restriction of CHemicals. The overall objective of the REACH Regulation is to ensure high levels of human health and environmental protection through the registration of chemical substances circulated in the EU and identification of their intrinsic properties.

The REACH Regulation requires registration of all the chemical products circulated in the EU market by EU situated manufacturers and importers, as well as non-EU companies exporting their products to the EU. The innovation of the REACH Regulation in comparison to previous frameworks is that it leaves the industry responsible for the management of the risks arising from chemicals and the provision of the corresponding measures for their safe handling. To complete the registration under REACH, different deadlines are provided according to the tonnage produced/imported/exported and the carcinogenicity/toxicity of the substance, varying from 2010 to 2018.

6. Conclusions & Recommendations

Packaging became an essential commodity in the modern life that at the same time causes a major environmental threat. Let us all be more responsible when it comes to packaging, either when planning, producing, using, discarding whatever way that is. We should think about both edges, commodity side and also the burden side. And there are much more in between than only the price.

The technically possible growth of bioplastics in the coming years will be limited by factors including high production costs, capital availability, technical challenges in scale-up, the short-term availability of bio-based feedstock and the need for the plastics conversion sector to adapt to the new plastics

"[Making money is a company's] imperative ... But it's not the only purpose. Increasingly companies are adopting the view that the purpose of a company is to contribute to the common good: its customers, its employees, and the community in which it operates. If you can connect the search for meaning of the individual with the purpose of the company, then magical things happen."

We should all thrive to make a positive difference in the world. With more responsible packaging we sure can.

At first glance the biocomposite packaging solutions do not look economic viable, but when you look deeper into the matter, not solely through the price of material the picture changed. Plastic becoming number one threat on one side and increasing demand for packaging (e.g. to go generation) bring us to discovering other, more sustainable solution that biocomposite packaging bring. There are still a lot of challenges to overcome, but there is also clear direction where to go.

These days sustainability is not something additional anymore it became a necessity. There are different pushes from the consumers awareness to the policy regulations. Anyone working in this field should obtain a mindset on how to contribute to at least one of the Sustainable Development Goals (SDGs) that are at the heart of the UN's 2030 agenda and how switching to a more circular approach.

Biocomposite packaging will not solve the problems of the modern world, but for sure can help ease them. This can be acknowledged only through a combination of measures, from regulations to voluntary changes in the way the society uses and disposes packaging. We need to build a cohesive group among all the actors in the value chain through open and sound communication and shared knowledge to come to the innovative solutions. Innovation is a key for the transformation of the packaging value chain.

Biocompack-CE project is aiming to establish a Transnational Biocomposite Packaging Center (http://www.paperbiopack.eu/) as an integrated virtual network platform of technology and business innovation service providers in the area of sustainable paper-plastics packaging solutions. The purpose of this platform will be to develop and strengthen the linkages among all the actors in the value chain of biocomposite packaging at one place and to deliver support (exchange of information, knowledge and resources) to companies and develop R&D-business ecosystems for implementing new market oriented projects concerning the application of biodegradable plastics in paper-plastic packaging solutions in Central Europe.

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