Bio-plastic - between current practices and the challenges of a sustainable future

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Abstract: *In a globalized economy built on intensive consumption of natural resources and environmentally damaging actions, it is imperative to identify solutions that help to reduce pollution. In line with efforts to maximize the value of natural resources and minimize toxic materials in the environment, many countries have developed bio-economic strategies that contribute to the conversion of bio-basic raw materials to develop organic products (bio-plastic , bio-pharmaceuticals, green chemicals etc.). In Europe, there are already countries that have established bio-economic policies (Denmark, Finland, Germany, France, Scotland and the Netherlands), and an European strategy is already being discussed at EU level. Countries that are already implementing bio-economic principles are positioned as research and innovation centers for bio-products, green energy, bio-economic processes and services. In this context, bio-plastics play an important role due to their potential to contribute to improving the quality of the environment and, implicitly, the well-being of the planet's inhabitants. Given the issues raised, the article aims to make a brief analysis of the importance and evolution of the field of bio-plastics at a globall and European level, trying to bring forth the best examples of good practice from countries that are already implementing such policies and whose economies are becoming more and more bio (green economies). In addition to being environmentally friendly, the bio-plastics sector also has an important potential to generate job growth, costs savings and natural resources etc.*

Keywords*:* bio-economy, bio-plastics, sustainable development

JEL Code : O1, O13, O33, O44

1.Introduction

By a generally accepted definition, economy encompasses all activities and services performed at a given location over a period of time, with the help of technologies, equipment, labor etc. In most cases, at the basis of any economic system are primary resources, raw materials, obtained from nature, which imply repeated transformations in order to obtain final products. In certain situations when new items emerge, the economy receives certain features, which, as a rule, bear the name of the source of origin. Thus, when biology is an important vector contributing to supporting mechanisms that generate high added value (plus-value), we can discuss bio-economics (or green, blue, circular economy, etc.).

Bio-economy is understood and accepted as a circular (closed) system, based on economic activities (production, development and use of products), based on biological phenomena and processes , resulting from both natural chemical processes as well as intensive research-development-innovation activities, promoted in particular for the benefit of the community.

Bio-economy has many facets: from production based on sustainable development principles to biomass conversion processes in a wide range of complex products (food, medicine, energy etc). Ussually, bio-economics is seen by many specialists as a transition economy in its way towards sustainable use of renewable resources in different areas, addressed from the perspective of environmental policies as a strategic, vital objective , based on actions and measures which can help reduce pollution and reduce climate changes that are so visible nowadays.

In theory, the concept of bio-economy is a relatively recent occurrence (at the beginning of this century), being dependent and evolving concurrently with the rapid advances in bio-technology, research-innovation, bio-innovation and organic growth etc. In some cases, the concept of bio-economy is so close to that of eco-bio-economy (viewed in particular from the perspective of the welfare economy), that some times we mistake one for the other.

Bio-economy is constituted both from the production of renewable biological resources as well as from waste and waste streams in sectors such as agriculture, forestry, fisheries, food industry, woodworking , pulp and paper processing, construction and infrastructure, the energy sector, certain industrial sectors (textile, chemistry, pharmaceutical) etc. Bio products can be used directly in special (ecological or biotechnological) technological processes or can be consumed as such (eg food, feed, bio-basic products, bio-energy etc.).

In 2009, according to an official OECD document analyzing and evaluating the world's economies, bio-economy is beginning to become a "significant part of the global economy built on ecological growth or green growth"". Since that document appeared, more and more countries have begun to transition to this type of economy, building and implementing national strategies and policies based on a high percentage of bio-processes and bio-technologies.

An important part of the global economy, the chemical industry transforms raw materials (oil, natural gas, water, metals and minerals) into over 70,000 different products , one of which is plastic . Nowadays, plastic, used almost in everything, is one of the most polluting materials in the world: it is high in oil consumption (oil is one of the most scarce and expensive resources at present) and for its elimination from nature it takes a very long time (at least 20 years for small plastic cups, 100 years for a plastic bottle - PET - and 500 years for products made of polystyrene foam). Starting with the second half of the 20th century, plastic became one of the most important materials used in the global economy, used in almost every aspect of everyday life: from transport to construction, telecommunications, broad goods consumption, food and health. Figures for world production of plastics from 1950 to 2012 show that it recorded an average annual growth rate of 8.7%. World plastics production amounted to 335 million tonnes in 2016 compared to 322 million tonnes in 2015 (an increase of 20 million tonnes in one year), according to data provided by PlasticsEurope , while in the European Union (EU-28) the increase was about 60 million tonnes in 2016 compared to 58 million tonnes in 2015.

In Europe, the statistical data on the consumption of plastics in different sectors of activity show that at the end of 2012, the packaging industry represented the largest consumer of plastics (39.4%), followed by construction (20 , 3%), automotive (8.3%) and electronics (5,4%). The consumption of plastic as a raw material in Europe rose to about 47 million tons (an increase of about 1.1% annually). The most requested categories were polyethylene PE-LD, PE-LLD and PE-HD with a weight of 29%, polypropylene (PP) by 19%, polyvinylchloride (PVC) by 11%, polystyrene (PS and PS-E) 7.5%, polyethylene terephthalate (PET) by 6.5% and polyurethane (PUR) by 7%. These polymers accounted for 80% of the total European consumption. The largest consumers were (2011) Germany with 12 million tonnes and Italy with 7 million tonnes, followed by France, the United Kingdom of Great Britain and Northern Ireland, Spain and Poland. The recycling rate for plastics was 60% (2011), while the recycling average for packaging amounted to 66% (with great differences from one country to another: Switzerland, Germany, Austria, Belgium, Sweden, Denmark , Norway, the Netherlands and Luxembourg recycle over 90% of plastic waste).

Although it is considered to be important for the environment, the recycling of plastic is done at a very high price, which leads to a limitation of the demand for such products. Approximately 75% of plastic packaging is chaotically stored, especially on farmland around villages or is thrown into water. By using large-scale bio-plastic, some of the issues outlined above can be significantly reduced, but this requires both financial and institutional, legislative efforts, etc .

2.Bio-plastic – sustainable material of the near future

The bio-plastic industry implies, in addition to recycling existing materials and the emergence of new materials (second-generation plastics and three-generation bio-plastics based on bio-equivalents of the main thermoplastics that dominate the market: polyethylene, polypropylene and polyethylene terephthalate). The first two stages are applicable today. In the near future it is possible that bio-plastic includes both biodegradable and compostable plastic. The attractiveness of bio-plastic as a substitute for petroleum-based materials largely depends on its ability to meet both environmental and economic objectives.

Bio-plastic is a renewable material whose production has a continuous growth trend due to the properties it presents. The importance of using bio-plastic is due to both reduced dependence on expensive raw materials, low greenhouse gas emissions throughout their life cycle, the fact that they offer more options compared to petro-plastic materials, that are based on innovative technologies based on eco-bio-products and their applications, and the high potential for job creation, etc. Although bio-plastic has a number of real advantages, there are a number of restrictions that limit its use:

• there is limited access to countries with low financial resources;

• there is significant competition from other sectors, such as bio-fuels, which also benefit from preferential support schemes;

• presents higher production costs compared to petrochemicals;

• one can find public resistance to the use of synthetic biology technologies;

• the lack of standardization / harmonization of standards at international level, in terms and concepts such as sustainability, may constitute a barrier to the international / regional bioplastics market (and not only).

These limitations can be corrected by a series of targeted actions in the form of policies that may have a potential impact on the bio-plastic sector (agricultural policy, R & D support, trade and industrial policies, tax incentives , quotas, standardization schemes, regulatory measures, etc.). This issue of limiting can help:

1. increase the number of countries that have special policies dedicated to the bio-plastics sector;

2. increase the recycling rate of plastic bags (the most widespread in the world);

3. inroduce an entire mix of policies (R-D-I și chimie or construction materials);

4. a higher demand on the international market would reduce associated costs (those related to building the production capacities needed for bioplastics etc.);

5. cooperation between countries or international bodies (EU and / or US or other countries) in the field of public aquisitions could stimulate the development of the bio-economic market.

3.Bio-plasticul – raw material and final product

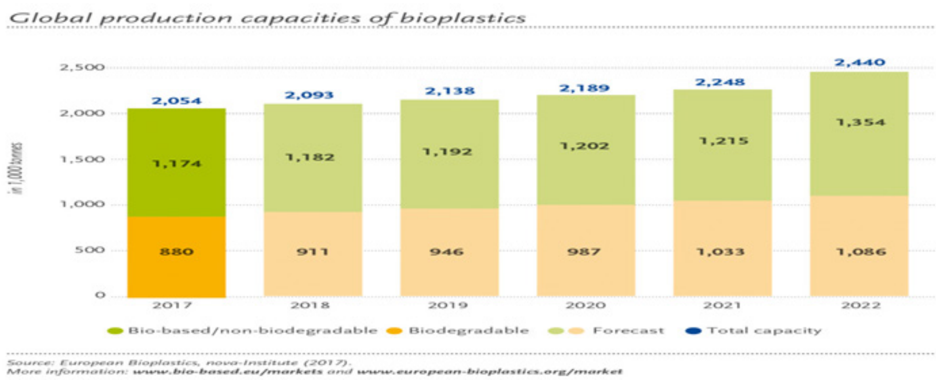
Nowadays, worldwide, through photosynthesis 60 million tons of organic material are produced, which are then either harvested and processed for use in various fields, or degraded by microbial degradation in their core elements: CO2, H2O and biomass within a global cycle without creating environmental problems and high costs .

We can say that plastic is a timeless material. An example of this is the fact that twenty times more plastic material is produced than fifty years ago, and the ever-growing world plastics production has surpassed that of steel. Most of this production is made from oil, and the degradation of conventional plastics releases a very large amount of carbon dioxide into the atmosphere. Bio-plastic was discovered after the Second World War, and thought to be a solution to the problems of the current society. Although there is a trend towards increasing production, the total volume of bio-plastic products remains small compared to petroleum-derived plastic.

Bio-plastics have their own market niche, especially in the field of packaging and consumer goods, where global demand has grown spectacularly from 850,000 tonnes (2011) to over 3.7 million tonnes in 2016 (Sursa: BCC Research, Wellesley, Massachusetts, USA). At the same time, the production of plastics based on renewable raw materials increases rapidly compared to traditional ones. Thus, in 2009, the production of bio-degradable plastic was 100 thousand tons, after which it began to decrease, so in 2016 it was only 1/7 of the total volume of bio-plastics materials produced worldwide. In Europe, bio-polymer consumption has also grown by about 32% per year, from 307,000 tonnes in 2011 to over 1.2 million tonnes in 2016. Similar growth patterns have been reached by some states on the American continent, while Asia has the highest growth rates (over 41% per year, with a volume of 1.1 million tonnes, 2016). Taking into account world commodity price trends, and especially the fact that oil price is rising, specialists expect some bio-plastic materials to remain, at least until the end of this decade, as expensive as those obtained traditionally (they will have the same value).

According to an analysis by European Bioplastic in 2017, the global production capacity of bio-plastics was 2.05 million tonnes, of which 1.174 million non-degradable bioplastic (57.2%) and 880 million tonnes bioplastic-biodegradable (Figure no. 1).

Figure no. 1: Global production capacities of bio-plastics

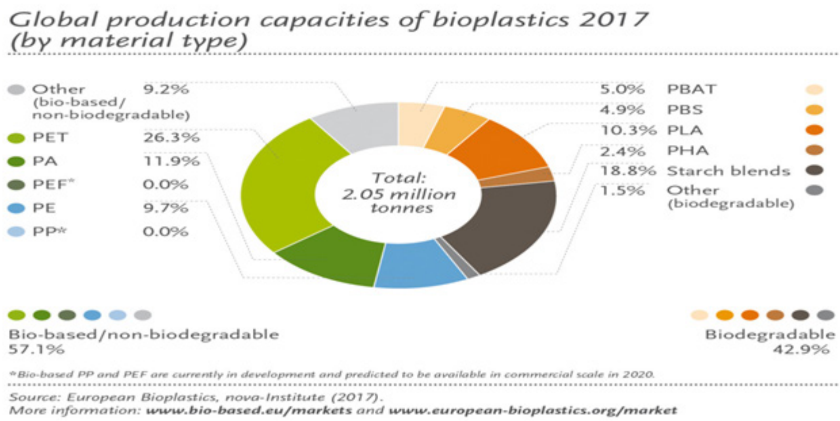


Source: European Bioplastics

A comprehensive bio-plastic market survey (Ceresana Research, 2009) estimated that in the years 2000-2008 the world consumption of bio-degradable plastics based on starch, sugar and cellulose (the three most important raw materials) increased by 600%. Moreover, according to a survey of the bioplastics industry (Shen and partners , 2009 some companies reported growth rates of up to 50% per year. Non-biodegradable materials, including PE based (polyethylene) and bio-based (polyethylene terephthalate) solutions, as well as bio-based PA (polyamides), currently account for about 56% (1.2 million tonnes) of the overall capabilities of bio-plastics production. It is expected that EP production will continue to grow even if the intention to increase production capacities for bio-based PETs is not at the rate set in previous years.

In 2017, world bio-plastics production was 2.05 million tonnes, of which about 26.3% was owned by PETs (non-degradable) (Figure no. 2).

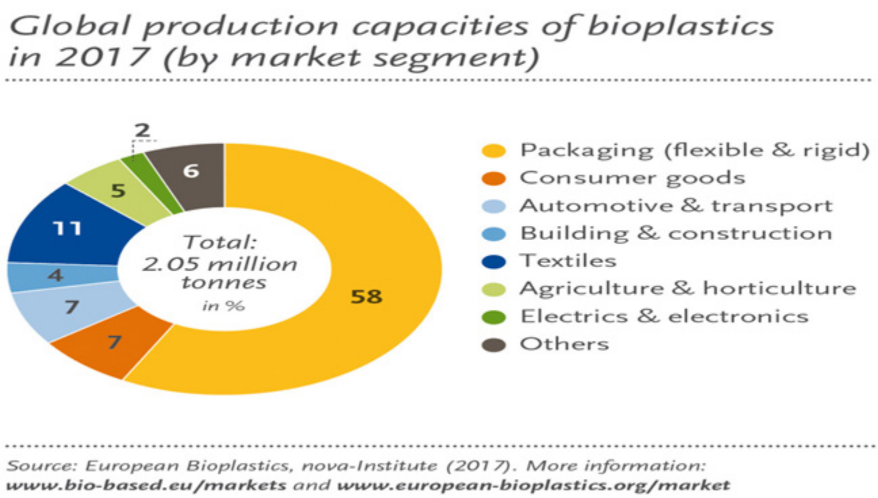
Figure no. 2: Global production capacities of bio-plastics, 2017



Source: European Bioplastics

Bio-plastics are used on a growing number of markets, from packaging, catering products, consumer electronics, automobiles, agriculture / horticulture, toys, textiles, etc. Packaging remains the most important product in this field, with nearly 60% (1.2 million tonnes) of the total bioplastics market in 2017 (Figure 3).

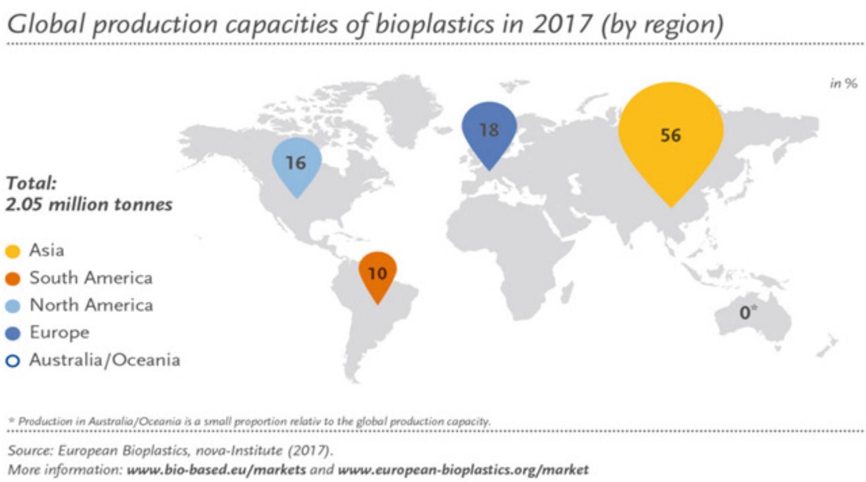
Figure no. 3: Global production capacities of bioplastics



Source: European Bioplastics

Given the real bio-plastic production and the development of regional capacities, Asia is the most important production center, with more than 50% of bio-plastics being produced here. Also, about one fifth of the global bio-plastic production capacity is located in Europe (Figure no. 4).

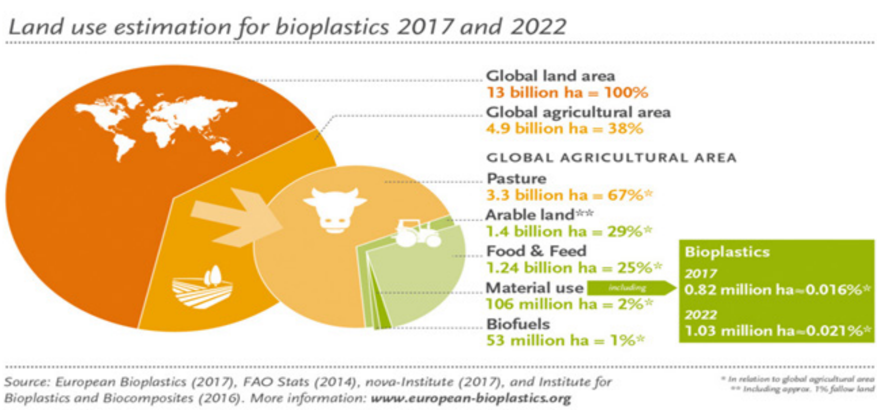
Figure no. 4: Global production capacities of bioplastics, in 2017



Source: European Bioplastics

The areas needed to cultivate the renewable raw material used in the production of bio-plastics was around 0.82 million hectares in 2017, accounting for less than 0.02% of the global agricultural area (which is about 5 billion hectares). About 97% of the area is used for grazing, animal feed and edibles. Despite the anticipated market growth in the coming years, the share of land use in bioplastics production remains relatively small. This clearly demonstrates that there is still no competition between raw material obtained from renewable sources for food production (edibles, food for animals, etc.) and the production of bio-plastics (Figure no. 5).

Figure no.5: Land use estimation for bioplastics 2017 and 2022



Source: European Bioplastics

Given the expected growth in the bio-plastic sector, some strategies also examine the implications of associated development policies, by types of measures and instruments, which could play an important role in creating a framework for their supporting production, dissemination and use.

4.Economic aspects of the bio-plastics sector

Bio-economy brings products that do not have a negative impact on the environment. At the same time, classical plastic materials are omnipresent and popular, therefore there is no reason to expect a reduction in demand for such materials in the medium term. In turn, an increase in demand for plastics would lead to an increase in demand for oil, whose consumption has increased in recent years at a rate of around 2% per year, even though it is obvious that the resource is becoming more and more difficult to obtain and production is not sustainable. There is some belief (some fully justified) that the price of oil will continue to rise under these conditions, and supply will become more and more volatile (Owen et al., 2010).

Doubling the volume of plastic production over the past 15 years, oil price volatility and increasing difficulties in identifying new oil sources have raised concerns about the sustainability of bio-plastic production growth. Therefore, it is necessary to identify with R-D-I, new raw materials and alternative materials for plastics.

Many of the world's economies depend heavily on fossil fuels: for example, the European Union is vulnerable to oil supplies and the volatility of its market. In order to remain competitive, the EU needs to reduce its carbon dioxide emissions but at the same time it needs to identify new biological products that contribute to economic growth and ecological competitiveness (European Comittee, 2012a). In a study entitled "Innovation for Sustainable Growth: A Bioeconomy for Europe", the European Comittee said the bio-economy sectors had a turnover of around € 2 billion, providing jobs for over 22 million people (9% of the total labor force employed in the EU) . Moreover, the Europe 2020 Strategy contains two major initiatives for job creation in the bio-economy sector: Innovation Union and Resource Efficient Europe , which are the basis for the development of the bio-economy, a key component of smart and ecological growth in Europe. Also, the European Commission's estimates of bio-economy funding through Horizon 2020 show that it could generate about 130,000 jobs and 45 billion euros of value added by all sectors of the bio-economy by 2025, including bio-plastics .

Another analysis on "Green Jobs for Sustainable Development," developed in Spain (Sustainlabour, 2012), believes that the bio-economy could provide between 400,000 and 500,000 green jobs, equivalent to 2.2% of all jobs in the entire country. The contribution of the green economy to the Spanish economy was estimated at 25 billion euros annually, equivalent to 2.4% of the total GDP.

As far as Belgium is concerned, bio-plastic materials are more important than the production of bio-base fuels. Table no. 1 presents some estimates of jobs created in the bio-economy area in the Flanders region . In this region, biological products (paper, wood fibers, bioplastics and biochemistry) create five times more added value (based on gross margin calculations) and ten times more occupation than bio-energy (electricity based on biomass or heat and biofuels). Similarly, (Carus and Partners, 2011) notes that the production and use of biological products can directly support 5 to 10 times more jobs and 4 to 9 times higher value added compared to production and use of energy based on biofuels.

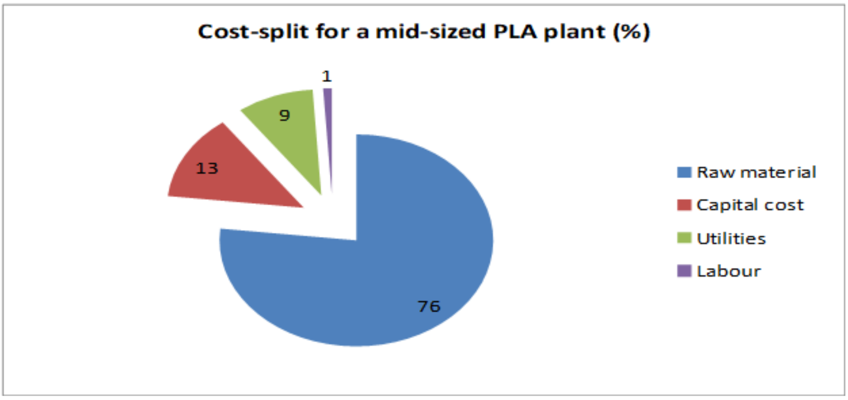
Table no. 1: The Flemish bioeconomy

	Gross margin		Employment	
	M EUR	%	M EUR %	%
Bio-based energy				
Bio based gas	38	3.3	374	4,0
Bio-based electricity	89	8.0	456	4.9
Bio-based heat	210	18.8	842	9.0
Bio-based fuels	25	2.2	146	1.6
Total	**362**	**29.4**	**1818**	**15.4**
Bio-based products				
Paper	215	19.3	1546	16.5
Fibreboards	256	22.9	1991	21.3
Bio-plastics	52	4.7	847	9.1
Bio-based chemicals	268	24.0	3532	37.7

Source: OECD based on Vandermeulen et al. (2011). FTE = Full-time labour equivalents

There are opinions that biofuel support policies have allowed the development of certain companies with a mix of private investment and government subsidies, but also through loans (Sparling and partners 2011), because an important economic barrier to the development of the bio-plastic industry is their manufacturing cost. Thus, biomass-based plastics are more expensive than their petro-equivalents, leading to higher market prices. For example, PHA plastics in the form of pallets, in 2009 had a price three times higher than that of polypropylene (DiGregorio, 2009). Costs associated with raw materials usually exceed production costs as shown in figure no. 6.

Figure no. 6: Cost-split for a mid-sized PLA (Polylactic acid) plant (%)



Source: OECD based on Uhde Inventa-Fischer-publicly available commercial documents

In 2011, bio-plastic prices experienced a fairly large variation, from 1.5 EUR per kg (PLA) to 15 EUR per kg, and for those in bulk the range was between 3 EUR and 6 EUR per kg. These prices are constantly changing depending on the amount of bioplastics produced. Although there is currently a price difference between petro- and bioplastics, in recent years bio prices have fallen, while petro-plastic prices have risen. It is also possible that bio-plastics could have a big impact on the prices of products in the direction of their decline. Moreover, in view of other factors such as the increase in the bioplastics supply and the growing awareness of the actual cost of removing petroleum-based plastics from the market, it is considered that the price difference will diminish over time.

As far as the technological advances in the field of synthetic biology are concerned, they can lead to cost savings, provided that a bio-consolidated process is developed, involving the usual stages of the production of biological products. Usually, biomass conversion processes require enzymes that hydrolyze carbohydrates present in pre-treated biomass to sugars and other fermenting micro-organisms. When properly-manufactured micro-organisms produce the necessary enzymes and fermented sugars released by the final products, the single-step biomass conversion process is called the Enhanced Bio-Process (EBP) and requires well-designed technology, with many specific features. Synthetic biology is a key element not only for the development of micro-organisms, but also for the design, assembly and implementation of different synthesis methods, which can lead to the production of new compounds. In this respect, an innovative breakthrough in this field was achieved at the end of 2011 when E. coli was shown to be able to produce three advanced biofuels (Bokinsky et al., 2011). The EBP strategy for the production of ethanol for bio-plastics and the direct production of bioplastics from biomass can be developed at a different level only through research and development.

With all these commendable aspects, there is currently a very high resistance to the introduction of bio-plastics at a commercial level. Currently, for example, in Argentina it is accepted that 99% of soybean production is genetically modified (Yankelevich, 2008).

In the long run, technology demand for genetically engineered products is expected to grow in Latin American countries. Thus, in April 2008, the Brazilian Bioscience Technical Committee (CTNBio) approved the first field experiments on sugars containing genetically modified sucrose (Janssen and Rutz, 2011). The use of GM sources and new technologies, such as synthetic biology, in bio-plastic production is predominantly governed by legislation. In the European Union, the impact of the governance regime on the acceptance and diffusion of genetically modified technologies is more restrictive than in any other parts of the world. As we have seen, regulatory processes can obstruct innovation systems, but there is a need to strike a balance between the need to stimulate innovation and economic growth on the one hand and the need to protect the public's interests on the other, this being a political decision-making issue.

CONCLUSIONS

Bio-plastics have an important role to play in the development of bio-economy, due to their potential to tackle environmental and economic issues in a unitary way. Bio-economy brings to the market products that do not have a negative impact on the environment, some of which are bio-plastics. Although there has been a tendency to double the volume of plastic production over the past 15 years, oil price volatility and increasing difficulties in identifying new oil sources may affect the sustainability of a sharp rise in bio-plastic production. In order to achieve visible worldwide results, greater involvement of all countries and, in particular, of the major plastics producers is needed, as well as the identification of new raw materials and alternative materials through a sustained innovation activity for plastics.

Bio-plastic can constitute, due to the properties it presents, an alternative to current plastic products whose production has an important upward trend. The importance of using bio-plastic is due to both reduced dependence on expensive raw materials, low greenhouse gas emissions throughout their life cycle, the fact that they offer more options compared to petro-plastic materials, the fact that they are based on innovative technologies based on eco-bio-products and their applications, and the high potential for job creation, etc. Although bio-plastic has a number of real advantages, the restrictions imposed by costs, sales outlets, regional interests, etc. could result in public resistance from both producers and consumers, a restriction that can be diminished and even canceled by a series of policy measures and actions such as supporting R-D-I, public-private partnerships, promoting standardization or harmonization of standards at international level etc.

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