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Economic opportunity or temporary phenomenon

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Ostfalia
University of Applied Science
IfR - Institut for Recycling

Authors: Prof. Dr. Hartmut Widdecke, Dr. Albert Otten, Dr. Andreas Marek, Stefan Apelt
Acknowledgements: Daniela Elpel, Monika Raschke, Olaf Jung, Till Quabeck, Rene Borowka

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Bioplastics – Economic opportunity or temporary phenomenon

In this chapter, the question of whether bioplastics represent an economic opportunity or only a temporary phenomenon will be discussed. Biological degradability in this context is rather a secondary matter, and consequently both biodegradable and non-biodegradable bioplastics play a role.

The worldwide climate debate has been a constant topic in politics, the economy and the media for several years. Considering the increasing demand for more environmental protection and conservation of resources by the population, many companies are also considering the possibility of basing their development and manufacturing on longer-lasting products. Above all, the constantly rising crude oil prices have compelled the plastics industry to invest increasingly in research and development of bioplastics. Increased demand for bioplastics is causing an expansion of production capacities.

Until now, these plastics had a niche existence and could scarcely be established on the market. However, this could change greatly in the near future. Therefore, both companies and experts see an economic chance for bioplastics.

Exact production figures and production capacities of bioplastics worldwide are difficult to obtain. Thus, for the most part, only estimates exist, which are constantly changing due to the rapid growth of the bioplastics sector. Besides the double-digit growth of the entire market for bioplastics, the production capacities will quadruple by 2011 according to the Nova Institute. Figure 1 shows that European Bioplastics anticipates an even sixfold increase from 262 kt annually to 1502 kt between 2007 and 2011. One can clearly perceive in the graph that bio-based and biodegradable bioplastics have and will have the greatest capacities for production in 2007 with 210 kt and in the future with 885 kt. It must also be kept in mind that bio-based and non-biodegradable bioplastics will also increase greatly in importance. Their capacities in 2007 were still at 30 kt but are expected to increase by 2011 to 575 kt. The production of bio-polyethylene by Braskem and by Dow and Crystalsev and the products of BASF will have a great share of this development, among others. The synthetic and biodegradable bioplastics will play rather a subordinate role. Their percentage share in the bioplastics will decrease in the future.

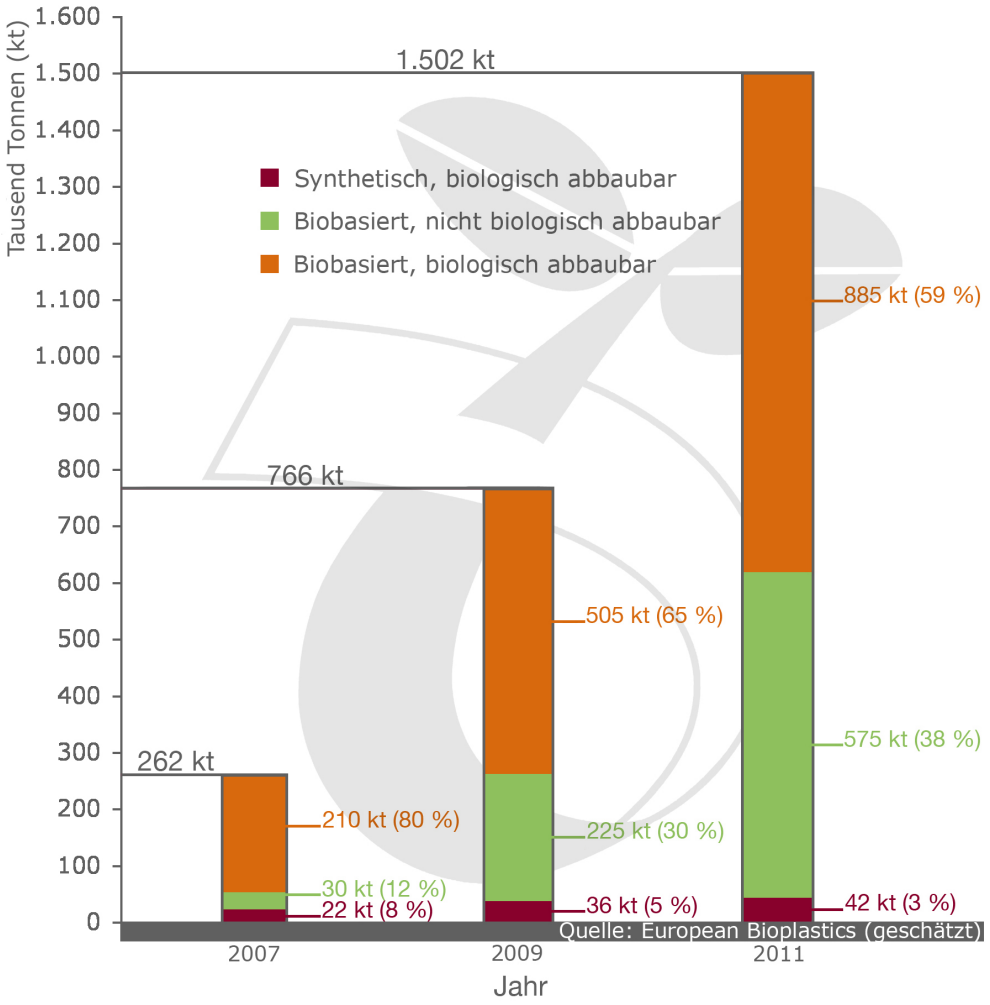

Figure 1: Worldwide bioplastics production capacity per year

The estimates presently used as a basis for South America will, in the near future, no longer be approximately correct, because the Brazilian Braskem corporation is building a production plant with an annual capacity of 200,000 tons for the production of bio-PE. The current production figures presently run to only 12 t per year in a pilot plant [2]. The two companies Dow and Crystalsev have also announced that they will build a plant for the production of bio-PE with an annual production capacity of 350,000 t [3]. The US concern NatureWorks is operating a plant for production of PLA with a capacity of 140,000 t per year. The production capacities of about 80,000 t in North America result from the fact that the entire theoretical capacities are not available due to technical problems[4].

Novamont has a production capacity for bioplastics based on complexed plant starch and biodegradable polyester of 35,000 t annually (2006).

DuPont and Tale & Lyle produce a polyester from 40% 1,3-propanediol that was produced biologically and have a capacity of 50,000 t annually.[5] BASF has announced that it will increase its production capacity of the bioplastic Ecoflex® (petroleum based) by 2010 from 14,000 t/year by 60,000 t/year[5]. Metabolix and Archer Daniels Midland Company (ADM)

are building a plant for production of 50,000 t/year of the PHA based bioplastic Mirel®[6]. The German corporation BIOP will increase in 2008 the BIOPAR® granulate production volume from 9000 to 17,000 t/year. An additional production facility is also planned for 2009[7].
Based on the worldwide production capacities and the overview of the capacities of the individual corporations, one can recognize that a great part of the available capacities is distributed among relatively few corporations throughout the world. Furthermore, the press reports that the expansion of capacities coincides with the estimates of increased capacity in the future.

As in the case of production capacities, there are also different accouncements regarding the data on the consumption of bioplastics. The Nova Institute estimates the consumption of biodegradable bioplastics in Western Europe at 60,000 to 70,000 t/year in 2007. The consumption of bioplastics in durable/long lasting applications in German is estimated at 30,000 – 40,000 t (2007)[8]. European Bioplastics, conversely, is expecting a total consumption of bioplastics in Europe of 50,000 to 100,000 t/year in 2007[9].

The worldwide consumption of plastics has increased strongly in recent years and will also continue to rise in the future. In 2004, according to the estimates of the Federal Environmental Office and the Association of Plastics-Producing Industries, worldwide about 220 million tons of plastic were consumed. In 2006, with an increase of about 10%, it was 245 million tons. The Association of the Plastics Producing Industries anticipates a further increase to 270 million tons for 2010[10,11].

In 2006, Europe had a share of 25% of the total world plastics market. Germany's share was about 8%. Not much has changed in terms of the percentage distribution in the past few years so that it should still be correct today[11].
The absolute production volume of plastics in 2007 in Germany is reported at 20.8 million tons by the Association of the Plastics Producing Industries. This corresponds to an increase of 2.8% over the previous year[12].

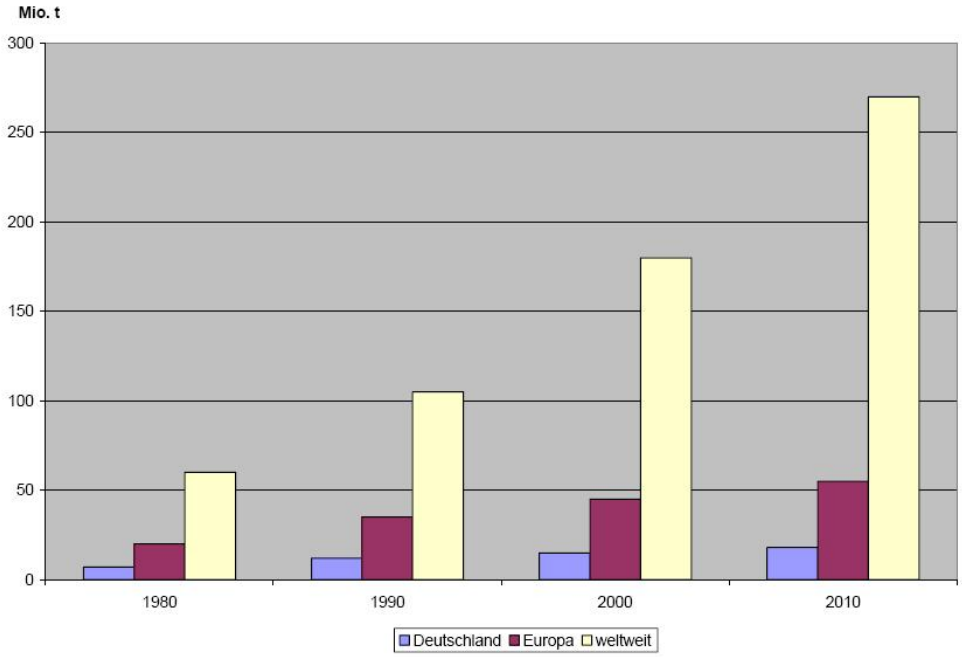

Figure 2: Development and forecast of the worldwide plastics consumption by 2010[10]

According to the figures, the present production capacities of bioplastics appear to be vanishingly small. European Bioplastics reports for 2007 a capacity of 262,000 t[1]. In a study by the Environmental Protection Office on the future of bioplastics, conversely, for the year 2006 a capacity of about 350,000 t is already reported. The variable data, however, do not alter the fact that the current share of bioplastics in the overall plastics market is below 1%[10].

According to the following statements, which the specialty journal "Packmittel" received from some company representatives regarding the development of bioplastics, one can recognize that the sector is in agreement regarding the anticipated development. They base this on a positive development of the bioplastics market and intend to expand their companies in this direction. The statements are already more than a year old but they still appear to be valid. This is due in part to the above-mentioned capacity expansions of many companies. They react to the potential of the bioplastics sector by building new plants to increase capacities.

"The development and acceptance of bioplastics will increase further." (Snehail Desai, Commercial Director, Nature Works).

"The dynamic development will continue – especially for foils." (Dietmar Heufel, Ecoflex Manager, BASF)

"The market development compels us to double our capacities by the end of 2007." (Stefano Facco, New Business Development Manager, Novamont)

"We at Treofan are working in both areas: traditional fossil plastics and bioplastics. We now already see a drastic shift in the direction of environmentally compatible packaging from annually renewable resources." (Frank Ernst, Business Development Manager, Treofan)

The chairman of the board of European Bioplastics, Harald Käb, believes that the present substitution potential of bioplastics could be 5-10% of the total plastics market of the EU. The prospects are said to be good both for biodegradable and also for non-biodegradable bioplastics[13].

The leading companies report that they are investing in technologies for bioplastics. Depending on company size, these investments are of different magnitudes. Certainly the investments of BASF are important; they are increasing their Ecoflex production to 74,000 t/year; NatureWorks with its capacity of 140,000 t and Novamont with investments of almost 110 million Euro.

Bioplastics are presently used primarily in the sector of packaging and foil production. Thus, most of the companies asked are of the opinion that in the intermediate term the greatest chances for bioplastics are in the packaging industry. The study of the "Global Market Situation of Bioplastics" by the Nova Institute for the Reifenhäuser Co. arrived at a similar result. According to it, there is great potential for supporting straps and food packaging as well as in compostable bio-trash bags[14].

The market analysis of Helmut Kaiser Corporate Consultants showed that in 2007, 65% of the

bioplastics were used in the packaging industry sector. The results highlightthe intermediate trend of the bioplastics[15].

In Germany alone, 5.6 million t of plastic packaging are consumed every year (status: 2005). Of these, 1.8 million t are short-lived products such as carrying bags or foils. Judging by the requirements for these plastics, it would not be a problem to use bioplastics in this sector. Therefore, every year almost 2 million t of petrochemical plastics could be replaced by bioplastics in the sector of short-lived packaging alone.

Judging by the statements made, the potential and market opportunities are real. Some companies, however, are somewhat hesitant in expressing themselves, e.g., Novamont, nevertheless sees a "possibly tremendously great potential"[13]. Other companies view the future market chances and the potential very positively and euphorically. Biotec speaks of "very good chances and a booming bio sector." NatureWorks also conjectures a "very strong future"[13].

In the estimation of the future possible application areas of bioplastics, here also many of the companies asked mentioned the packaging sector. DuPont sees the "opportunities in the improvement of existing bioplastics and the development of new bioplastics." The improvement probably involves the development of mixed forms from different bioplastics, through which their properties are improved and the petroleum components reduced. In addition, bioplastics can also be reinforced with natural fibers or other fibers.

The development of new bioplastics will be necessary if other industry sectors are also to be reached. Thus, Pacovis explicitly states "the construction and automobile industry, in the long term, many technical applications still remain to be implemented." This thesis is confirmed by the market analysis by Helmut Kaiser Corporate Consulting, according to which in 2025, 25% of the bioplastics could be used in the automotive and electronics industry. At the same time the percentage share in the packaging industry will drop to 40%[15].

In the automobile industry, Toyota is a pioneer in the field of bioplastics. Other automobile corporations such as Volkswagen, Mazda, BMW and Ford are doing research along this line. Siemens Corporate Technologies and BASF have formed two research groups (BioPro and BioFun), which are researching, inter alia, the development of high quality plastics from renewable raw materials[16].

The high demand for bioplastics can no longer be met by the current production capacities. Therefore, the existing and too low capacities of the raw material producers should be selectively expanded. It is assumed that the above-noted capacity expansions of the production facilities by 2010 can satisfy the anticipated demand for bioplastics. In particular, these planned expansions of the production plants for bioplastics suggest that the demand for bioplastics is not a temporary phenomenon.

Harald Käb of European Bioplastics listed them as follows[17]:

- Europe: 80,000 – 150,000 t
- Germany: 5000 – 80,.000 t
- USA: anticipated: 150,000 t (incl. monomers)
- China, Japan (Asia): ~ 50,000 t (uncertain data)

- Bio-based PE: 350,000 t (DOW / Crystalsev), 200,000 t (Braskem)

The bio-based PE will play a greater role, above all, in the near future. The plants of Braskem and Dow and Crystalsev together can produce 550,000 t per year. Since they are built in Bra zil, South America will become an important producer of bioplastics.

Concerning the anticipated prospects for compostable bioplastics compared to non-degradable, bio-based polymers, the prospects for both types of plastic are estimated to be neither better nor worse, since both have their advantages. The use of compostable bioplastics or non-degradable, bio-based polymers depends on the field of usage and the requirements. These are different for every application which means the best price-performance ratio will decide which plastic is used.

The announcements of Biostarch and Novamont regarding the role of the legislature are quite interesting. They think that the speed of the market growth must be promoted by corresponding laws. In Germany, above all, it is said to be difficult to bring innovations onto the market since other laws often prevent this. As an example of this, one can mention the bio-waste and fertilizer regulation which provides that products for composting must consist of renewable raw materials. Products with petrochemical components that are demonstrably certified as compostable per DIN EN 13432 may nevertheless not be composted according to the law.

European Bioplastics is working on legislative initiatives to create good boundary conditions for innovations and which should improve the planning, legal and investment security for the economy. Two examples of legislative initiatives have been accomplished in Germany and France. In 2005, in Germany a transitional regulation of the packaging law was adopted. According to it, compostable plastic packaging is freed of the return obligation until the end of 2012. In 2006, France adopted a regulation that prescribes that after 2010 disposable bags must be biodegradable[18].

These changes in the law, however, are not without dissenting votes and have been strongly criticized in part. Thus the Frankfurt economic journalist believes that in France this only pertains to agricultural interests and the compartmentalization of French markets. He supports this argument with the fact that the replacement of 85,000 plastic bags by bio-based trash bags would comprise only 0.3% of the French domestic waste. At the same time, however, the sale of starch potatoes would increase by 50%. This is said to make it clear that the French government is actually promoting agricultural interests[19].

Other objections to the use of bioplastics come from PlasticsEurope, the representative of the European plastics manufacturers and from the French environmental and energy efficiency authority ADEME. They are of the opinion that the use of bioplastics should be analyzed in a differentiated manner and in addition the possible environmentally polluting effects must be studied more closely[19].

In Germany there has been negative criticism on the part of the BGK (Federal Compost Community). BGK criticizes the disposal of “fully compostable” bottles in normal biological refuse since they represent a awkward factor in the bio-waste system with a ten-week treatment time.

Additional resistance comes from the paper industry which speaks of distortion of competition by the political promotion of bioplastics[19].

At present, bioplastics are used primarily in short-lived and less critical applications. The high requirements imposed on plastics often limit the use of bioplastics. To expand their spectrum of uses, there must be more investment in research and development. Presently, a major problem is the fact that many bioplastics must still be blended with petroleum-based copolymers because of the areas of their use. The goal is to develop bioplastics with the lowest possible content of petroleum components that can be used without problems in the automotive, electronic and construction industry.

An example in research and development is the combination of several companies via BIO-PRO Baden-Württemberg GmbH. Here, 57 companies and 34 research facilities have organized themselves into the "Biopolymers/Biomaterials" cluster, which was awarded by the Fed. Govt. in 2007 a 10 million euro grant for research. The goal of the cluster is "to identify and develop new types of plastics by the use of microbiological and biochemical procedures, bioprocessing techniques and bio-engineering methods."[20]

Polylactic acid (PLA), which is currently the most economically successful bioplastic, is a good example of the significance of the biotechnology procedures within the scope of synthesis of monomers or polymers based on renewable raw materials. PLA is a bioplastic that has already been used successfully in some long-term applications in the automotive and electronic industries. The requirements, above all in the electronic sector, are that the plastic must be heat resistant, flame retarding, shape stable and heat conducting. However, these are also the reasons why PLA often still has to be blended with petroleum components.

As early as 1998 Toyota built components of PLA in some models. However, this usually involved only fiber material and insulating materials[21]. In the past 6 years, additional products have been put on the market by Fujitsu, Sony and NEC, which contained PLA in long-term applications.

- In June 2002 Fujitsu used PLLLA in an infrared shield in computers.
- In Aug. 2002 Sony made the Walkman housing from PLA
- May 2003: Toyota used PLA for spare tire wrappers and floor mats.
- Sept. 2004: NEC used a PLA/Kenaf composite in dummy cards for the PC
- Jan. 2005: Fujitsu made a PC housing from flame-retarding PLA composite (with petroleum-based plastic blend)
- March 2006: NEC and NTT DoCoMo used a PLA/Kenaf composite in a cell phone holder[22]

In the future, work will be done to improve the mechanical properties of PLA, which can be achieved, for example, by adding glass fibers or impact-tough modifiers[21]. In the Nano Electronics Research Laboratories of NEC, among others, work is being done with PLA-Kenaf composites of 90% biomass. The mechanical properties of these composites already reach approximately the values of glass-fiber reinforced polycarbonates or even exceed them. The disadvantage, however, is in the price, which is clearly higher than that of standard plastics[22].

DuPont is developing a PBT substitute that may be used both in the automobile and in the electronics industry and in various consumer goods. Sorona® is a bioplastic consisting to 37-40% of renewable raw materials and can be produced by polymerization of bio-propanediol (bio-PDO) with terephthalic acid or dimethyl terephthalate. DuPont reports that an increase in the content of renewable raw materials to 50-60% may be possible through process optimizations. The basis of bio-PDO in this case is glucose obtained from corn. In two or recently genetically modified bacteria, the glucose is transformed into bio-PDO in a fermentation step[21].

In the automobile industry, besides Toyota, VW – among others - is developing applications of bioplastics. AT the Motor Show 2007 in Los Angeles, VW presented a prototype of the "Space Up! Blue". Its instrument panel and interior door liner are said to consist of bioplastics, according to the data[23].

Mazda in mid-2006 developed a bioplastic consisting to 88% of PLA and which can be used in the vehicle interior. By 2013, the Mazda Motor Corporation in collaboration with the University of Hiroshima wants to bring a cellulose-containing bioplastic from vegetable wastes to serial maturity. The advantage of this plastic is that the raw material does not compete with food production. This problem will be discussed in more detail below[24].

From the examples cited, one sees that there has been a lot of research on long-term applications in the field of bioplastics. In addition, the companies are getting closer to the goal of extremely minimizing the use of petroleum components. In this regard, Braskem appears to be one step ahead of its competitors. In official reports, it is stated that the repeatedly mentioned Bio PE already consists of 100% renewable raw materials. Braskem intends to "serve markets with high demands for performance capacity and quality" in this way[25].
It remains to be seen how the bio-PE will alter the market. Users and fabricators have a positive attitude toward the product, at any rate, since no new machines are needed for fabrication and there are no risks.

On the other hand, the great potential of PLA appears to be certain. The studies of the German Federal Environmental Office, of the Nova Institute and the Special Agency for Renewable Raw Materials e.V. all assume that PLA will have good prospects on the market. PLA has the greatest chances of growth and will be marketed successfully, above all, when the demand by the packaging industry rises. As a result, the production capacities will have to be enlarged, as is the case, for example, already at Toyota and Mazda. Both auto corporations are expanding their PLA production or are getting into PLA production. Greater capacities would mean that the price of PLA has become clearly more attractive. In 2007, the price at € 1.40/kg closely approached that price of polypropylene at € 1.10/kg. It is therefore not excluded that PLA will reach the same price level as standard plastics[26].

An important topic - with regard to the use of renewable raw materials - is the competition for agricultural areas for biogenous fuels, foods, and other biogenous raw materials, such as bioplastics. The advantage of using renewable raw materials is the fact that there is greater security of supply and independence of fossil raw materials. However, the disadvantage is the competition for the use of agricultural areas. The problem is best explained by the example of bioethanol.

In recent years, the agricultural raw material prices have clearly risen. The prices for corn and wheat reach new highs since harvest losses and a greater demand for bioethanol drove the prices up[27]. On the raw material exchanges, in July 2008, corn was traded at more thatn 750 US$ per ton. (see Fig. 3). This price was caused, among other reasons, by the distillation plants in the US. In 2006 they distilled 11%, in 2007 20% and in 2008 31% of the corn crop.

The demand for bioethanol also caused an increase in the price of wheat. Thus, wheat was sometimes sold on the raw material exchange at more than $1200/ton (see Fig. 3).
Considering this price development and the resulting rise in average food prices, it is not surprising that biogenous fuels have suffered a loss of image in society. The direct relationship between the demand for bio-fuels and food prices is confirmed by the Federal Statistics Office.[28]

Figure 3: Price evolution of corn and wheat on the raw materials exchange in the past 3 years[29]

In this development, plastics manufacturers and fabricators see a disadvantage of bioplastics. They fear that there could also be a loss of image of the bioplastics and that this could adversely affect the market.

An example of a study by the Federal Environmental Office shows that in the case of replacement of the total German demand for plastics by bioplastics, about half of all agriculturally used areas would be required for the raw materials. Economically and technically considered, naturally, this example is not realistic. However, it shows that usage competitions could occur and that work is needed for better utilization of the agricultural potential. One possibility would be to develop new procedures for production of bioplastics from straw and agricultural waste[30]. These raw materials are not in competition with food and have scarcely been utilized to date. Presently, Mazda is working on driving its research in this direction.

In order to replace petroleum by agricultural raw materials for material utilization, a much smaller area will be required than in the case of its use for energy. This fact can easily be derived from the present proportions of types of utilization of petroleum, of which only about 6% is used for materials but 94% for energy.
In addition, the biofuel production problem will, in the long run, be resolved increasingly by direct utilization of solar and wind energy, which can make use of a much higher proportion of solar radiation.
In this way, considerable areas are released for material utilization of renewable raw materials. According to the Nova Institute, it appears that sufficient agricultural areas are available in the long term for renewable raw materials of industry. Secondary products and residual materials from food production can also assure a considerable part of the raw material supply of industry. By using industrial biotechnology, these residual materials of lesser value can be refined into high-quality raw materials and industrial materials [31].
Bio-materials in this case can also be produced from potential foodstuffs such as starch and sugar, as is done in the case of modern biopolymers. The reservations with respect to bio-materials related to this can be made relative in this connection.
On the one hand, the energy can be utilized considerably more efficiently by wind power installations and solar installation than by production of bio-fuels, where only the energy content of the biomass is of interest. On the other hand, more area-efficient crops for food production can be made use of and thereby lower the area requirement.

Summary

Various factors are decisive for the development of the bioplastics market. Both the development of crude oil prices and the development of the prices for renewable raw materials play a part. Furthermore, the expansions of the fields of use and the availability of raw materials must be considered. Political decisions may also have a substantial influence. The final factor is the investments made in basic research.

The evolution of the prices of petrochemical plastics is important for the bioplastics market, since the two types of plastic are in price competition with each other. High prices for petroleum-based plastics may lead to an advantage for bioplastics and further their market development. In that case, however, the raw material prices for bioplastics should not be overlooked. As mentioned initially, the latter have also risen and also lead to a price increase for bioplastics. They are also correlated with the availability and the cultivation areas of renewable raw materials.

The expansion of the fields of application could positively alter the bioplastics market by enabling the use of bioplastics even in long-lived products. The automobile industry and electronics industry, above all, are interested in this development.

Political decisions to promote bioplastics may accelerate the market integration and facilitate the introduction of innovations. Blind actionism, however, should be avoided and rational changes in the laws should be based on environmental balances.

Basic research can assure that other sources of renewable raw materials can be utilized, such as straw, agricultural wastes or lignocellulose. If economical and efficient processes are developed, then the prices of raw materials will decrease as a result and relax the competition

for utilization.

Based on these factors, it is difficult to make a statement concerning the future opportunities for bioplastics. In the intermediate term, they will certainly exploit their potential in the packaging sector. In the long term, it remains to be seen how the factors will evolve and whether the bioplastics with new and improved properties and competitive prices will hold out against the petrochemical plastics. Most companies and experts view the future of plastics - based on renewable raw materials - quite optimistically.

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