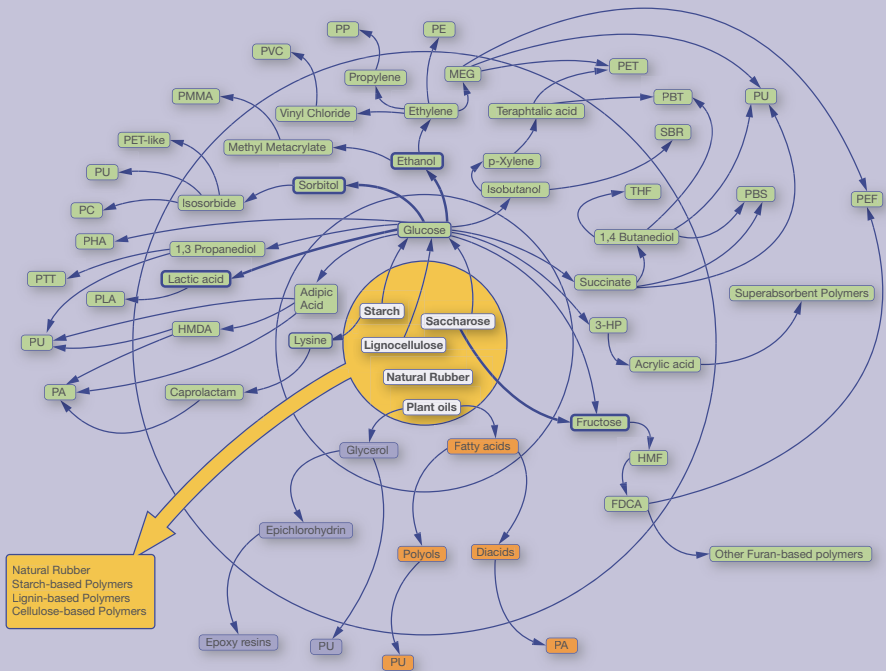


# Market study and Database on

## Bio-based Polymers in the World Capacities, Production and Applications: Status Quo and Trends towards 2020



Bayer MaterialScience



## Bio-based polymers – Production capacity will triple from 3.5 million tonnes in 2011 to nearly 12 million tonnes in 2020

**Bio-based drop-in PET and PE/PP polymers and the new polymers PLA and PHA show the fastest rates of market growth. The lion's share of capital investment is expected to take place in Asia and South America.**

Germany's nova-Institute is publishing the most comprehensive market study of bio-based polymers ever made. The nova-Institute carried out this study in collaboration with renowned international experts from the field of bio-based polymers. It is the first time that a study has looked at every kind of bio-based polymer produced by 247 companies at 363 locations around the world and it examines in detail 114

companies in 135 locations (please see Table 1). Considerably higher production capacity was found than in previous studies. The 3.5 million tonnes represent a share of 1.5% of an overall construction polymer production of 235 million tonnes in 2011. Current producers of bio-based polymers estimate that production capacity will reach nearly 12 million tonnes by 2020. With an expected total polymer production of about 400 million tonnes in 2020, the bio-based share should increase from 1.5 % in 2011 to 3 % in 2020, meaning that bio-based production capacity will grow faster than overall production.

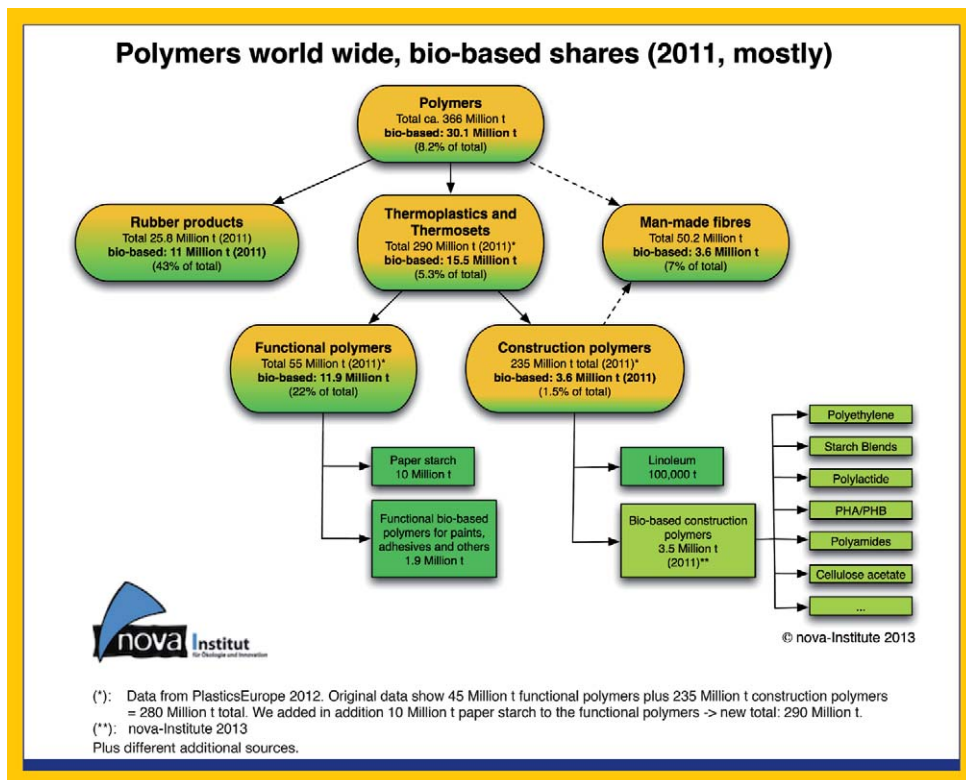


Figure 1: Polymers worldwide, bio-based shares (mostly 2011)

**Table 1:** Bio-based polymers, short names, average biomass content, producer companies and locations

BIO-BASED POLYMERS		AVERAGE BIOMASS CONTENT OF POLYMER	PRODUCING COMPANIES UNTIL 2020	LOCATIONS
Cellulose Acetate	CA	50 %	9	15
Polyamide	PA	rising to 60 %*	14	17
Polybutylene Adipate Terephthalat	PBAT	rising to 50 %*	3	3
Polybutylene Succinate	PBS	rising to 80 %*	11	12
Polyethylene	PE	100 %	3**	2
Polyethylene Terephthalat	PET	30 % to 35 %***	4	4
Polyhydroxy Alkanoates	PHAs	100 %	14	16
Polylactic Acid	PLA	100 %	27	32
Polypropylene	PP	100 %	1	1
Polyvinyl Chloride	PVC	43 %	2	2
Polyurethane	PUR	30 %	10	10
Starch Blends ****		40 %	19	21
<b>Total companies covered with detailed information in this report</b>			<b>114</b>	<b>135</b>
Additional companies included in the "Bio-based Polymer Producer Database"			133	228
<b>Total companies and locations recorded in the market study</b>			<b>247</b>	<b>363</b>

\* Currently still mostly fossil-based with existing drop-in solutions and a steady upward trend of the average bio-based share up to given percentage in 2020

\*\* Including Joint Venture of two companies sharing one location, counting as two

\*\*\* Upcoming capacities of bio-pTA (purified Terephthalic Acid) are calculated to increase the average bio-based share, not the total bio-PET capacity

\*\*\*\*Starch in plastic compound

Table 1 gives an overview on the covered bio-based polymers and the producing companies with their locations at the time of the release of the market study. The database contains a total of 247

companies in 363 locations. More detailed information is provided for 114 companies in 135 locations.

The most dynamic development is foreseen for drop-in biopolymers, which are chemically identical to their petrochemical counterparts but at least partially derived from biomass. This group is spearheaded by partly bio-based PET (bio-PET) whose production capacity will reach about 5 million tonnes by the year 2020, using bioethanol from sugar cane. The second in this group are bio-based polyolefins like

PE and PP, also based on bioethanol. But “new in the market” bio-based polymers PLA and PHA are also expected to at least quadruple the capacity between 2011 and 2020.

Michael Carus, managing director of nova-Institute, reacted to the survey results thus: “For the very first time we have robust market data about worldwide production capacity of all bio-based polymers. This

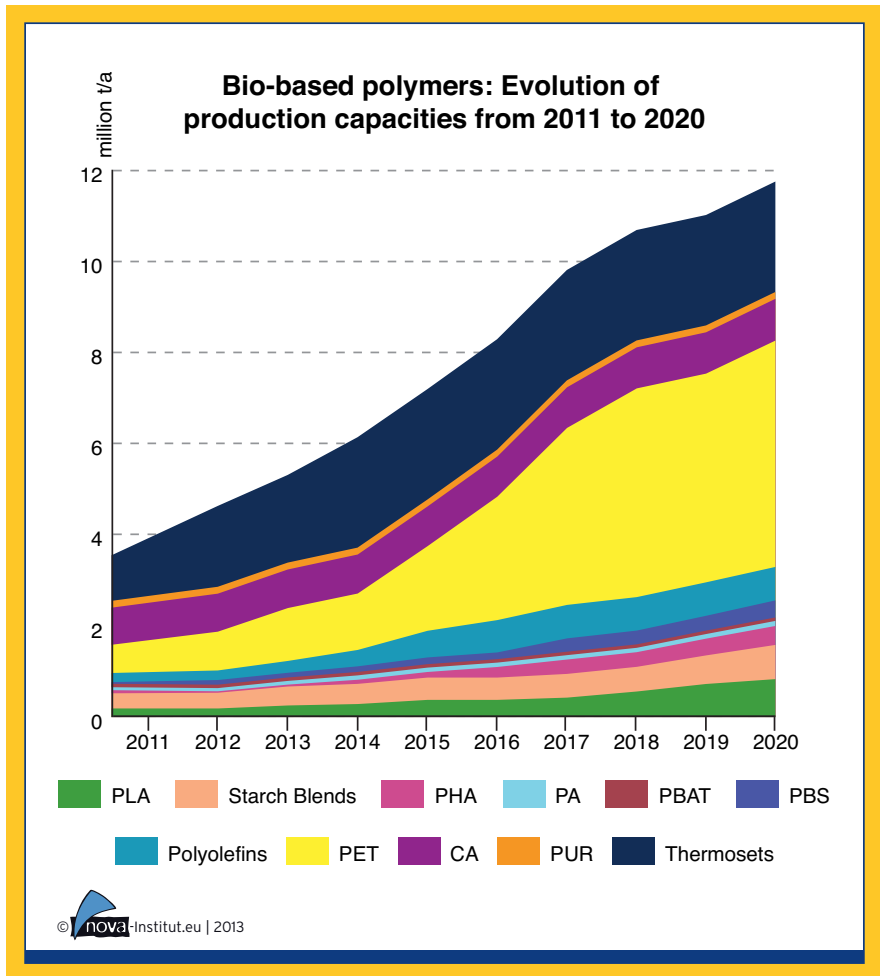
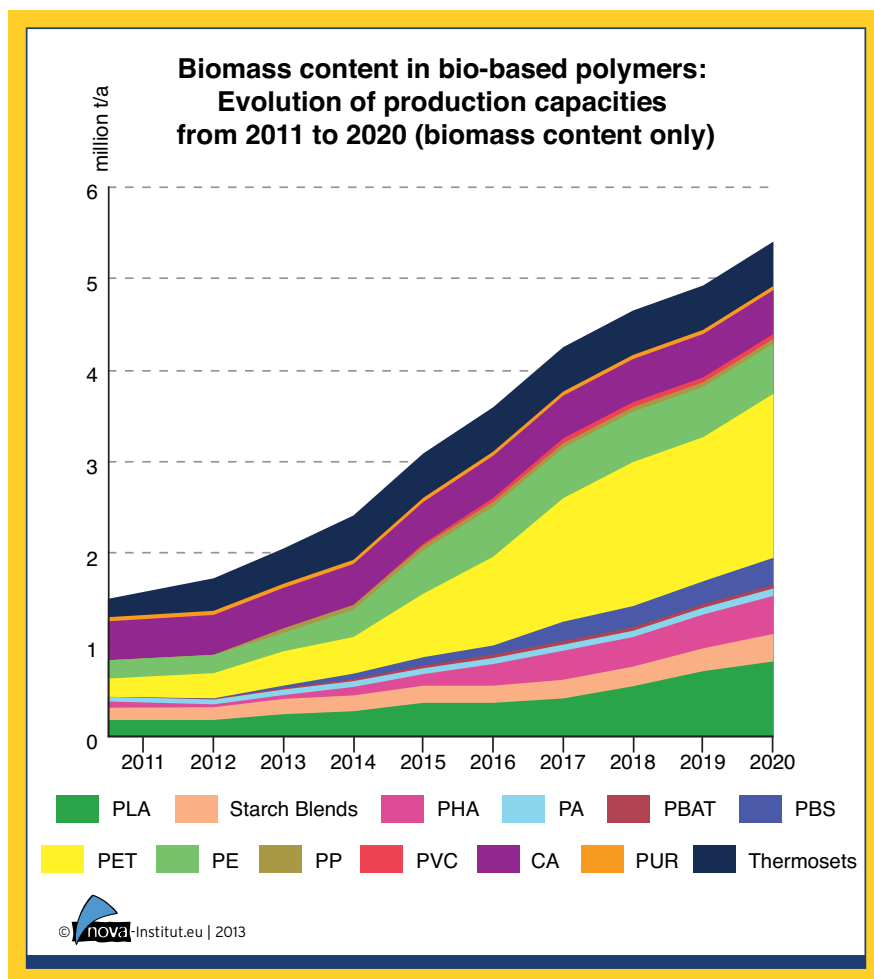


Figure 2: Bio-based polymers: Evolution of production capacities from 2011 to 2020

is considerably higher than in previous studies, which did not cover all polymers and producers. The forecast of a total capacity of 12 million tonnes by 2020 – a tripling of 2011 levels – suggests that bio-based polymers are definitely polymers for the future. It is also shown that the development of bio-based polymers is still very dynamic. Only five years ago, nobody would have expected bio-PET to grow to

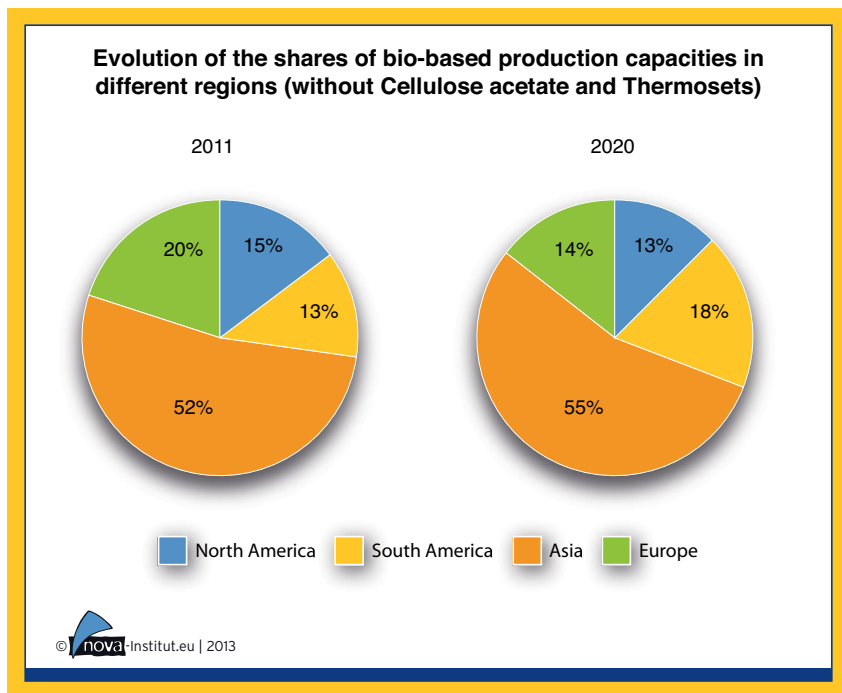
the biggest group among the bio-based polymers due to an initiative by one big brand-owner. This could happen again with any other bio-based polymer. PLA and PHA also have a remarkable growth ahead of them, even without the existence of such a ‘supply chain captain’.



**Figure 3:** Biomass content in bio-based polymers: Evolution of production capacities from 2011 to 2020 (biomass content only, see Table 1)

Most investment in new bio-based polymer capacities will take place in Asia and South America because of better access to feedstock and a favourable political framework. Europe's share will decrease from 20 % to 14 % and North America's share from 15% to 13 %, whereas Asia's

will increase from 52 % to 55 % and South America's from 13 % to 18 %. So world market shares are not expected to shift dramatically, which means that every region of the world will experience development in the field of bio-based polymer production.



**Figure 4:** Evolution of the shares of bio-based production capacities in different regions (without Cellulose acetate and Thermosets)

The report summary of the market study was published in the April 2013 issue of **Industrial Biotechnology**.

The figures included in this brochure can be downloaded in high resolution at: [www.bio-based.eu/market\\_study/pressrelease](http://www.bio-based.eu/market_study/pressrelease)

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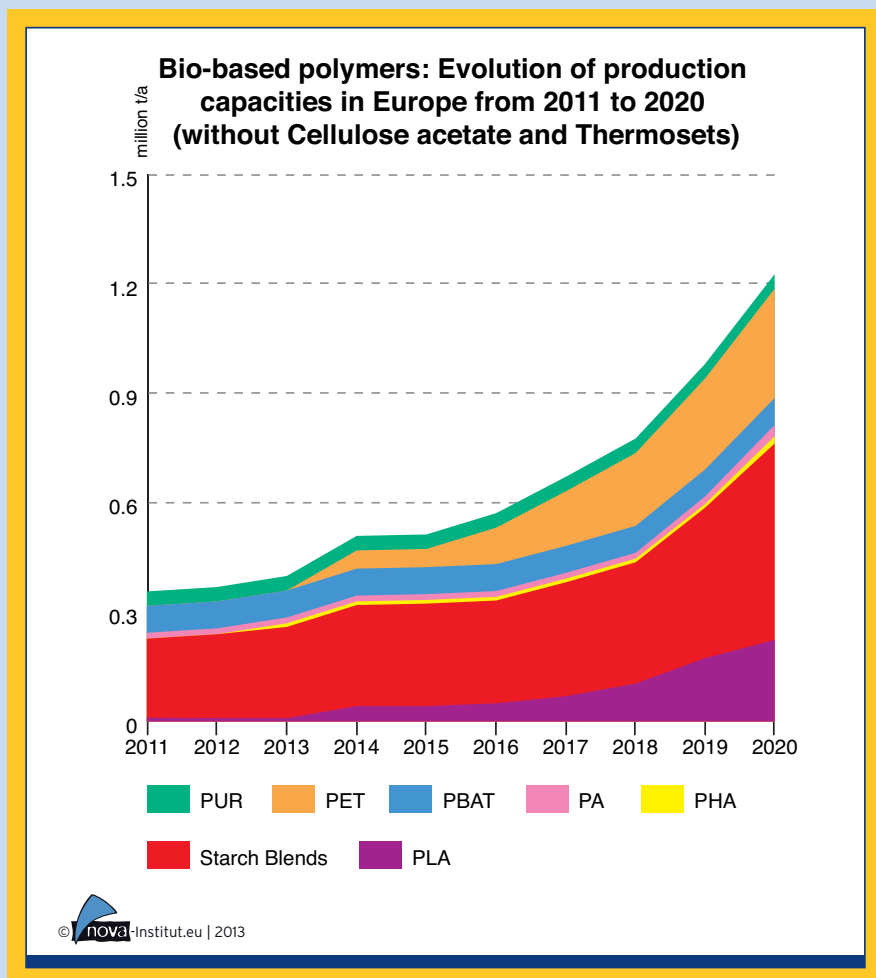


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## Production Capacities for Bio-based Polymers in Europe – Status Quo and Trends towards 2020

The “Bio-based Polymers Producer Database” shows that Europe’s position in producing bio-based polymers is limited to just a few polymers. Europe has so far established a solid position mainly in the field of starch blends (blends of polymers with native starch or thermoplastic starch)

and it is expected to remain strong in this sector for the next few years (see Figure 5). Nevertheless, new developments and investments are foreseen in Europe: some years after the installation of industrial scale PLA capacities in North America and Asia, the first European industrial-



**Figure 5:** Bio-based polymers: Evolution of production capacities in Europe from 2011 to 2020 (without Cellulose acetate and Thermosets)

scale PLA plant is scheduled to become operational in 2014.

PET production is growing worldwide, largely due to the Plant PET Technology Collaborative (PTC) initiative, whose global value chain development will lead to the introduction of future production facilities in Europe by 2015.

One noteworthy finding of other studies is that Europe shows the strongest demand for bio-based polymers, while production tends to take place elsewhere, namely in Asia and South America. The bio-based polymer production facilities for PLA and PHA located in Europe are currently rather small, and there are next to no production capacity figures for the latter. On the other hand, bio-based PUR and PA production has gradually taken off in Europe and is likely to remain stable in order to supply the growing markets on the building and construction and automotive sectors. Europe does host industrial production facilities for PBAT (shown in Figure 5), which although still fully fossil-based, is expected to be increasingly bio-based reaching shares of 50% by 2020, to judge by industry announcements and the capacity development of its bio-based precursors.

With leading chemical corporations, Europe has a particular strength and great potential in the fields of high-value fine chemicals and building blocks for the production of PA, PUR and thermosets among others. However, only few specific, large-scale plans for bio-based building blocks with concrete plans for the production of bio-based polymers have been announced to date.

### **EU: No dedicated policies to promote bio-based polymers**

The European Union's relatively weak position in the production of bio-based polymers is largely the consequence of an unfavourable political framework. In contrast to biofuels, there is no European policy framework to support bio-based polymers, whereas biofuels receive strong and ongoing support during commercial production (quotas, tax incentives, green electricity regulations and market introduction programmes, etc.). Without comparable support, bio-based chemicals and polymers will suffer further from underinvestment by the private sector. It is currently much more attractive and safe to invest in bio-based polymers in Asia, South America and North America.

#### **Remark:**

Figure 5 shows the production capacities for bio-based polymers except for thermosets and cellulose acetate. There is a simple reason for this: although good expert estimations of world thermoset and cellulose acetate production capacity are available, based on the global development of their bio-based precursors, it is not possible to break this information down by region.



## Authors of the study



**Michael Carus** (Dipl.-Phys.) (Germany) is a physicist and founder and managing director of nova-Institute. He has worked in the Bio-based Economy field for over 15 years. This includes biomass feedstock, bio-based chemistry, plastics, fibres and composites. His work focuses on market analysis, techno-economic and ecological evaluation and creating the political and economic framework for bio-based processes and applications. Carus is main author of the “Policy paper on Bio-based Economy in the EU: Level Playing Field for Bio-based Chemistry and Materials”, and is considered to be one of the leading experts for the industrial material use of biomass. Seven experts from the nova-Institute team contributed to the study.



**Wolfgang Baltus** (PhD) (Thailand) worked for BASF for 15 years and was responsible for the business development of environmental friendly coatings in Asia. Since 2008 Baltus has been working for the National Innovation Agency (NIA) in Bangkok. He is regarded as one of the leading experts on bio-based polymer markets and policy in Asia.



**Dirk Garrez** (PhD) (Belgium) is one of the leading policy consultants on a Bio-based Economy in Brussels. He was director of EuropaBio, the European Association for Bioindustries, until 2011. He is now Managing Director of Clever Consult, Brussels. In 2013 he was hired to be the coordinator of the new industrial association BIC (Bio-based Industries Consortium), which will organise the PPP (BRIDGE – Bio-based and Renewable Industries

for Development and Growth in Europe) between the EU Commission and more than 40 bio-based economy companies.

**Harald Kaeb** (PhD) (Germany) is a chemist and has an unblemished 20-year „bio-based chemistry and plastics“ track record. From 1999 to 2009 he chaired the board and built up “European Bioplastics”, the association that represents the bioplastics industry in Europe. Since 1998 he has worked as an independent consultant helping green pioneers and international brands to develop and implement smart business, media and policy strategies for bio-based plastics.



**Jan Ravenstijn** (MSc) (The Netherlands) has more than 35 years experience in the chemical industry with Dow Chemical and DSM, including 15 years in executive global R&D positions in engineering plastics, thermosets and elastomers. He is currently a visiting professor and consultant to the CEOs of biopolymer companies and has published several papers and articles on the market development of bio-based polymers. Ravenstijn is regarded as one of the world’s leading experts in his field.



**Stefan Zepnik** (PhD) (Germany) studied Business Engineering at the Martin Luther University Halle-Wittenberg and gained his PhD at the Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT. He became group manager for “Material Development” at the “Bio-based Plastics” department in 2013.



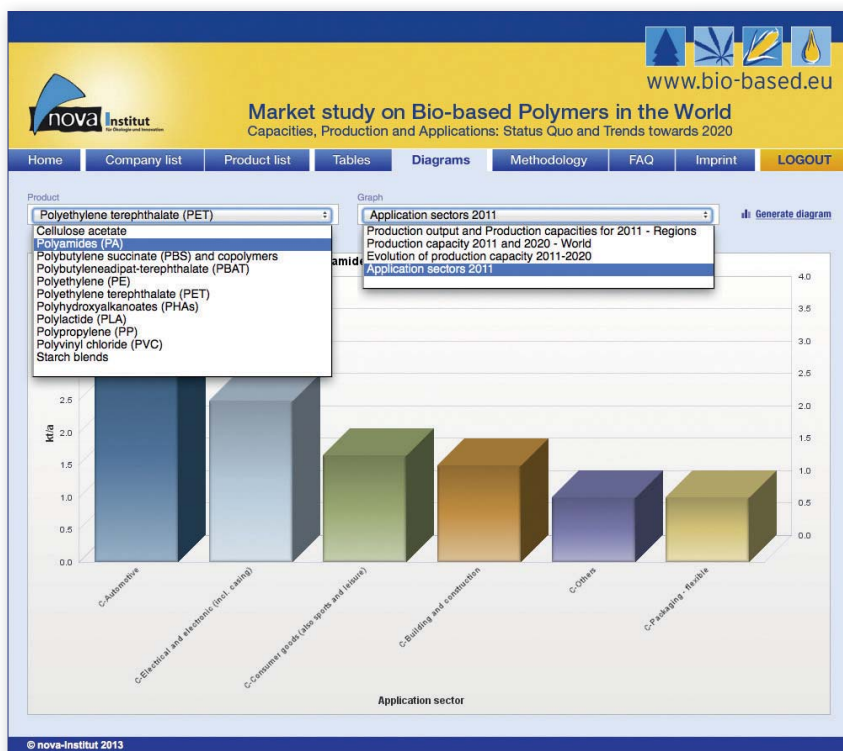
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## “Bio-based Polymers Producer Database” and updates to the report

To conduct this study nova-Institute developed the “Bio-based Polymers Producer Database”, which includes a company profile of every company involved in the production of bio-based polymers and their precursors. This encompasses (state of affairs in 2011 and forecasts for 2020) basic information on the company (joint ventures, partnerships, technology and bio-based products) and its various manufacturing facilities. For each bio-based product, the database provides information about production and capacities, feedstocks, main application fields, market prices and bio-based share.

The database will be constantly updated by the experts who have contributed to this report. **Buyers of the report will have free access to the database for one year. nova-Institute will generate an annual update of the report based on the existing report and the continuously updated database.** Everyone who has access to the database can automatically generate graphics and tables concerning production capacity, production and application sectors for all bio-based polymers based on the latest data collection (see example below).



## Content of the full report

This over 360-page report presents the findings of nova-Institute's year-long market study, which is made up of three parts: "market data", "trend reports" and "company profiles".

The "**market data**" section presents market data about total production and capacities and the main application fields for selected bio-based polymers worldwide (status quo in 2011 and trends towards 2020). Due to the lack of 100% reliable market data about some polymers, which is mainly due to the complexity of their manufacturing value chain structure (namely thermosets, cellulose acetate) or their pre-commercial stage (CO<sub>2</sub>-based polymers), this section contains three independent articles by experts in the field who present and discuss their views on current and potential market development. However, this part not only covers bio-based polymers, but also investigates the current bio-based building block platforms.

The "**trend reports**" section contains a total of six independent articles by leading experts in the field of bio-based polymers and plastics. Dirk Carrez

(Clever Consult) and Michael Carus (nova-Institute) focus on policies that impact on the bio-based economy. Jan Ravenstijn analyses the main market, technology and environmental trends for bio-based polymers and their precursors worldwide. Wolfgang Baltus (NIA) reviews Asian markets for bio-based resins. Roland Essel (nova-Institute) provides an environmental evaluation of bio-based polymers, and Janpeter Beckmann (nova-Institute) presents the findings of a survey concerning Green Premium within the value chain leading from chemicals to bio-based plastics. Finally, Harald Kaeb (narocon) reports detailed information about brand strategies and customer views within the bio-based polymers and plastics industry. These trend reports cover in detail every recent issue in the worldwide bio-based polymer market.

The final "**company profiles**" section includes 114 company profiles with specific data including locations, bio-based polymers, feedstocks, production capacities and applications. A company index by polymers, and list of acronyms follow.

## Order the full report

The full 360-page report contains three main parts – "market data", six "trend reports" and 114 "company profiles" – and can be ordered for 6,500 € plus VAT at:

[www.bio-based.eu/market\\_study](http://www.bio-based.eu/market_study)

This also includes one-year access to the "Bio-based Polymers Producer Database", which will be continuously updated. The full report will be update yearly.

