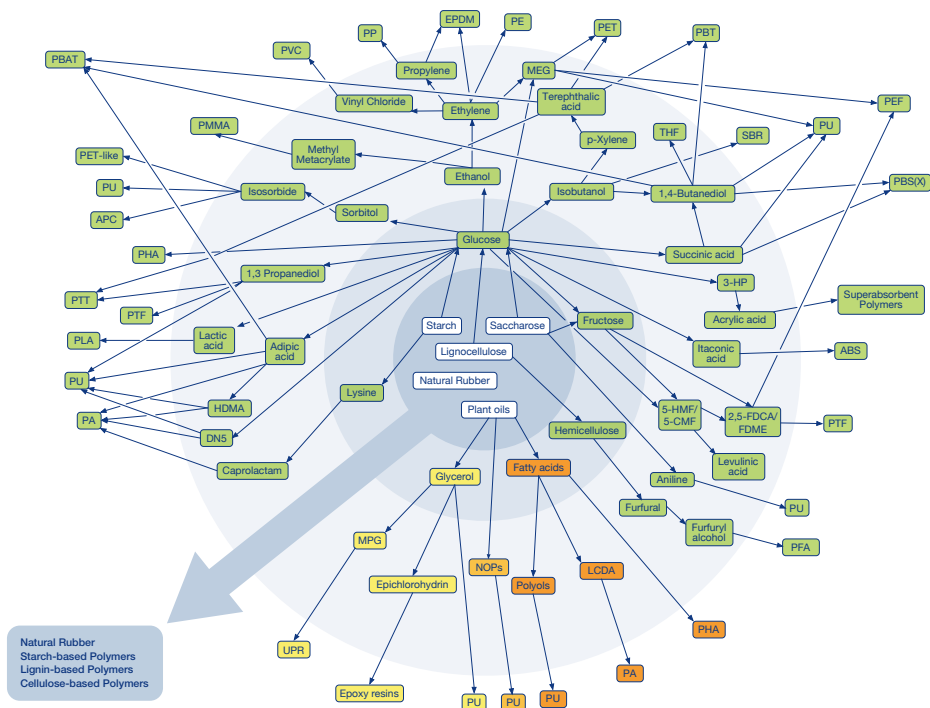


# Bio-based Building Blocks and Polymers – Global Capacities, Production and Trends 2018–2023



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Doris de Guzman, Harald Käb, Achim Raschka, Jan Ravenstijn  
February 2019

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## Global Markets and Trends of Bio-based Building Blocks and Polymers 2018–2023

### Executive summary

**2018 was a very good year for bio-based polymers: Several additional capacities were put into operation.**

The new market and trend report “**Bio-based Building Blocks and Polymers – Global Capacities, Production and Trends 2018–2023**” from the German nova-Institute shows capacities and for the first time also production data for all bio-based polymers. In 2018 the total production volume reached 7.5 million tonnes – these are already 2% of the production volume of petrochemical polymers. The potential is much higher, but is currently hampered by low oil prices and a lack of political support.

The production of bio-based polymers has become much more professional and differentiated in recent years. By now, there is a bio-based alternative for practically every application. The capacities and production of bio-based polymers will continue to grow with an expected CAGR of about 4% until 2023, almost at about the same rate as petrochemical polymers and plastics. Therefore, the market share of bio-based polymers in the total polymer and plastics market remains constant at around 2% (Figure 1).

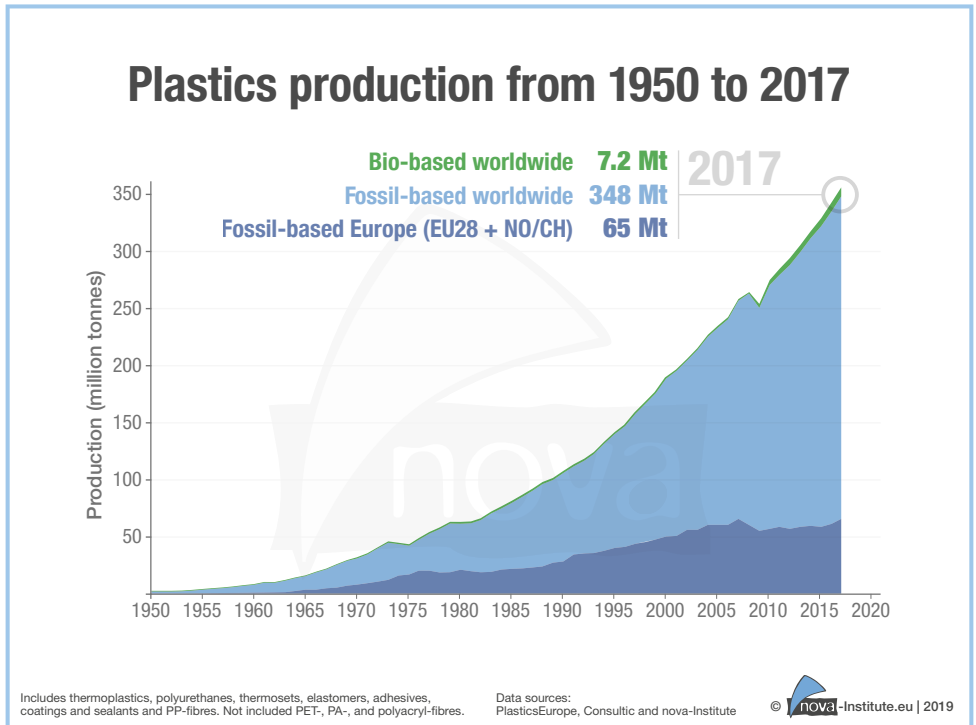


Figure 1: Plastics production from 1950 to 2017 (nova-Institut 2019)

The increase in production capacity is mainly based on the expansion of the polylactic acid (PLA) production in Thailand, the polytrimethylene terephthalate (PTT) and starch blends in US. Especially PLA and starch blends will continue to grow significantly until 2023. Also new capacities of bio-based polyamides, polyethylene (PE) and, for the first time, polypropylene (PP) and poly(butylene adipate-co-terephthalate) (PBAT). The great hopeful polyethylene furanoate (PEF) will presumably only be able to offer commercial capacities after 2023.

Overall, the market environment remains challenging with low crude oil prices and little political support.

- So far, the two major advantages of bio-based polymers have not been politically rewarded. The first advantage is that bio-based polymers replace fossil carbon in the production process with renewable carbon from biomass. This is indispensable for a sustainable, climate-friendly plastics industry and is not yet politically rewarded.
- The second advantage is offered by about a quarter of bio-based polymer production: They are biodegradable (depending on the environment) and can therefore be a solution for plastics that cannot be collected and enter the environment where they can biodegrade without leaving behind microplastics. Only a few countries such as Italy, France and, in future probably Spain will politically support this additional disposal path.

The most important market drivers in 2018 were brands that want to offer their customers environmentally friendly solutions and critical consumers looking for alternatives to petrochemicals. If bio-based polymers were to be accepted as a solution and promoted in a similar way as biofuels, annual growth rates of 10 to 20% could be expected. The same applies as soon as the price of oil rises significantly. Based on the already existing technical maturity of bio-based polymers, considerable market shares can then be gained.

The market report is updated every year and the update for the year 2018 offers very special highlights: It contains comprehensive information on capacity development from 2018 to 2023, per bio-based building block and polymer and for the first time production data for the year 2018, per bio-based polymer. A total of 17 bio-based building blocks and 16 polymers are covered in the report. In addition, the new issue includes analyses of market developments and producers per building block and polymer, so that readers can quickly gain an overview of developments that go far beyond capacity and production figures. For the first time, a detailed research, calculation and explanation of the market development of cellulose acetate (CA), bio-based epoxy resins and bio-based polyurethanes was made possible through a cooperation with the main experts in this area. The deep dive into the producing companies was comprehensively updated and shows now 173 detailed company profiles – from start-ups to multinational corporations.

The data published annually by European Bioplastics ([www.european-bioplastics.org/market/](http://www.european-bioplastics.org/market/)) are taken from the market report of the nova-Institute, but with a reduced selection of bio-based polymers.

## Bio-based Polymers

Figure 2 shows all commercially realized pathways from biomass via different building blocks and monomers to bio-based polymers.

As in previous years, we have added several pathways and some new intermediates.

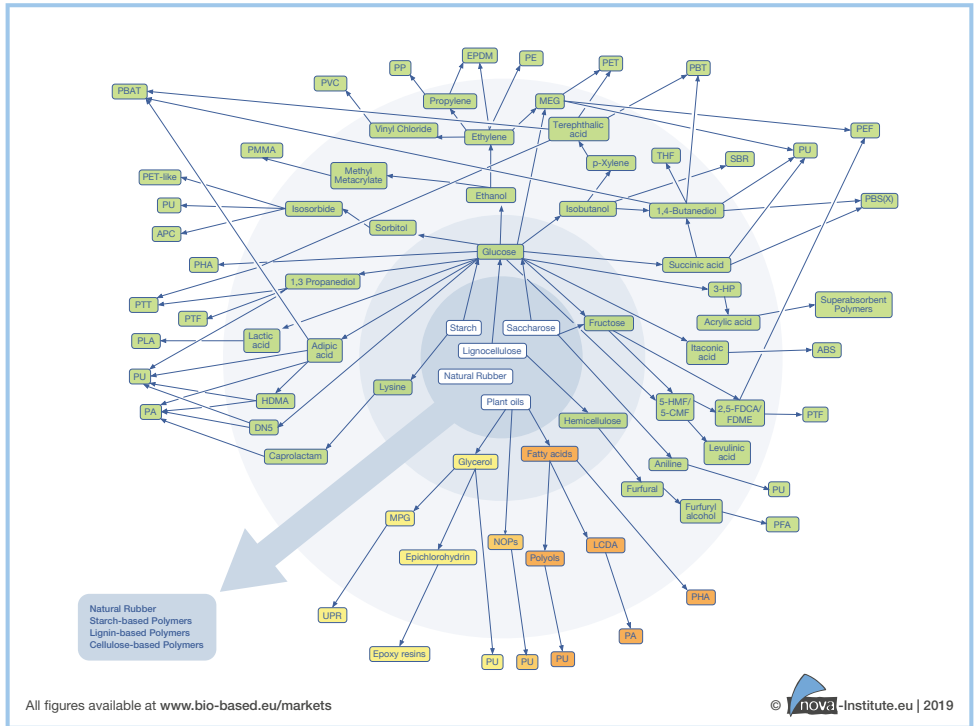
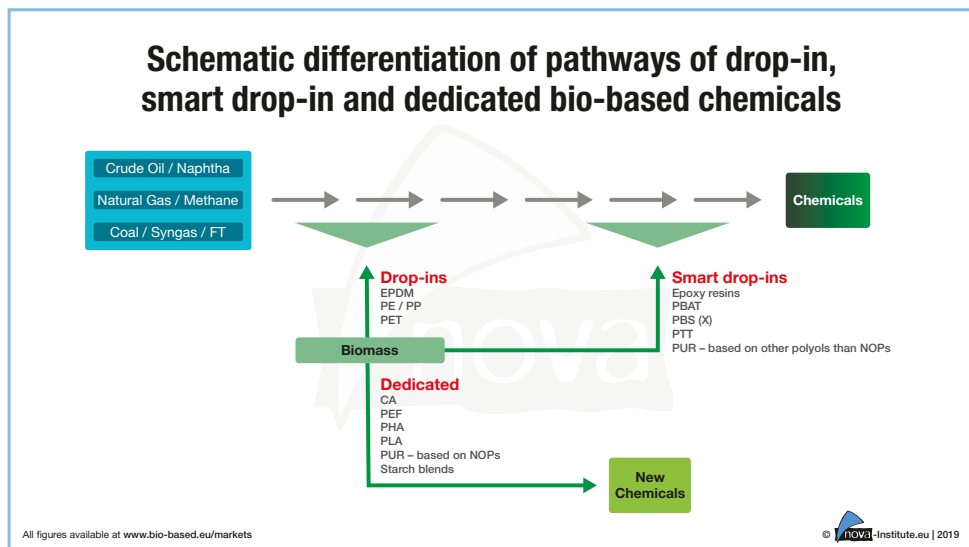


Figure 2: Pathways to bio-based polymers (nova-Institut 2019)



**Figure 3:** Schematic differentiation of pathways of drop-in, smart drop-in and dedicated bio-based chemicals.<sup>1</sup> Selected bio-based polymer examples are shown for each classification group.

Figure 3 shows the different pathways of bio-based “drop-in”, “smart drop-in” and “dedicated” inputs within the chemical production chain. For each group certain bio-based polymers are exemplarily shown. The different bio-based polymer groups are subject to different market dynamics. While the drop-ins have direct petrochemical counterparts and can substitute them, the dedicated ones have new properties and functionalities that petrochemistry does not provide. Both have their own advantages and disadvantages from a production and market perspective.

Figure 4 summarises the results of the results of the 380-page report and shows the development of capacities from 2018 to 2023 on the basis of forecasts by current and some additional

producers. Here an increase is shown from 8 Mio. tonnes production capacity in 2018 to 9.6 Mio. tonnes in 2023, which means an expected yearly growth rate of about 4% (CAGR).

With an expected CAGR of 10% between 2018 and 2023, Europe will display the highest growth of bio-based polymer capacities compared to other regions of the world (see Figure 7). If only the new dedicated polymers (for definition see Figure 3) are considered, the growth rates are expected to be even higher (CAGR = 5%), as Figure 5 shows. In the group of dedicated bio-based polymers, price pressure stemming from cheap crude oil is lower than for other groups because there are no direct petrochemical counterparts.

<sup>1</sup> Source: Carus, M. et al.: Bio-based drop-in, smart drop-in and dedicated chemicals. Version 2017-12. Free download at: [www.bio-based.eu/technology](http://www.bio-based.eu/technology).

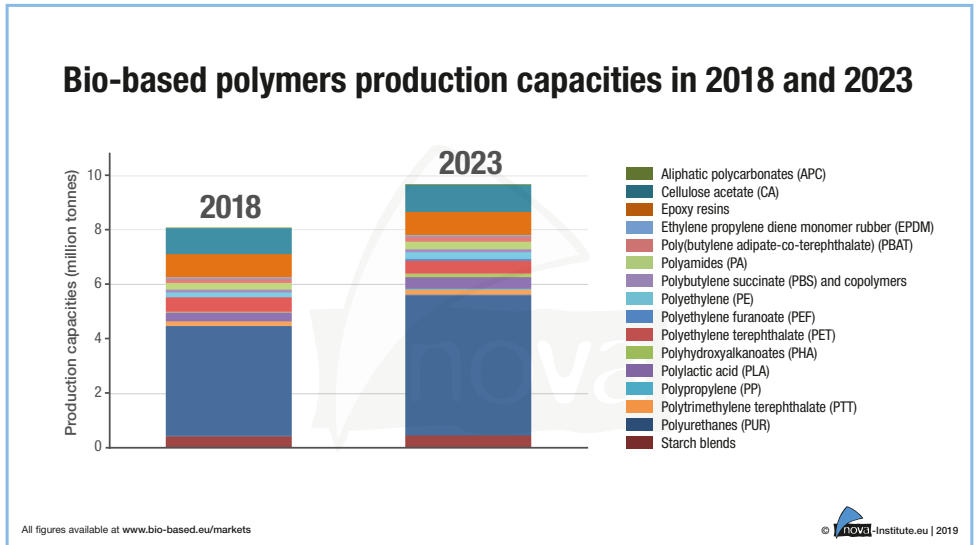


Figure 4: Bio-based polymers production capacities in 2018 and 2023

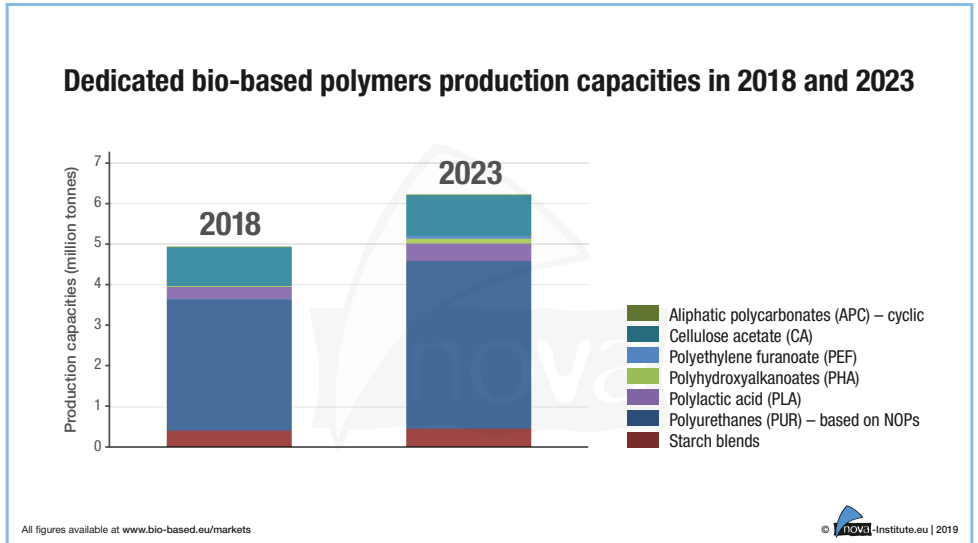


Figure 5: Dedicated bio-based polymers production capacities in 2018 and 2023

## Bio-based Building Blocks

Figure 6 illustrates the development of capacities for the main bio-based building blocks, the core of the new bioeconomy, used for the production of polymers. Between 2018 and 2023, the CAGR of 4.5% will be only slightly higher than that of bio-based polymers (4%) as a whole.

The building blocks can be used in structural polymers as well as in functional polymers (for definition see below) and also in various other applications such as food, feed, cosmetics or pharmaceuticals.

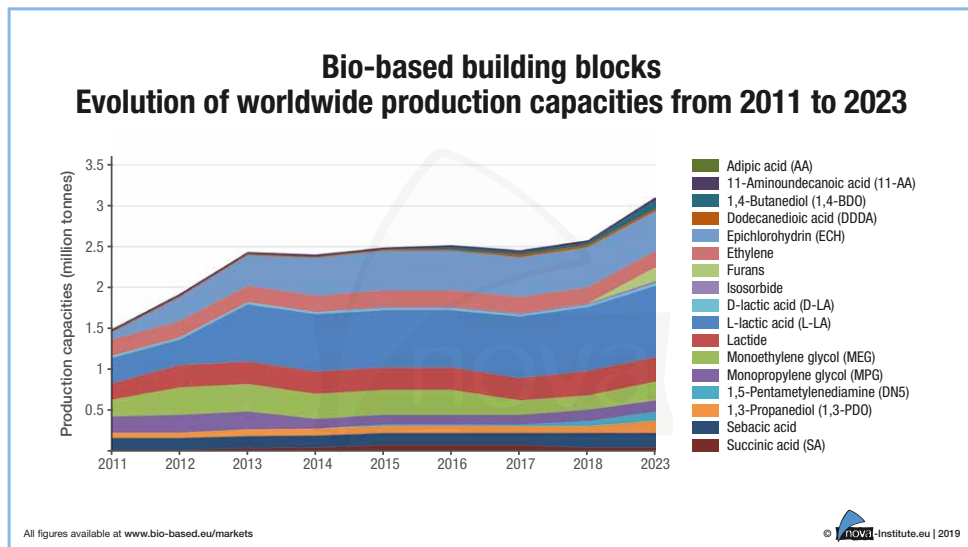


Figure 6: Bio-based building blocks – Evolution of worldwide production capacities from 2011 to 2023

The overall production capacity of bio-based building blocks increased about 5% (120,000 t/a) in 2018, although some pioneers went bankrupt. The overall forecast for bio-based building blocks evolution worldwide indicates a total growth by 4.5% until 2023 with

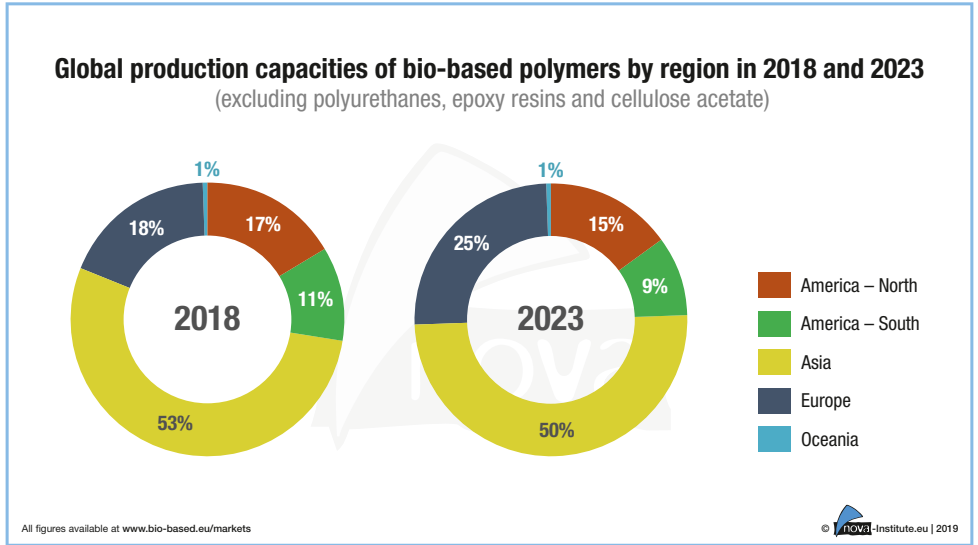
1,3-propanediol (1,3-PDO), 1,4-butanediol (1,4-BDO), 1,5-pentamethylenediamine (DN5) and 2,5-furandicarboxylic acid (2,5-FDCA)/furan dicarboxylic methyl ester (FDME) being the main drivers.



## Global production capacities of bio-based polymers by region

Besides the leading Asian region which has installed the largest bio-based production capacities worldwide with 53% in 2018, Europe follows with 18% and North and South America

with 17% respectively 11%. In the next five years, the share of Europe will rise to 25% until 2023 – all other regions will face decreasing shares (see Figure 7).



**Figure 7: Global production capacities of bio-based polymers by region in 2018 and 2023 (excluding polyurethanes, epoxy resins and cellulose acetate)**

This increase is mainly due to the dedicated bio-based polymers PEF, PHA, PLA and starch blends as well as the new established bio-based production capacity of PP, the increase in PE capacity and an increase in polyamides and PBAT.

This shows that the substantial investment in research and development in Europe is bearing fruit. Now, if the political framework were designed more favourably, the bioeconomy in Europe could really flourish. Technology and business are ready.

## Market segments for bio-based polymers

Today, bio-based polymers can be used in almost all market segments and applications, but the applications per polymer are very different.

Figure 8 shows a summary of the applications for all polymers.

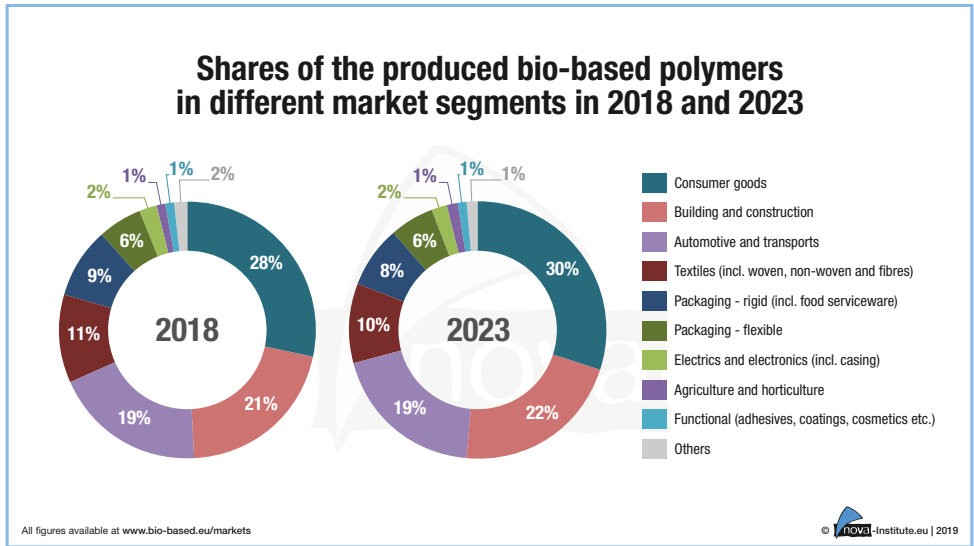


Figure 8: Shares of the produced bio-based polymers in different market segments in 2018 and 2023

Consumer goods make up the largest share of actually produced bio-based polymers with 28% in 2018 (mainly PUR, epoxy resins and PA), followed by the building and construction sector (epoxy resins, PA, PUR) with 21%, the automotive and transport sector with 19% (epoxy

resins, PA, PUR) and the packaging (flexible and rigid) (PLA, PBAT, PE, PET, starch blends) with 15%, as well as textiles (wovens and non-wovens) (CA, PA, PLA, PTT) with 11%. For 2023, no significant changes are expected with regard to market application shares.

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**Update 2018**

**Bio-based Building Blocks and Polymers – Global Capacities, Production and Trends 2018–2023**

**Authors:**  
Pia Stoczninski, Pia Stoczninski, Michael Carus, Wolfgang Balth, Doris de Gooijer, Harald Kahl, Achim Raeschke, Jan Ravensstijn  
February 2019

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**Authors:** Achim Raeschke, Pia Stoczninski, Jan Ravensstijn and Michael Carus, now Institut GmbH, Germany  
February 2019

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<b>Pharmaceutical/Cosmetic</b> <ul style="list-style-type: none"> <li>• Active ingredient for active cosmeceuticals</li> <li>• Amino acids</li> <li>• Chemical synthesis, water-based synthesis</li> <li>• Ethanol-based solvents</li> <li>• Functionalized polymers</li> <li>• Functionalized polymeric membranes</li> <li>• Hydrogels (pharmaceuticals, antibodies, diagnostics)</li> <li>• Polymeric membranes</li> <li>• Polymer thin films</li> <li>• Reactors for biocatalysis</li> <li>• Reactors for the production of biobased-A</li> </ul>	<b>Industrial</b> <ul style="list-style-type: none"> <li>• Solvents</li> <li>• Engineering plastics and epoxy casting resins</li> <li>• Polyurethanes</li> <li>• Methacrylates, ketones, epoxides of polyurethanes</li> <li>• Monomers for polyurethanes, polyurethane-ureas, urea-ureas</li> <li>• Polyurethanes</li> <li>• Glycolic acid</li> <li>• Surface coating agent</li> <li>• Cellulose derivatives</li> <li>• Cellulose derivatives</li> </ul>
<b>Food</b> <ul style="list-style-type: none"> <li>• Bread softening agent</li> <li>• Flavor enhancer</li> <li>• Flavoring agent and acidic component</li> <li>• Food packaging</li> <li>• Preservative (citric acid, butyric acid)</li> <li>• Protein stabilizer</li> <li>• Protein stabilizer</li> <li>• Protein stabilizer</li> <li>• Protein stabilizer</li> <li>• Protein stabilizer</li> </ul>	<b>Succinic Acid</b> <ul style="list-style-type: none"> <li>• Succinic Acid</li> <li>• Chemical synthesis, water-based synthesis</li> <li>• Solvents</li> <li>• Engineering plastics and epoxy casting resins</li> <li>• Polyurethanes</li> <li>• Methacrylates, ketones, epoxides of polyurethanes</li> <li>• Monomers for polyurethanes, polyurethane-ureas, urea-ureas</li> <li>• Polyurethanes</li> <li>• Glycolic acid</li> <li>• Surface coating agent</li> <li>• Cellulose derivatives</li> <li>• Cellulose derivatives</li> </ul>
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**Authors:** Pia Stoczninski, Pia Stoczninski, Achim Raeschke, Michael Carus, now Institut GmbH, Germany  
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Dr. Harald Kahl, narcon Innovation Consulting, Germany  
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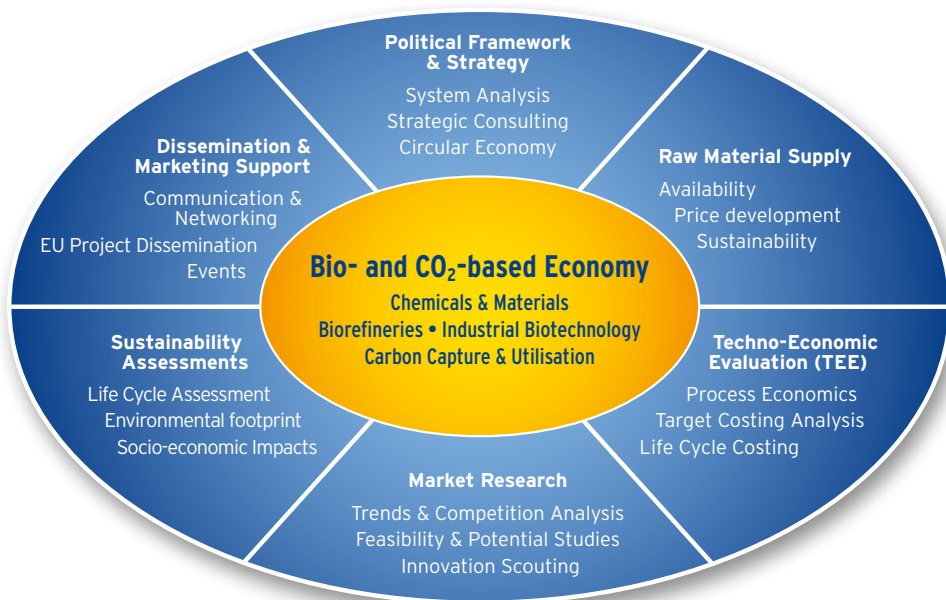
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