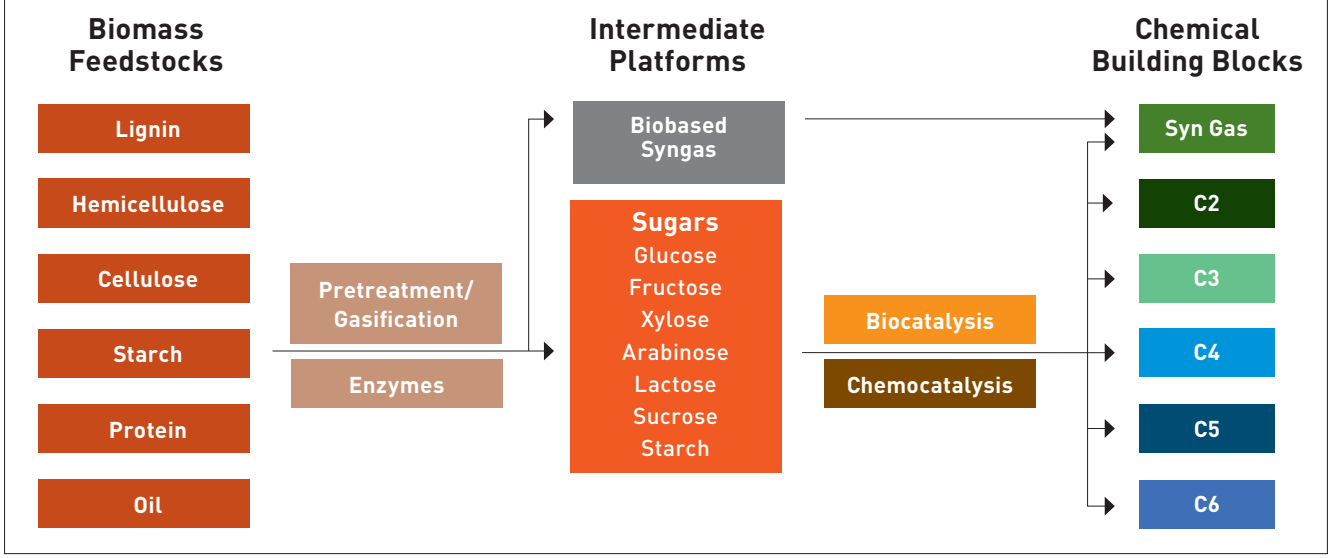
Fact Sheet

Industrial Biotechnology in Germany

Biorefinery – A Chemical Building Block Perspective
A Selection of Players in the Value Chain

Biorefinery: From Biomass to Chemical Building Blocks



Raw Materials

Starch and sugar are the most commonly used raw materials in biorefinery processes today. The German starch and sugar producers are established companies who can look back on decades of production experience. Agreed outputs are guaranteed at well-known German quality levels and market-competitive prices.

Opportunities
Safe and secure raw materials supply at market-competitive prices.

Research & Development

The R&D environment provides the basis for the economic success of the German industry. Close interaction between industry and science ensures quick times to market. As well as numerous universities, there are also a number of world-renowned non-university institutes. These include the Fraunhofer Society and Leibniz Association.

Opportunities
R&D cooperation and extensive networking.

Business

Innovative research with the goal of commercialization also drives German companies (who in biorefinery terms primarily come from the chemical industry). Industry drivers include the sustainable "design" of industrial processes pushed by rising fossil fuel prices, limited natural resources, and stricter environmental legislation.

Opportunities
R&D cooperation and business partnering.

Raw Materials (Starch and Sugar)[1]

	Starch (1.5 million tons)	Location	Source
01	AVEBE	Dallmin	potato
02	AVEBE	Lüchow	potato
03	Cargill	Barby	wheat
04	Cargill	Krefeld	maize
05	Crespel & Deiters	Ibbenbühren	wheat
06	Emsland Stärke	Emlichheim	potato
07	Emsland Stärke	Golßen	pea
08	Emsland Stärke	Kyritz	potato
09	Emsland Stärke	Wietzendorf	potato
10	Jäckering	Hamm	wheat
11	Kröner-Stärke	Ibbenbühren	wheat
12	Kröner-Stärke	Hamburg	wheat
13	Südstärke	Sünching	potato
14	Südstärke	Schrobenhausen	potato

	Sugar (4.2 million tons)	Location	Capacity (t/d)[2]	Staff[3]
15	Nordzucker	Clauen	11,000	145
16	Nordzucker	Klein Wanzleben	15,000	178
17	Nordzucker	Nordstemmen	13,500	184
18	Nordzucker	Schladen	10,000	153
19	Nordzucker	Uelzen	18,000	263
20	Pfeifer & Langen	Appeldorn	7,500	80
21	Pfeifer & Langen	Euskirchen	10,000	170
22	Pfeifer & Langen	Jülich	15,000	185
23	Pfeifer & Langen	Könnern	16,500	220
24	Pfeifer & Langen	Lage	7,500	70
25	Südzucker	Brottewitz	6,000	90
26	Südzucker	Ochsenfurt	15,000	200
27	Südzucker	Offenau	13,000	150
28	Südzucker	Offstein	15,800	220
29	Südzucker	Plattling	15,000	180
30	Südzucker	Rain	12,000	220
31	Südzucker	Wabern	7,000	70
32	Südzucker	Warburg	5,000	40
33	Südzucker	Zeitz	12,400	160
34	Suiker Unie	Anklam	10,500	130

[1] *Other renewable resources, such as wood and wheat, still require additional development efforts such as:*
- *further optimized enzymes*
- *improved space-time yield*
- *better pretreatment processes*
- *adjustment to existing chemical processes*

[2] *Tons sugar beet per day*

[3] *Permanent staff*

Biorefinery: Starch and Sugar Producer

Renewable Resources in Germany

In 2008, around 2 million hectares or almost 17 percent of Germany's arable lands were used for growing renewable resources (starch: 1 million hectares, sugar: 0.36 million hectares). Additional raw material for industry and energy comes from Germany's forests which cover some 11.8 million hectares or one third of the country's total land area.

Starch

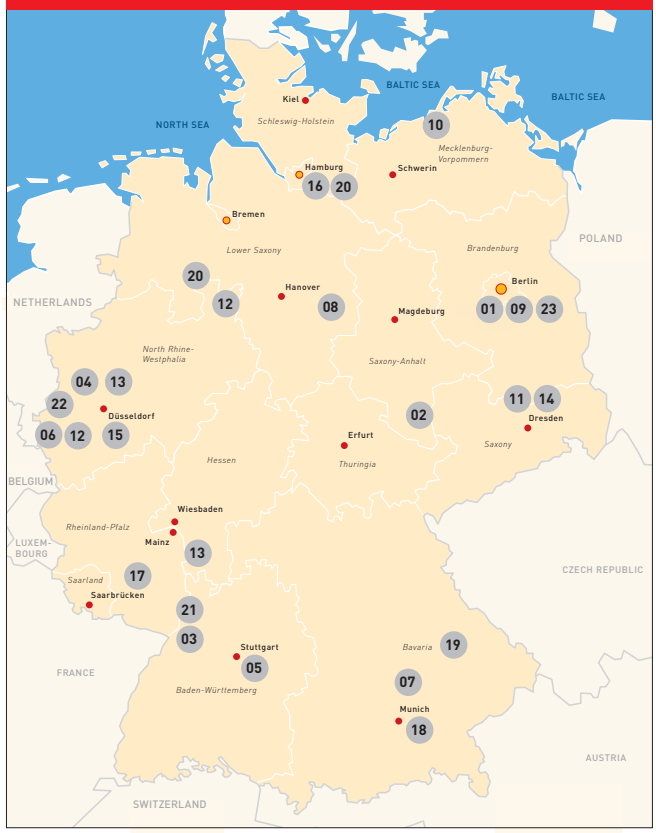
In Germany, starch is mainly produced from wheat (2008: 33%), potatoes (42%), and maize (25%). In 2008, eight companies with 14 production plants (2,300 employees) processed 4.4 million tons of agricultural commodities into 1.5 million tons of starch, 13 percent of which was used for industrial processes (e.g., chemistry, fermentation).

Sugar

White sugar production (from sugar beet) in 2009/2010 was 4.2 million tons (beets contain 18% saccarose – 16 percent more than the previous year. Of this sum, only five percent was used for industrial processes (chemistry, fermentation).

		Biomass	Enz./Pretreat.	Sugars	Biocatalysis	Chemocatalysis	Syngas	C2	C3	C4	C5	C6
	Fraunhofer Institutes											
01	Applied Polymer Research (IAP)	■	■	■	■	■						
02	Center for Chemical-Biotechnological Processes (CBP)	■	■	■	■	■	■	■	■	■	■	■
03	Chemical Technology (ICT)	■	■	■		■		■	■	■	■	■
04	Environmental, Safety and Energy (UMSICHT)	■	■	■	■	■	■		■	■		■
05	Interfacial Engineering & Biotechnology (IGB)	■	■	■	■			■	■	■	■	■
06	Molecular Biology and Applied Ecology (IME)	■	■	■	■		■		■	■		■
07	Process Engineering and Packaging (IVV)	■	■	■								
08	Wood Research (WKI)	■	■	■								
	Leibniz Institutes											
09	Agricultural Engineering (ATB)	■	■	■	■				■			
10	Catalysis (LIKAT)	■		■		■	■		■	■	■	■
11	Polymer Research (IPF)	■	■	■								■
	Universities											
12	Aachen Technical University (RWTH)			■	■				■	■		
13	Dortmund Technical University (BCI)		■		■					■		
14	Dresden Technical University	■			■	■	■	■	■			
15	Düsseldorf University (IMET)		■		■							
16	Hamburg-Harburg Technical University	■		■	■							
17	Kaiserslautern Uni.	■	■		■			■	■	■		
18	Munich Technical University (TUM)	■	■		■	■						
19	TUM – Science Center Straubing	■	■	■	■			■	■	■	■	■
	Non-university Institutes											
20	Institute for Wood Technology & Wood Biology (HTB)	■	■	■							■	■
21	Karlsruhe Institute of Technology (KIT)	■	■		■	■	■	■	■	■	■	■
22	Research Center Jülich (FZJ)				■					■	■	■
23	Research Institute BioPos e.V.	■	■	■	■	■	■	■	■	■	■	■

Biorefinery: R&D Institutions



Research & Development Landscape in Germany

- In 2008, R&D expenditures rose to an all-time high of 2.64 percent (EUR 66 billion) of national GDP.
  -OECD average is around 2.28 percent (2007)
  -EU-27 average is around 1.77 percent (2007)
- 410 universities with world class scientific research institutions
- 11,000 patents granted by the European Patent Organization (EPO) in 2009 (No. 1 worldwide)

Fraunhofer-Gesellschaft

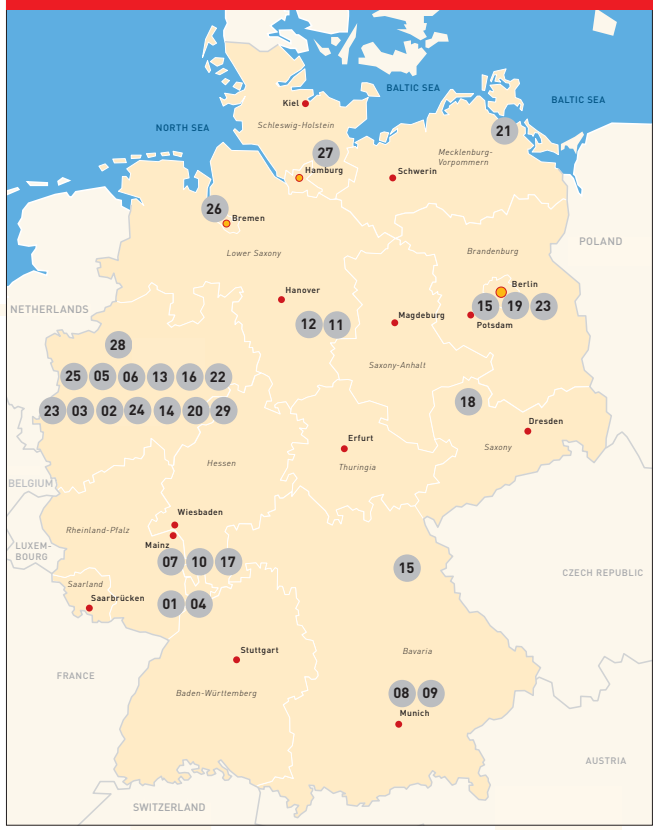
Founded in 1949, the Fraunhofer-Gesellschaft maintains more than 80 research units in Germany, including 59 Fraunhofer Institutes. The majority of the 17,000 staff are qualified scientists and engineers who work with an annual research budget of EUR 1.6 billion.

Leibniz Association

The Leibniz Association is the umbrella organization for 86 institutions conducting research or providing scientific infrastructure with an annual budget of EUR 1.3 billion. Members include 7,100 scientists and academics (total: 16,000 people) working in the social, economics, spatial and life sciences as well as in mathematics, the natural and engineering sciences.

	Large Companies	Biomass	Enz./Pretreat.	Sugars	Biocatalysis	Chemocatalysis	Syngas	C2	C3	C4	C5	C6
01	BASF	■	■	■	■	■			■	■		■
02	Bayer Material Science	■					■		■	■	■	■
03	Cognis				■	■						
04	Crop Energies	■	■	■	■		■		■			■
05	Evonik	■		■	■		■		■			■
06	Lanxess				■	■				■		
07	Merck				■							
08	Süd-Chemie	■	■	■	■	■		■	■	■	■	■
09	Wacker		■		■	■		■	■	■		
	SME´s											
10	AB Enzymes	■	■		■			■				
11	Amino			■	■							
12	ASA SPEZIAL-ENZYME				■							
13	Autodisplay Biotech				■							
14	Bioreact	■	■		■			■				
15	Bioworx		■		■							
16	bitop			■	■							
17	BRAIN		■		■					■		
18	c-Lecta		■		■							
19	Cyano Biofuels				■			■				
20	DIREVO Industrial Biotechnology				■							
21	Enzymicals				■							
22	evocatal		■		■				■			
23	Phytowelt Green Technologies	■			■							
24	Protagen				■							
25	Senzyme		■									
26	SeSaM-Biotech				■							
27	SternEnzym				■							
28	W 42 Industrial Biotechnology				■							
29	X-Zyme				■							

Companies Active in the Biorefinery Value Chain



Pilot and Demonstration Plants

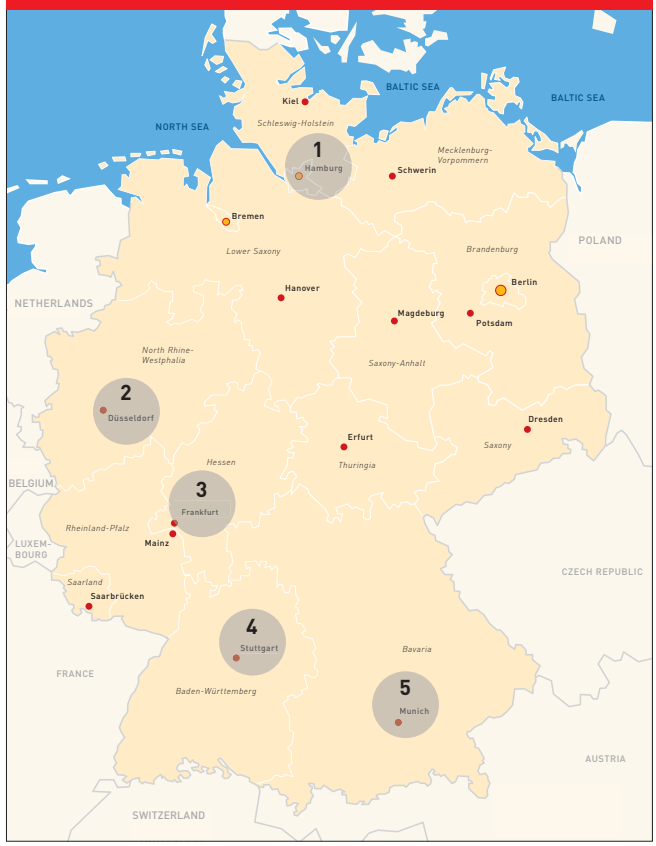
Süd-Chemie
Süd-Chemie started building Germany's largest demo plant (2,000 tons, EUR 28 million) in Straubing for the production of bioethanol (from agricultural waste) based on their *sunliquid*® process in August 2010.

Uhde Inventa-Fischer
As a leader in technology and equipment for the production of polyester and polyamide polymers, Uhde Inventa-Fischer operates pilot plants in Berlin for its 2-Reactor process.

Wacker
Wacker is reliant on acetic acid and ethylene as building blocks for its vinyl acetate monomers. In October 2009, Wacker began operating a 500 tons per annum pilot plant that produces acetic acid via its *ACEO*® process in Burghausen, Germany.

	Industrial Biotechnology Cluster (Federal Funding, Number of Partners)
1	**BIOCATALYSIS2021, Hamburg (EUR 20 million, 67 partners)** The cluster is helping unlock nature's biodiversity by using advanced screening technologies and applying a unique generation of microbial biocatalysts that function in non-conventional conditions (e.g., extreme temperatures, pressures, pH values, concentrations of salt and solvents).
2	**Cluster Industrial Biotechnology 2021 – CLIB2021, Düsseldorf (EUR 20 million, >70 partners)** The cluster focuses on projects and technologies relevant to the (bio)chemical industry. Special focus is placed on innovative monomers, biocatalytic conversions, downstream processing, and biotech products for a wide range of applications (e.g., adhesives, lubricants, cosmetics, building blocks for pharmaceuticals).
3	**Cluster Integrated Bioindustry – CIB, Frankfurt (EUR 5 million, 59 partners)** Focus on fine and speciality chemistry. The significant advantage of the cluster is that individual components (i.e., research, development, production, and financing) are carefully matched.
4	**Cluster Biopolymers/Biomaterials, Stuttgart (EUR 20 million, 100 partners)** The cluster supports R&D projects that focus on the development of innovative biomaterials at competitive prices and make them available on the market by way of process optimization along the value creation chain.
5	**BioM WB, Munich (EUR 5 million, 74 partners)** Network of enterprises and research institutions to develop novel processes and products in the field of biogenic building blocks and performance proteins. The network's stated aim is the proper exploitation of lignocellulosic material (e.g., straw) using the novel process of sequential enzymatic hydrolysis (SEH) for monosaccharides, phenols, and other secondary metabolites which are transformed into basic building blocks like sugar alcohols and acetates.

Industrial Biotechnology Cluster



The BioIndustry 2021 Competition (BMBF)
In order for industrial biotechnology innovations and research results to be transformed more rapidly into marketable products, the BioIndustry 2021 initiative was launched by the German Federal Ministry for Education and Research (BMBF) in 2007. Federal funding to the value of EUR 60 million is available until 2011. To date, five industry clusters with differing focal points have been awarded funding through the program.

The Industrial Biotechnolgy Clusters
The clusters have developed networks comprising (chemical) industry companies, biotechnology start-ups, science institutes, customer industries, and investors right across Germany.

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