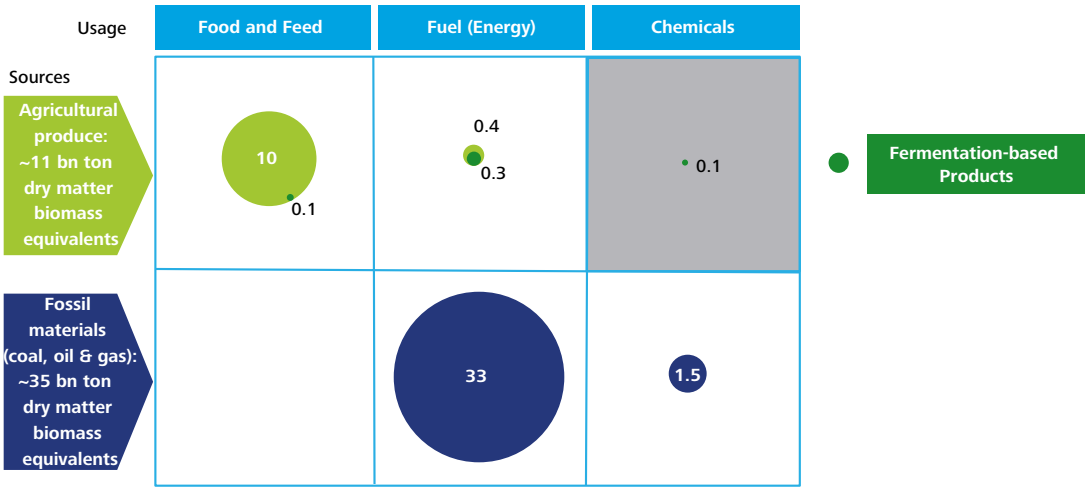
Executive summary

The European chemical industry is a strong, innovative and important sector in key countries like Germany, Belgium and the Netherlands (revenue in the Netherlands 51 billion euros excluding pharma, 8% of GDP in 2013)[38]. However, it has been losing competitive ground recently, mainly due to higher energy prices. Announcements of investment in new production facilities are comparatively rare. Clearly, the industry needs to explore new ways to create a sustainable competitive advantage.

Fortunately, a golden opportunity is to be found in increasing the applications of industrial biotechnology and biobased feedstock for the fermentation-based chemical industry. This opportunity spans the entire value chain, from seed to "drop-in" chemicals and new functional molecules with new properties. Current examples at opposite ends of this value chain include the potential of the 'Energybeet', developed by the seed producer KWS, and the additional properties of Avantium's technology for producing PEF for Coca Cola's PlantBottle™ replacing the conventional PET bottle.

In the broader economic context, a remarkable development that has almost escaped notice is the ratio between the prices for crude oil and white sugar. Before the turn of the millennium, the ratio between Brent Crude and London's No 5 contract for white sugar, both in US$/GJ, hovered around 7. However, soaring oil prices and low sugar prices in 2000 led to the ratio plummeting to about 3. The ratio continues to decline gradually. Given the high correlation between raw and white sugar prices, the trend for the main feedstock for fermentation is identical.

Crops and arable land use for fermentation-based chemicals will remain insignificant compared to food, feed and fuel while the added value is high



• All figures are indicative; Biofuel excludes wood; See separate table with detailed figures covering added value, arable land use

Source: FAO, IEA, EIA, Sanders & Bos (2013), Deloitte Analysis

Figure 1 – Global fossil and agricultural inputs and usage in 2012 (bn ton dry matter biomass equivalents)

The fermentation-based chemical industry, while growing, is still small compared to petrochemicals. Oil and gas are mainly used for energy and only a small share for chemicals – ca. 4% and another 4% for the energy required to make the chemicals.

The concerns and uncertainties about climate change have produced another relevant development. All major global brand-owners of consumer products are pushing harder for sustainability in their product portfolio, end-to-end value chains and consumer brand marketing. Given the limited availability of arable and fertile land, the use of sugars for fuel and, to some extent, high value-added biobased chemicals and materials using first-generation fermentation technology raises additional questions. Figure 1 above and table 1 below attempt to put the debate in perspective.

The potential of fermentation-based chemical products and materials

The global fermentation-based industry is already worth over 127 billion dollars. It processes up to 200-250 million tons of carbohydrate equivalents (CHEQ) annually from either sugars, starches or cellulosic origins, including finished products such as production grade white sugar and intermediates such as thick juice and cane juice. By far the largest share goes to bioethanol – 94% in terms of volume and 87% in terms of value. However, as table 1 illustrates, functional molecules (including plastics) provide a much higher economic added value and market growth in the biobased chemical segment compared to alcohols and biogas. Also, the added value in relation to the use of arable land is very attractive for functional molecules. The projected annual growth until 2020, excluding alcohols, is 6.5%, which is well-above projected GDP growth.

Market overview for key fermentation products in 2013 and annual growth projection until 2020

Category	Market Size in product output (quantity produced)	Average theoretical yield	Market size in carbohydrate input required	Market size in value	Average added value generated from carbohydrate	Market growth until 2020	Arable land use*
	Mln ton	Ton product/ ton glucose	Mln ton CHEQ	Bn USD	USD/CHEQ	% CAGR	Mln ha
Alcohols	99.8	0.51	195.1	110.0	164	4.4%	25.08
Amino Acids	7.1	0.92	7.8	11.0	1,010	5.6%	1.00
Organic Acids	2.9	1.05	2.8	3.5	850	8.8%	0.36
Biogas	0.1	0.27	0.5	0.2	0	5.0%	0.06
Polymers	0.2	0.93	0.2	0.6	2,600	13.5%	0.03
Vitamins	0.2	0.96	0.2	0.7	3,100	2.6%	0.03
Antibiotics	0.2	1.00	0.2	0.8	3,600	4.0%	0.03
Industrial Enzymes	0.1	1.00	0.1	0.3	2,600	8.0%	0.01
Total	**110.5**		**206.8**	**127.0**		**4.6%**	**26.6**

*Land use estimates vary greatly with the different region and the crop used to produce the sugar, current estimates are based on weighted average yields (ton CHEQ / ha) of sugar cane and sugar beet

Note: Rough-cut added value from carbohydrate obtained by market value – average cost of CHEQ at 400 USD per ton and ignoring side-streams, energy, etc.

Source: BCC Research, FO Licht Renewable Chemicals Database, NOVA Institut, FAO/OECD, Deloitte Analysis

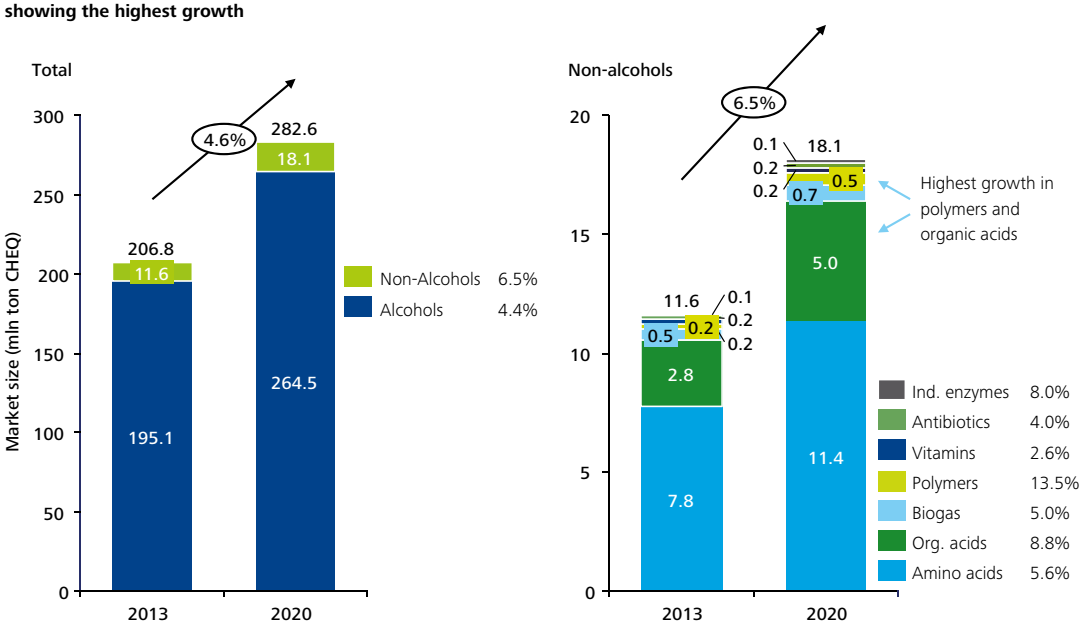
Global Arable Land
1,500 mln ha

Table 1 Market overview for key fermentation products

The key product using fermentation process technology today is bioethanol (included in alcohols in table 1 above). This development is driven by the relatively ease with which ethanol can be produced and, more importantly, by regional requirements for supplements to fossil fuels for the transportation sector. The latter is stimulated by various regulatory measures in the US, Brazil and Europe.

Other key fermentation products with sufficient market potential (i.e. excluding bioethanol) equate to roughly 11.6 million tons of carbohydrate equivalents and have a turnover potential of 17.1 billion dollars (see table 1). These include amino acids, organic acids such as lactic and succinic acid, as well as polymers such as xanthan.

Market studies show a projected base case growth of 5% CAGR with alcohols staying the key segment and polymers showing the highest growth



Note: 2020 outlook is based on available predictions where possible and extrapolation in case no explicit predictions are available

Source: BCC Research, FO Licht Renewable Chemicals Database, NOVA Institut, OECD-FAO Agricultural Outlook 2013, Novozyme 2013 Annual report, DSM Factbook 2014, Deloitte Analysis

Figure 2 – Global fermentation market in 2013 and projection for 2020 (mln ton CHEQ)

The competitiveness of North-West Europe and sugar beets

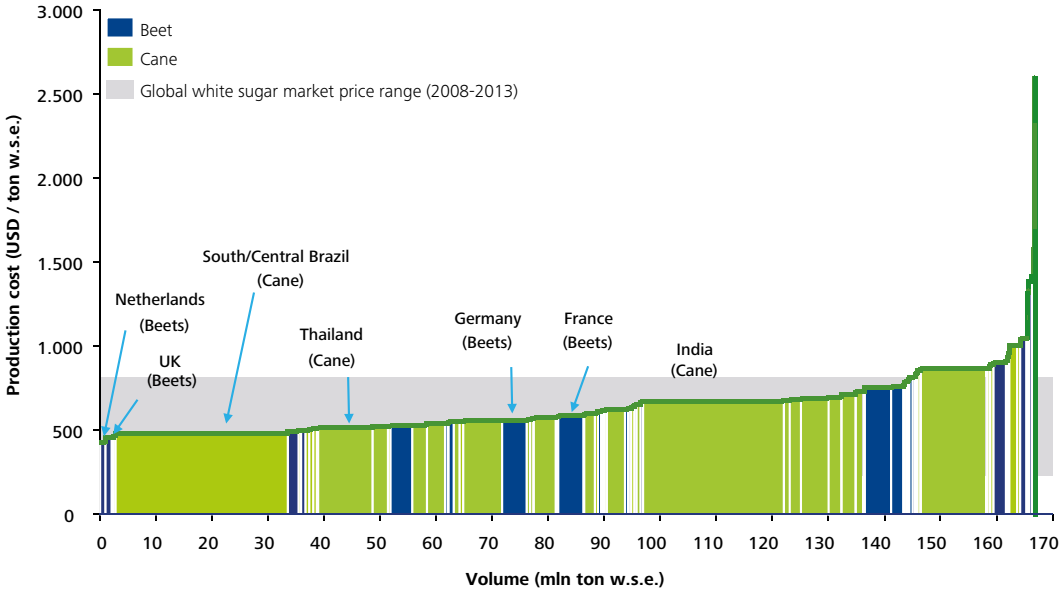
The attractiveness of the fermentation-based chemical industry depends on the price levels of the functional molecules as chemical products, including the mainly fossil-based alternatives with which they compete, the yield of fermentation processes and the market prices for biobased feedstocks.

Sugar, a major biobased feedstock, comes either directly from cane or beet or indirectly from corn or tapioca starch, and it can be competitive against fossil alternatives for selected high-value-added products. Globally, four main regions emerge as attractive locations for fermentation businesses, each with a different feedstock:

- Brazil, mainly sugar cane
- US, mainly corn
- South-East Asia, mainly tapioca/cassava and sugar cane
- North-West Europe, mainly wheat and sugar beets

The cost levels to produce sugar in North-West Europe are amongst the lowest in the world due to increasing crop and sugar yields in the fields and from production efficiencies. Although weather conditions are also relevant, our analysis of the underlying drivers show the relative cost position is likely to improve further in the coming years. The global supply-cost curve for the most recent season shows the impact of efficiency improvements.

In the last season, volumes have been higher than average and the Netherlands has taken the lead in low cost sugar production



Note: Production costs of raw sugar converted to w.s.e. multiplying by 1.087 (polarisation constant) and adding refining costs of $65 / ton, raw sugar volume converted to w.s.e. by dividing volume by 1.087; Note 2: Production costs for beet and cane include for both land and factory costs for labour, capital (incl. a.o. land rent and depreciation), input (incl. a.o. seeds, fertilizer, chemicals, and energy), and factory by-product revenue.

Source: LMC International Sugar & HFS report 2014, UNICA Harvest Reports 09/10 – 12/13, Deloitte Analysis

Figure 3 – Global supply curve of sugar 2012/2013 (USD/ton w.s.e)

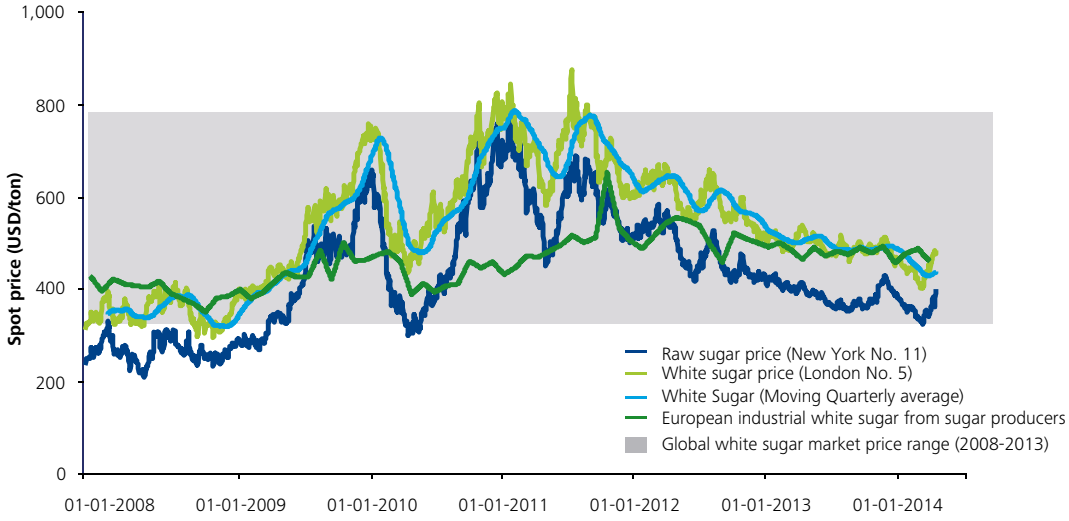
Sugar beet from North-West Europe and especially the Netherlands appears to be particularly cost competitive due to low inbound and outbound transportation costs, high sugar yields per hectare of land, large-scale facilities and the ability to supply ample volumes of thick sugar juice on a year-round basis. Other benefits include access to the tightly knit network in the ARRRA region (Antwerp-Rotterdam-Rhine-Ruhr-Area) and the high level of education in the cluster in both chemical and agricultural technology.

Dispelling the myth surrounding European white sugar prices

A recent EC report on industrial white sugar, as shown in figure 4 below, shines an interesting light on the perception that European prices still exceed world market prices:

- EU prices were higher the world market prices before 2009, leading companies to invest elsewhere
- EU prices were below London No 5 white sugars between 2009 and 2012
- EU prices for non-food sugars converged to world market levels in 2013

Prices for white and raw sugar have ranged between $350 and $800 per ton over recent years, European industrial white sugar has been less volatile and converged to world market levels



Source: FO Licht, Deloitte Analysis

Figure 4 – Raw and white sugar prices 2008-2013 (USD/ton)

Furthermore, the EU will be lifting production quotas for food-grade sugar in 2017. Deregulation means the production volume of sugar beets sales will grow substantially. It also entails production shifts to the most efficient growing areas in Europe.

Investment hurdles

The preface already referred to some of the hurdles that legislators and other stakeholders need to address to create a level playing field. The most relevant of these is the set of measures that stimulates the use of biomass for biofuels. These measures discourage investment in European facilities that produce high value-added biobased materials because they limit access to biomass for other uses and increase net costs. The unintentional consequence is the advantage given to fossil-based alternatives. Surveys and analysis by TNO show that this factor and the insufficient availability of venture capital adversely affect the pilot and commercialisation phases in particular[17, 18].

This report shows that it is worthwhile taking on these challenges. The biotechnological (r)evolution has the potential to stimulate innovation, economic growth and create jobs. Today, the convergence of the chemical and agricultural eco-system and the biotechnological knowhow in North-West Europe make for a prime location. Fermentation is where 'Agri meets Chemicals'.