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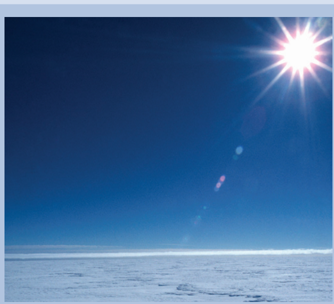

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Chemurgy trilemma

Cath O'Driscoll
Deputy editor

A dilemma is one or actually two things. But the word that is needed to describe the current fuel, feed and food crisis is a 'trilemma', according to Christian Patermann, a former programme director for the EU Commission, speaking at the recent European Forum for Industrial Biotechnology (EFIB) meeting in Dusseldorf, Germany. The crux of the problem is working out how to produce enough of all three sustainably to satisfy the demands of an ever-enlarging population – particularly one that includes a bigger proportion of more affluent middle classes with an appetite to eat more meat.

'Longer term, what is needed is to move away from agricultural sources of carbon altogether and find other routes to achieve energy independence that do not conflict with what's on the dinner table'

While there are many possible solutions, the focus of the EFIB event was on producing more of what we need – food, feed, fuel and chemicals – from plants, by opting to substitute traditional polluting petrochemical feedstocks for renewable sugars and oils. And the emergence of this new bio-based economy also comes accompanied by another word: 'chemurgy', pointed out Sarah Hickingbottom, senior research economist at consultancy LMC International – an idea that dates back to the 1930s, around the time of Henry Ford's invention of a car built from soya beans and hemp.

Growing all of the things we need and want in plants may be theoretically achievable, but the big question is how much extra land will this require – and what effect, if any, this may have on food prices? According to figures from LMC, the amount of land dedicated to growing arable crops around the world remained roughly the same between 1980 and 2002, but all of that changed in the past 10 years when an extra 90m ha has been brought into production as demand growth outpaced yield growth.

The real 'game changer' has been biofuels, Hickingbottom said: over the past decade more than 140m t of crop demand has been added by the biofuels sector, with a significant impact on the land area needed. LMC's *Feedstocks for bio-based chemicals* report says that roughly 900m ha of land is currently being used to grow arable crops,

and forecasts this figure will grow by 50m ha by 2020 to meet future demand increases.

Supply of palm oil alone is expected to increase from the current 47m t/year to 95-97m t/year by 2025.

Cellulosic ethanol, produced by fermentation either of dedicated energy crops or of waste biomass, such as corn stover and wheat straw left after harvest, is promoted as a more sustainable biomass source that does not compete with food production. Three commercial-scale plants are currently under construction in the US, while Europe hosts four demonstration plants, including a 1000t/year facility which came onstream in July 2012 in Bavaria using Clariant's *sunliquid* fermentation technology, according to group vp corporate R&D Andre Koltermann. The front-runner, however, is Beta Renewables in Italy, which is now in the commissioning phase with a commercial-scale 60,000 t/year facility due to start production from Q4 2012, said coo Michele Rubino, referring also to a premium on green electricity in Italy that allows it to benefit by returning 15MW of power from lignin to the grid.

Longer term, researchers argue that what is needed is to move away from agricultural sources of carbon altogether and find other routes to achieve energy independence that do not conflict with what's on the dinner table. One early starter in this direction is New Zealand firm LanzaTech, which uses the waste gases from steel production – which is rich in carbon monoxide – among possible inputs to produce ethanol. Feedstock flexibility is key, according to chief scientific officer Sean Simpson, as it also allows the firm to be more competitive by benefiting from the prevailing economics. The technology can also extract energy from municipal solid waste (MSW) that would otherwise be sent to landfill.

Elsewhere at EFIB, the discussions centred on the practicality of extracting more of the wealth of carbon riches buried in the world's oceans. While more than 70% of the Earth's surface is covered by oceans, less than 3% of global food production occurs there, commented Kjartan Sandnes, head of R&D at Marine Bioproducts in Norway. Only a third of the global fish catch ends up as food on the dinner table, while another third is discarded as waste.In May 2012, the company opened a new 60,000 t facility for processing salmon backbones, heads and viscera etc, employing continuous hydrolysis to convert these low value wastes into bioactive peptides, flavour ingredients and peptones – including one product already commercialised in high end dog foods to lower the risk of pet allergy.

While fish are a source of oils and proteins, another of the oceans' bounties, seaweeds, comprise carbohydrates, proteins and ash, already widely exploited for fertilisers, said Ana-Lopez-Contreras of Wageningen University in the Netherlands.

Unlike plant biomass, however, the composition of seaweed is highly variable, both seasonally and between different species – a big consideration when establishing biorefinery operations of the type the group is developing in the North Sea.

Identifying these new renewable feedstocks, however, is just the first step. The real trick is to transform them to the chemicals and products of interest – not just the old petrochemical replacements but new and better materials with improved functionalities and performances.

At SilicoLife in Portugal, chief scientific officer Isabel Rocha outlined how researchers are now attempting to do this with the aid of complex algorithms that compute the best metabolic pathways to re-engineer microbes as the optimal cell factories. 'Our idea is to build maps and algorithms to go from [chemical] A to [desired product] B,' Rocha said, drawing an analogy with GPS. The result is a series of pathways showing which genes to delete and over-express to maximise bioprocess efficiency.

French firm Global BioEnergies has taken a different approach to the problem, explained ceo Marc Delcourt. The company is in the process of re-engineering microbes to produce light olefins – compounds that are not produced in nature but which are potentially invaluable as starting points for a plethora of petrochemical products.

The first of these light olefins on the firm's hit list is isobutene, for which a *de novo* pathway has already been identified and an industrial pilot plant is in preparation. With an estimated cost of $1500/t even from first generation plant feedstocks, Delcourt is confident that genetically bioengineered isobutene will already be competitive with its petrochemical equivalent.

As the first of the second generation commercial-scale biofuels and chemicals plants start finally to come onstream, meanwhile, we can only wait and watch to see what developments will take place in future.

For now the forecast for the industrial biotechnology sector remains uncertain, like the weather, with bright outbreaks of innovation overshadowed by dark funding clouds that threaten to scupper progress. And as this summer's droughts in the US and Russia have once again highlighted, the acid test will be what impact all of this has on food prices. A trilemma indeed.

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