

IS THERE LIFE AFTER FERT?

With gas prices rocketing and fossil fuels scheduled to be phased out, what is the future for artificial fertilisers? SIMON FAIRLIE investigates.

In March 2021 the wholesale price of natural gas began to rise and increased exponentially until by mid September it was 550 percent higher than it had been six months previously. The UK's leading manufacturer of nitrogen fertilisers, the US-owned firm CF, shut down its two factories because they could not operate economically at that price.

The Government immediately went into a panic, and came to the rescue of one of the factories with an undisclosed amount of taxpayers' money. This ostensibly was not through concern for fertiliser supplies, but because the carbon dioxide that is a by-product of producing nitrogen fertilisers is used for slaughtering animals and preserving food, and hence is a vital element in the UK's just-in-time supply chain.

By the end of 2021 the price of gas was still five times higher than it had been at the beginning of the year. This crisis, along with the lorry-driver shortage, reinforced the views of a growing number of economists who predict the demise of just-in-time logistics. But it also exposed a more serious weakness in the food production process — the dependence of artificial fertilisers upon fossil fuels.

Analysts are wondering if a shortage of nitrogen fertiliser might affect global crop yields in 2022. "Who's going to get the scarce tons that are out there?" asked CF's Chief Executive Tony Will in an on-line conference. "There's going to be a lot of unmet demand that's going to be pent up. We do think yield is going to be, on a global basis, off next year, because there's not enough tons available."¹

Grey, Blue or Green?

British non-organic farmers apply some 800,000 tonnes of artificial nitrogen every year² — enough to grow a bumper wheat crop on all of the UK's four million hectares of arable cropland. Its manufacture currently relies upon the fabrication of ammonia through the Haber-Bosch process, using so-called "grey hydrogen" derived from natural gas. Ammonia creates more CO₂ emissions in its manufacture than any other industrial chemical reaction, uses about one percent of the world's energy production and accounts for about one percent of its CO₂ emissions.³ Globally over 80 percent of ammonia is used to make nitrogen fertiliser. However only 17 percent of the nitrogen in the fertiliser is consumed by humans in crops, dairy and meat products. The remainder leaches into the soil, air and water causing widespread biodiversity losses, eutrophication, and air quality issues from particulates, matter, emissions of greenhouse gases and stratospheric ozone loss.⁴



CF's fertiliser plant at Billingham, Teeside, which was temporarily shut down in September 2021 because of the cost of gas. The company's other British factory, at Ince in Cheshire, remains closed.

Recently the fertiliser industry has been looking into ways to reduce its global warming impact. One approach is to continue to use natural gas to make hydrogen but capture or store its carbon missions underground — so-called "blue hydrogen", but this remains an experimental technology, and would still involve the release of some CO₂ and methane. The real alchemist's stone for these scientists is "green ammonia", derived from "green hydrogen" produced by electrolysis using renewable electricity, which in theory could be zero carbon. European manufacturers such as the Norwegian company Yara, and the Spanish firm Fertiberia, are leading the way.

There are problems, of course. Green hydrogen is two to three times as expensive as blue hydrogen, which in turn is more expensive than grey hydrogen. Electrolysis plants are costly, and currently only have a lifespan of ten years. But technopundits are optimistic that this cost will be reduced over time. Some rare metals required for processing may become hard to source, but again, analysts are confident that alternatives can be found.⁵

However the biggest obstacle to the production of zero carbon fertiliser may be that it is not alone in looking to green hydrogen for a solution. Every industrial process currently reliant on natural gas or oil — heavy goods, air traffic, steel production, cement, heating, etc — is after a slice of the green hydrogen pie, and at the moment that pie is tiny. The International Renewable Energy Agency reckon that to meet current scheduled demand the 0.2 gigawatt capacity of existing electrolysis facilities would need to increase 400-fold to 85 gigawatts by 2030, an annual growth rate of 83 percent — and this is barely a third of what will be necessary worldwide to keep global warming beneath two degrees.⁶



Yara's nitrogen fertiliser factory in Norway, soon to be electrified; and nature's nitrogen factory, probably found in your garden.

Bloomberg come to a similar conclusion:

Producing hydrogen at the scales required will be challenging. Meeting 24 percent of energy demand with hydrogen in a 1.5 degree scenario will require massive amounts of additional renewable electricity generation. Around 31,320 terawatt hours of electricity would be needed to power electrolyzers – more than is currently produced worldwide from all sources.

Add to this the projected needs of the power sector and total renewable energy generation excluding hydro would need to top 60,000 terawatt hours, compared to under 3,000 today. China, much of Europe, Japan, Korea and South East Asia may not have enough suitable land to generate the renewable power required.⁷

Nitrogen Plants

One should not underestimate the ability of human ingenuity to rise to a challenge when circumstances require it. In the wake of the gas price-hike it seems that every energy and chemical company in Europe is clambering aboard the good ship Green Hydrogen — even Jim Racliffe's Ineos, once a vociferous advocate of fracking, has switched allegiance. The hydrogen lobby is frantically organising conferences and webinars on subjects such as “Rolling Out Electrolysers to Meet Demand”.

But one should also not underestimate the ability of governments and industry to miss targets, underestimate expenses or simply cock things up. If fossil fuels become scarce and expensive as a result of moves to address climate change, as one hopes they will, then fertilisers made from “green ammonia” could well become the more competitive option, but that doesn't mean that they will be cheap.

What happens if renewable electricity and electrolysis are in short supply and fertilisers end up being so expensive that farmers are deterred from using them? There is one tried and tested alternative for land managers, which is not prohibitively expensive, and that is to grow legumes — plants that through bacterial action fix nitrogen from the atmosphere into the soil, the most widespread in the UK being clover. In essence, organic farming.

There are two main ways of doing this. The traditional approach is mixed farming: rotating arable production with grass/clover leys fed to livestock, as practised in England in the 18th and 19th centuries before the advent of artificial fertilisers. The classic example is the Norfolk four course rotation of wheat, turnips, barley and clover, but other crops such as beans and potatoes can be included.

The alternative is to cut out the livestock and reduce the system to a simpler stockless rotation growing leguminous green manures either as main crops or as cover crops. The rotation usually includes peas or beans, which are also legumes, and supply the protein foregone by not rearing animals.

The stockless rotation uses somewhat less land than the traditional system to provide a given amount of nutrition — in the order of ten percent if the livestock are dairy cows.⁸ On the other hand, mixed farming provides a more varied diet, including high quality proteins and fats (which explains why many vegans eat a lot of imported food). It is also able to incorporate external biomass into the cycle that is not easily accessible to stock-free systems from animals grazing on land that cannot be cultivated.

However in the UK, both organic systems require considerably more land to produce a given quantity of food than does chemical farming. The average yields of organic cereals, especially wheat, are up to 50 percent lower than yields of chemical wheat. This is not solely due to differences in nitrogen fertiliser application and uptake, but also to the use of herbicides and pesticides by chemical farmers.⁹

If artificial fertilisers are in short supply, then the country has two choices. Either to expand its area of arable land from 4.9 million hectares, possibly to as much as seven or even eight million hectares; or to reduce the volume of cereal produced. Since in a biological economy without fossil fuels, and less than ample supplies of hydrogen and other alternative sources of energy, there will be competition for the use of land (for biomass production, forestry, carbon sequestration, biodiversity etc), the acreage that society is willing to consign to arable food production may be limited.



A sanitised version of a midden in a mock Victorian farm in Shropshire. When plastics made from petroleum are abolished and we return to a biologic economy, almost everything that is of no use to humans or pigs can be either burnt or thrown on the midden, and in both cases will find its way back to the land. Farmers make the best bin-men.

Something would have to give, and the obvious candidate would be the wheat, barley and other grains grown to feed animals. If this notoriously inefficient way of feeding humans were drastically cut back, factory farms churning out thousands upon thousands of chickens and pigs at absurdly low profit margins would become inoperable for lack of feedstock. Their disappearance would be a blessing, since they employ low standards of animal welfare, rear disease-prone animals dependent upon antibiotics, and are polluters of soil, water and air. The nitrogen and other nutrients in animal manure which are beneficial when spread evenly across the land, become highly problematic when concentrated in one place around such massive livestock operations.¹⁰

The plant-based products that filled their place would be sourced from the peas and beans that play a fertility-building role in organic and especially stockless rotations. Important pioneering work in this regard has been carried out by Hodmedod foods, while other firms are now breeding soya beans that can be grown in the UK's climate.

Red or White?

Monogastrics like pigs and chickens compete with humans for grain, but ruminants help to build the fertility that is needed to grow that grain, by consuming vegetation that we can't eat. When cows graze grass and clover in a rotational system, 85-90 percent of the nitrogen they ingest comes out of the rear end in the form of an ideal compost-making material, not least when mixed with cereal straw. Meanwhile much of the nitrogen fixed by the clover lies in its roots and stolons where the cows cannot touch it. Similarly if cattle or sheep are let out by day to graze on non-arable land and are brought in at night, they introduce additional nitrogen into the system.

In an agricultural economy where chemical fertilisers are in short supply, ruminants are cheaper to rear than monogastrics. That is why, during the years of the Second World War, when grain imports from North America were restricted, and indeed

well into the 1950s, beef and lamb were more affordable than pork, and chicken was a luxury. The trend that has seen so-called red meats (beef and lamb) replaced by white meats (chicken and pork) in recent years, thanks to cheap grain and soya protein, would be rapidly reversed in the absence of chemical nitrogen.

That is not to say that the number of cattle and sheep in the UK would increase. There is no surplus of land and, as already noted, there is already competition from other sectors for land currently grazed by ruminants. Livestock farmers will need to focus either on animals that produce protein and fat relatively efficiently, or on those that provide other services as well as food for humans. The main options in a mostly organic agricultural economy are as follows.

Milk Dairy cows convert grass and other feed into human-edible protein and fat about three times as efficiently as beef cows; they also require richer food than beef cows since they metabolise large volumes of milk every day. They are therefore better suited to the clover and grass leys of a mixed organic farm than are beef cows.

In an agro-economy where there are limits to the area of land that can be devoted to livestock, dairy cows will provide the UK population with considerably more animal nutrition than will beef cattle.

Calves All animal populations are genetically disposed to bearing more offspring than are required to ensure the continuance of the species, on the assumption that many young will die before they reach sexual maturity. Dairy cows are no exception, and dairy farms produce a large surplus of calves, most of which are destined for beef. In the absence of artificial fertilisers most beef cattle would be cross-bred cows (beef father, dairy mother) for two reasons: because of constraints on the area of land available for beef rearing; and because yields per cow would go down, so the number of calves produced for a given amount of milk would increase. This is to be welcomed because calves that are the by-product of the dairy industry have a lower environmental impact than calves that are the offspring of a cow whose only economic purpose is to produce calves. If land constraints are great, then beef calves may be slaughtered for meat at a younger age than now, since they put on weight faster in the first year than in the following two years. This may sound odd and unfortunate, but it is already what happens to lambs.

Suckler beef There will however still be a demand for suckler cows rearing pedigree beef calves to maintain bloodlines, and to provide hardier animals for conservation grazing in localities where cattle are required to maintain a certain level of biodiversity.

Sheep Sheep are unpopular at the moment in some circles, and it is true that they occupy a lot of land to provide not very much human nourishment. But until recently that was not their main purpose — in Britain they were primarily valued for two other services: one was the supply of wool, which is currently worthless, but will become a valued commodity once again when the oil-based plastic textiles that cause such waste and pollution are eliminated.¹¹

The other was the ease with which flocks of sheep harvested distant biomass during the day, chopped and shredded it, digested it, transported it in the evening to arable fields, deposited it there overnight in the form of manure, and trampled it into the soil with their feet — all without using a drop of fossil fuel. In the absence of artificial fertilisers, (and possibly also of cheap fuel) sheep would very likely be employed to provide this service once again. In some instances this would require the employment of real shepherds who guarded the flock (as too would the introduction of wolves by rewilders); the enhanced value of sheep could pay for this additional labour.¹²

Pigs and Chickens Grain shortages would probably result in a reduction in the number of chickens reared for meat. Pig-rearing could only be maintained on any scale if the bans on feeding waste food (swill) and meat and bone meal were lifted.

The Changing Face of Britain

In 2020 the Committee on Climate Change — part of the Department for Business, Energy & Industrial Strategy (BEIS) — published its report *Land Use: Policies for a Net Zero UK*, forecasting a 30 percent decline in cropland and a 22 percent decline in pasture land throughout the country. The Committee seems blissfully unaware how much of our food is reliant upon fertilisers derived from fossil fuels, and has nothing to say about where we will source fertility in the future.

Henry Dimbleby's 2021 *National Food Strategy*, which more cautiously predicts a one percent decline in agricultural land use per year, does acknowledge the problem and makes a stab at identifying a solution:

“Thousands of new techniques are being trialled to wean farming from its reliance on industrial fertiliser and red diesel. In our researches we have seen some amazing new technologies at work . . . botanists dipping maize seeds into a solution of nitrogen-fixing bacteria to reduce the need for fertiliser.”

But botanists are not farmers. When it comes to actual practice in the field, the Food Strategy's case study is an arable farmer, called Craig Livingstone, who has reduced his artificial fertiliser use by 32 percent largely by adopting organic methods: introducing a rotation, growing cover crops, grazing with sheep, and importing green waste compost and farmyard manure.

The fact is that currently the only proven alternative to artificial nitrogen fertiliser is nitrogen fixation through legumes, in other words organic husbandry. And while this remains the case it is surely wise to take a searching look at what the implications are for future land use should there have to be a widespread return to organic farming.

As we have seen there will either have to be more land under arable cultivation, or else a drastic reduction in the volume of grain produced to feed livestock. Either way, the prospect of reducing the amount of arable and pasture land by as much as 30 percent, is out of the question, reducing opportunities for

tree-planting, rewilding and other uses. Ruminants, which are fertility builders, will be prioritised over monogastrics, which are fertility consumers. The accent will be on land-sharing, in contrast to the land-sparing agenda espoused by the Committee on Climate Change.

Under a largely organic regime, British agriculture would also become less regionally specialised. Organic nitrogen isn't delivered from two factories in the north of England: the potential to fix it from the atmosphere is spread out fairly evenly across the entire country — wherever there is photosynthesis. The dynamics that have enabled the bulk of industrial fertiliser to be applied to the flat dry land in the east of the country, because it is deemed to have a “comparative advantage”, will no longer obtain. The arable farms of the east will have to introduce clover and herbal leys or lucerne into their rotations, and probably bring in livestock to benefit, while the livestock farms of the west, instead of leaching surplus nutrients into the watercourses, would be applying this fertility to the arable fields that were put down to grass a century or so ago.

A return to mixed farming would bring with it numerous blessings: reduced water pollution, greater agricultural biodiversity, healthier soils, reduced reliance on pesticides and herbicides, more farm jobs and more varied and interesting work. It is what organic farmers have been proposing for the last 80 years, but the advocates of industrial agriculture, whose only concerns are maximum yields per acre and cheap food, have the louder voice and it is that voice that BEIS and its Committee on Climate Change are listening to. We can only pray that their scientists don't find a way to produce cheap artificial fertiliser — maybe just some expensive stuff that can be kept in reserve if there really isn't enough organic fertility to feed everyone.

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This article is the fourth in a series on how people might live if the only way to achieve zero carbon is through drastic reductions in the use of energy.

The others are “Liquid Assets”, in *The Land* 26; “Cars — an Exit Strategy” in *The Land* 27; and “Keep the Home Fires Burning”, by Kris de Decker, in *The Land* 28.