

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

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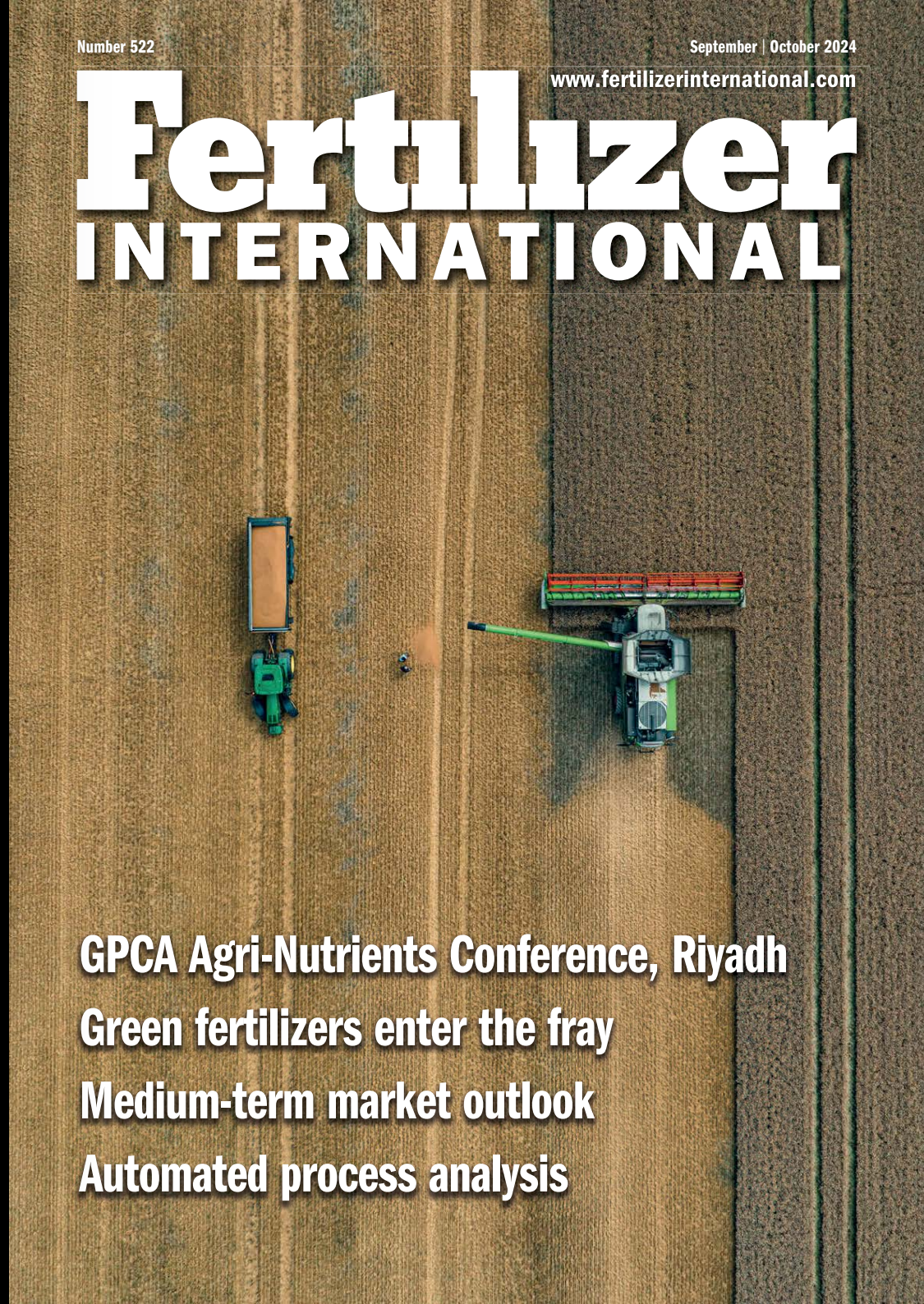
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Fertilizer INTERNATIONAL



GPCA Agri-Nutrients Conference, Riyadh
Green fertilizers enter the fray
Medium-term market outlook
Automated process analysis



CONTENTS

What's in issue 522

HIGHLIGHT 1

GPCA Agri-Nutrients Conference, Riyadh

HIGHLIGHT 2

Green fertilizers enter the fray

HIGHLIGHT 3

Medium-term market outlook

HIGHLIGHT 4

Automated process analysis

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ISSUE 522
SEPTEMBER/OCTOBER 2024



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Cover: Drone view of Harvesting wheat harvester, United Kingdom
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10 The latest supply outlook from IFA's Laura Cross



14 The food sector dash for 'green' fertilizers

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NUMBER 522

SEPTEMBER | OCTOBER 2024

CONTENTS

- 7 US fertilizer industry update**
 The US fertilizer industry is ranked fourth globally in terms of total production capacity. The Biden administration has earmarked \$900 million for investment in fertilizer assets to boost domestic production capacity and reduce input costs to farmers.
- 10 IFA's medium-term outlook – a supply/ demand driven market**
 The International Fertilizer Association (IFA) recently published its annual medium-term outlook for the fertilizer market. Laura Cross and Armelle Gruère of IFA's Market Intelligence Service outline its key findings.
- 13 Controlled-release fertilizers for sustainable farming**
 ICL's Ronald Clemens talks to Fertilizer International about the role of controlled-release fertilizers in sustainable agriculture.
- 14 Green fertilizers enter the market**
 The last year has seen the first shipments of low-carbon 'green' fertilizers from companies such as Yara, Fertiberia, OCI and Sabc Agri-Nutrients. Partnerships with food manufacturers and retailers are helping to grow this emerging market and drive demand.
- 19 Ulexandes – the leading Latin American boron producer**
 We profile Ulexandes, a fast-expanding supplier of agricultural boron products with production plants in both Bolivia and Peru.
- 20 Nitrogen technology showcase**
 We highlight recent production advances and innovations in nitrogen fertilizer production from Casale and Stamicarbon, two global leaders in process technology.

PHOSPHATES AND POTASH INSIGHT

- 23 Tessenderlo – leading on liquids and a solubles success**
 We talk to Nicolas White, Portfolio & Knowledge Director at Tessenderlo Kerley International (TKInt), about recent strategic developments at the company. These include major investments in new production, transshipment and storage capacity.
- 25 Automated process analysis and sorting**
 Sophisticated control of phosphates production is now possible thanks to the availability of real-time process analysers. The emergence of laboratory robots is also improving process efficiency and delivering cost savings.

REGULARS

- 3 Editorial**
 What are farmers thinking?
- 3 Market Insight**
- 5 Industry News**
- 7 People & Calendar**
- 28 Index to advertisers**

CONTENTS

What's in issue 522

HIGHLIGHT 1

GPCA Agri-Nutrients Conference, Riyadh

HIGHLIGHT 2

Green fertilizers enter the fray

HIGHLIGHT 3

Medium-term market outlook

HIGHLIGHT 4

Automated process analysis

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ISSUE 522
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What are farmers thinking?



The International Fertilizer Association's annual Global Markets Conference is an in-depth event for those tracking the market. This year's two-day gathering in London in July lived up to its billing as a meeting of curious minds (*Fertilizer International* 521, p4).

For me, some of the most memorable insights came from David Fiocco of McKinsey & Company ¹.

Ultimately, the fortunes of the upstream fertilizer industry are decided by our downstream customers – farmers – those faraway rural folk on the other side of the farm gate. We should therefore be thankful that McKinsey and a senior partner like David Fiocco make it their job to talk to growers globally – to find out exactly what farmers are thinking and what informs their buying decisions.

McKinsey does this through its annual global *Farmers Insights Survey*, now in its fifth year. The latest survey took place between January-March 2024 and questioned around 4,400 farmers across nine countries.

David handily summarised this year's survey results for London conference delegates by communicating five key things McKinsey were hearing from farmers:

1. Increased input prices remain a top risk

Despite recent price declines, growers still believe that increases to input costs are the top risk to their profits – with extreme weather now a close second. Indeed, extreme weather and climate are the top risks for Latin American and European growers. Overall, farmers are increasingly concerned about the collective risks to their businesses from extreme weather events, commodity prices and worker shortages

2. Practices driving input efficiency are up

One highly encouraging survey finding is that practices such as variable rate fertilization and the use of biologicals, controlled-release fertilizers and stabilised fertilizers are on the rise, being driven by a desire to improve yields and reduce production costs. The top three reasons behind the adoption of these sustainable practices were highly commercial too: yield benefits, lower production costs and the generation of additional revenues.

3. More than one-third of farmers use biologicals
McKinsey found that the adoption rate for biologicals among growers globally is above one-third

currently and rising. Some 90 percent of farmers expect to maintain or increase their spending on biological products such as biostimulants. What's more, buying behaviour is largely independent of fertilizer price hikes, with almost two-thirds of growers saying will either maintain or increase their expenditure on biologicals, regardless of changes in crop protection and fertilizer prices.

4. Technology adoption rises

Nearly half of growers around the world are using technology in their operations, with adoption on the up. In this year's survey, McKinsey has seen a roughly one-fifth increase in the percentage of growers adopting or willing to adopt technology. This is especially true where farm tech has an operational focus – such as variable rate fertilization.

5. Input distributors are soil health influencers

Farmers globally cited their input providers as key influencers when looking for recommendations on soil health, with these even being ranked as the top advisors in North America and Europe. Growers identify soil health as an increasingly important topic, McKinsey found, with input distributors consistently ranked as the key advisors on this topic.

One of the key takeaways for David Fiocco was the way in which farmers are responding to increasing weather and climate risks by innovating. McKinsey expects to see greater adoption of new practices and novel products in future, biologicals being one example, with a specific focus on improving soil health.

These findings chimes completely with my recent conversation with Ronald Clemens of ICL about the sustainability benefits of controlled-release fertilizers (see article on page 24).

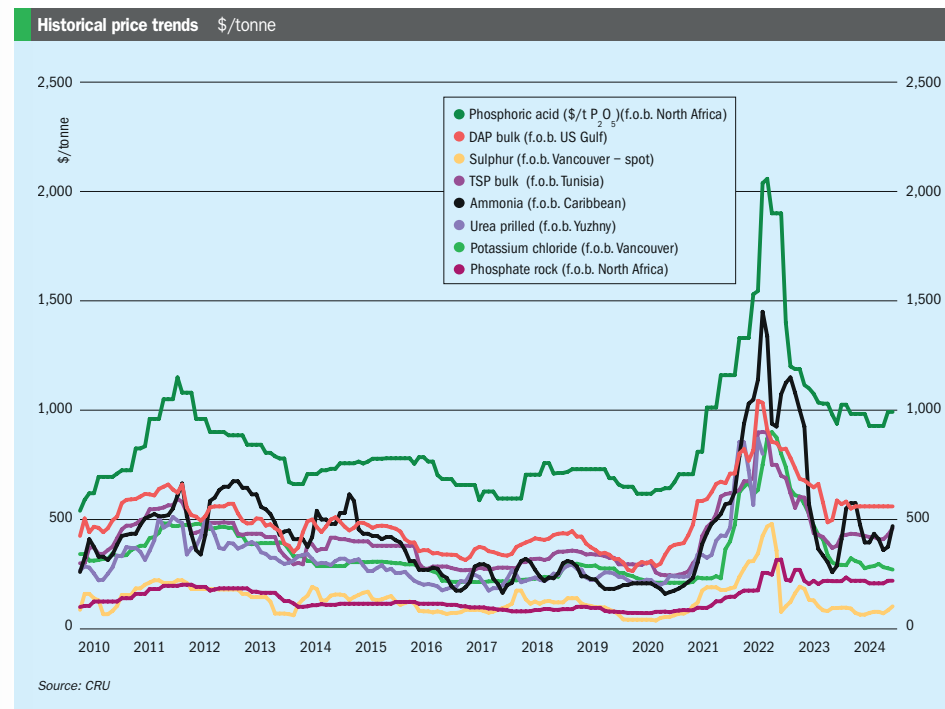
One valuable piece of feedback from McKinsey's informative survey is this: growers globally see their input providers as trusted advisors on soil health – a reputation this industry would be wise to build on. ■

Reference

1. Fiocco, D., 2024. The voice of the farmer in 2024: global insights. *IFA Global Markets Conference*, 9-11 July 2024, London.

S. Inglethorpe
Simon Inglethorpe, Editor

Market Insight



PRICE TRENDS

Market snapshot, 15th August 2024

Urea: A stand-off between buyers and sellers has left prices fairly flat in recent weeks with little liquidity. India's latest import tender was, however, finally confirmed for 29th August closing. The tender's long shipment window allows NFL to secure tonnages through to end-October and took the market by surprise. This is a bearish signal that should increase dramatically the volume offered to NFL. The tender could exclude volumes from China with supply instead focused on the Middle East and Russia.

Other markets were slow to come forward in mid-August. Brazil saw offers pushed to \$360-365/t cfr on news from India, but buyers have yet to respond. Europe has been slow to step up with sales still below Egyptian aspirations of \$360/t f.o.b. Mopco did achieve \$357/t f.o.b for 5,000 tonnes, although this has yet to trigger any rally in sales. NOLA, meanwhile, took a plunge on the news from India with prices suddenly dropping \$10/st to \$305/st f.o.b. for August.

Ammonia: Benchmarks west of Suez have been supported by limited regional availability at key export hubs. Nutrien sold 25,000 tonnes from Trinidad to multiple buyers in NW Europe in mid-August at \$550-555/t cfr, a sizeable premium on the \$375/t f.o.b. last achieved by the company in late June. Prices on delivered sales into Europe could therefore move up further, given that last done business with Algeria was at \$520/t f.o.b.

East of Suez, all eyes were on India, with tentative suggestions that FACT awarded its latest purchase tender at \$415/t cfr. This was taken as a sign of healthy demand from downstream Indian phosphate fertilizer producers ahead of the Kharif growing season. That demand should be mainly satisfied by the Middle East, with Ma'aden once again stepping in to export 175,000 tonnes in September. Demand elsewhere in the region remained subdued in mid-August, with limited spot interest from South Korea, Taiwan and China.

Phosphates: Tight supply remained the overwhelming driver for DAP markets east of Suez in mid-August. In India, fresh deals pushed DAP prices up by \$30/t. Activity in most other key global markets, meanwhile, remained sluggish. Two DAP deals to India were concluded at \$620/t cfr compared to sales at \$590/t cfr in early August. The Indian DAP benchmark has now increased an average of \$110/t, or 22 percent, over the past three months.

Demand for DAP/MAP in the Americas is seasonally slow. New Orleans barge prices for MAP remain at a premium due to the persistence of tight supply, though they did soften \$5/st in mid-August to \$635/st FOB.

Potash: Global spot prices were little changed in mid-August as low demand engulfed the potash market. Brazilian granular potash held at an average of \$300/t cfr as demand remained lacklustre. The Southeast Asian potash market saw little movement as suppliers



Market price summary \$/tonne – mid-August 2024

Nitrogen	Ammonia	Urea	Ammonium Sulphate	Phosphates	DAP	TSP	Phos Acid
f.o.b. Caribbean	470	-	f.o.b. E. Europe 225	f.o.b. US Gulf	560	-	-
f.o.b. New Orleans	-	342	-	-	-	-	-
f.o.b. Yuzhny	Port closed	Port closed	-	f.o.b. N. Africa	595	460	992
f.o.b. Middle East	335	313	-	cfr India	620	-	950
Potash	KCl Standard	K ₂ SO ₄	Sulphuric Acid	Sulphur			
f.o.b. Vancouver	271	-	cfr US Gulf	128	f.o.b. Vancouver	103	-
cfr India	281	-	-	-	f.o.b. Arab Gulf	108	-
f.o.b. Western Europe	-	649	-	-	cfr China	133	-
f.o.b. Baltic	220	-	-	-	cfr India	148	-

Prices are on a bulk, spot basis, unless otherwise stated. Phosphoric acid is in terms of \$/t P₂O₅ for merchant-grade (54% P₂O₅) product. Sulphur prices are for dry material. n.a. = not available.

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and buyers struggle to see eye to eye on the future price outlook. China's inland prices fell once again, marking their lowest levels since late March at an average of RMB2,390/t fca (\$334/t).

Sulphur: The tone across global sulphur markets remained bullish in Mid-August, with many traders expecting further price increases on upcoming business. Fresh spot purchases of sulphur were, however, limited following a wave of activity in Indonesia, Brazil and India earlier in August.

The China market in particular was inactive, having kicked off the current price rally with July's buying blitz. A sales tender from Kuwait did, however, achieve a reported price in the upper \$120s/t f.o.b., suggesting that further increases were likely across benchmarks in coming weeks. For now, the Middle East spot price was assessed up at \$115-120/t f.o.b. in mid-August. Its mid-point is now at its highest level since March 2023, having climbed more than 50 percent over the past two months.

OUTLOOK

Urea: While some correction in North African prices may be necessary to entice European buyers back, emerging urea demand is expected to support prices in August/September, while China's return to the export market is likely to prompt prices falls again in the fourth quarter.

CRU expects some demand to emerge from Europe in the latter part of August and September offering support to Egyptian prices. The August price rebound in China is expected to be short lived. With higher production rates than last year,

CRU is anticipating a return to fourth quarter exports from China of up to 1.5 million tonnes.

Ammonia: While ongoing supply issues are expected to provide price support in the very near term, particularly in the West, they should eventually revert to seasonal patterns. Black Sea capacity additions, pencilled in for early in the fourth quarter, could also place downward pressure on prices.

Benchmarks west of Suez have gained a lot of ground in recent months. The natural-gas curtailments in Trinidad, which first emerged in June to support prices, are unlikely to be resolved before September. CRU expects prices to correct slightly downwards into the fourth quarter, assuming curtailments in Trinidad have ceased.

East of Suez, the supply-demand picture has been more balanced since Saudi producer Ma'aden resumed production at its MWSPC II unit earlier in July. As a result, export prices in the Middle East should not diverge too far from latest average assessments of around \$350/t f.o.b.

Phosphates: Global DAP/MAP markets have diverged in recent weeks, with those east of Suez climbing higher and those in the Americas experiencing slight downwards pressure. India's DAP prices are playing catch up with increases elsewhere, having reached \$590/t cfr on 1st August.

Demand from India is rising while supply remains tight. India's DAP prices are therefore forecast to rise to a monthly average of \$613/t cfr by November before stabilising. Brazilian MAP demand, in contrast, has slowed considerably, with

a short-term ceiling on prices at \$635/t cfr now likely. Demand is expected to pick up again later in the year. With US supply even tighter than it is elsewhere, and fall season demand starting from late September onwards, New Orleans DAP prices are forecast to firm to \$563/st f.o.b. for November before softening slightly.

Potash: Most spot prices are anticipated to fall to a low in October before slowly rebounding.

The India 180-day standard contract was assessed at \$279-283/t cfr and – despite this settlement – the lower end of this range may be difficult for buyers to achieve. While this provides a floor for the market, most potash spot prices are expected to decline marginally until October before starting to rally.

Sulphur: Prices are expected to increase above current levels initially before declining slightly by the end of the year, as good availability should limit the upside despite improving demand.

Overall, the recent growth in sulphur production, in addition to producer stock drawdown and high China inventories, is expected to limit upwards potential for prices in the short term and keep sulphur prices low relative to phosphates. Nonetheless, good affordability, by continuing to support raw materials purchasing, leaves room for further price increases.

Port inventories in China at 2.6 million tonnes are well above the 2023 and 2022 averages of 2.1 million tonnes and 1.4 million tonnes, respectively. While recent firming in domestic phosphate markets has added support, these high stocks should limit the sulphur price upside. ■

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CONTENTS

What's in issue 522

HIGHLIGHT 1

GPCA Agri-Nutrients Conference, Riyadh

HIGHLIGHT 2

Green fertilizers enter the fray

HIGHLIGHT 3

Medium-term market outlook

HIGHLIGHT 4

Automated process analysis

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ISSUE 522
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PARAGUAY

Yara to purchase renewable calcium ammonium nitrate (CAN) from Atome

Atome plans to use surplus hydroelectricity from the Itaipu dam on the Brazilian-Paraguayan border to power its Villeta low-carbon fertilizer project.

Norway's Yara International has signed Heads of Terms for the offtake of calcium ammonium nitrate (CAN) from Atome's low-carbon fertilizer project in Villeta, Paraguay.

This covers the long-term supply of all of the CAN produced by the innovative Paraguayan plant. Yara plans to market and sell this low-carbon fertilizer as part of the YaraBela product line. The 264,000 t/a capacity 'green' fertilizer project incorporates a 145MW electrolyser powered from baseload renewable electricity.

Atome expects to signal the go-ahead for the flagship project with a final investment decision (FID) later this year. The project's front-end engineering and design (FEED) study was completed earlier in

2024. It is scheduled to begin producing and exporting CAN fertilizer from 2027.

"The entry into this strategic relationship with global crop nutrition leader Yara is a significant milestone for Atome on the path to realizing our flagship Villeta Project which will be one of the largest renewable fertilizer production facilities in the Western Hemisphere. Proving significant off-taker interest for our renewable product gives a clear path to the finalization of funding, FID and the commencement of work onsite at Villeta," said Olivier Mussat, Atome's CEO.

Off-taker interest will also help accelerate the development of other projects in the pipeline, says Atome, including the company's 300MW Yguazu project in Paraguay and its 120MW Costa Rica project.

Chrystel Monthean, EVP Americas at Yara, said the company was looking forward to developing a strategic long-term relationship with Atome:

"Decarbonizing the food systems is at the forefront of our strategy. Many of the food companies active in South America have committed to decarbonization targets and our collaboration with them reveals that the decarbonization of the production of fertilizers combined with the use of agro-nomical best practices can significantly reduce the crops' carbon footprint."

She confirmed that fertilizers produced from Villeta will become part of a new portfolio called Yara Climate Choice. These will include fertilizers manufactured using both renewable energy and carbon, capture and storage (see article and interview pages 27-35).

"Signing the Heads of Terms for the Villeta project is a first step to open the opportunity to further expand our portfolio with fertilizers produced with renewable energy in the Americas. The project's in-land location could open logistical advantages for some of our growing markets in Mercosur," Monthean said.

Atome also announced in July that it had secured a 30-year term Free Trade Zone (FTZ) contract for Valleta. This provides the project with tax free status and offers long-term fiscal security, says Atome, as well as benefiting the economics of the project.

Spain has now produced 3,000 tonnes of potato chips, thanks to the use of fertilizers produced by Fertiberia with green hydrogen.

Fertiberia's Impact Zero line (see article on p33) reduces crop CO₂ emission. They also function as enhanced efficiency fertilizers. These help to boost crop yields by improving nutrient uptake and minimising nutrient losses.

"This represents one more step towards achieving our goal of reducing carbon emissions to reach net zero by 2040," said Christian Cerezo, head of the Agriculture Department at PepsiCo Southwest Europe.

Alfredo Segura, Sales Director at Grupo Fertiberia, said: "The success of the first phase of this partnership confirms that our Impact Zero line meets its goals to reduce emissions and [improve] agronomic efficiency. We will continue working with PepsiCo. to further reduce our carbon footprint

with a fertilisation plan which will provide even better results."

FRANCE

Nextchem secures green fertilizer plant design contract

Nextchem is to carry out a feasibility study and pre-FEED (front-end engineering design) contract for a low-carbon fertilizer plant in France on behalf of the Fertighy consortium.

The planned 500,000 t/a capacity plant will produce nitrogen-based fertilizers using Stamicarbon's green ammonia and nitric acid technologies. The plant will also incorporate Nextchem's electrolyser and green hydrogen technology. Both Nextchem and Stamicarbon are part of Italy's Maire Group.

The Fertighy consortium, established in 2023, is composed of a diverse range of European food, energy, engineering and financial sector companies – namely EIT InnoEnergy, RIC Energy, Maire, Siemens Financial Services, InVivo and Heineken. The partners all share a common interest in bringing about industrial and agricultural decarbonisation.

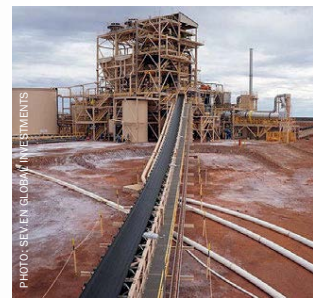
The consortium's inaugural plant in France, which is scheduled to start construction in 2027, will produce half a million tonnes of low-carbon nitrogen-based fertilizers annually, using green hydrogen generated by renewable electricity. This avoids up to one million tonnes of CO₂ per year that would typically be generated using a conventional nitrogen fertilizer production process such as steam methane reforming (SMR). Fertighy is planning to replicate its low-carbon fertilizer production concept in a number of European countries

AUSTRALIA

SO4 achieves first SOP production

SO4 successfully produced sulphate of potash (SOP) at its Lake Way plant in Western Australia at the end of July. The company, which is owned by Czech-based Sev.en Global Investments, hailed this as a significant milestone in its progress towards full commercial operation.

The Lake Way SOP project, which has been in development for more than seven years, has a chequered history. It was originally commissioned in April 2021 and began commercial production in June that year under its previous Australian owner Salt Lake Potash. Sev.en then



SO4 is commissioning its SOP processing plant at Lake Way, Western Australia, having made a substantial investment in the project since 2022.

acquired the project in 2022 after Salt Lake Potash went into administration, having struggled to finance and fully commission the plant.

Sev.en has made significant investments in the production process since 2022. These include the installation of new froth flotation units in the process plant to manage the diverse composition of feedstocks. Using solar evaporation ponds to harvest potassium-rich salts has also been a major advance towards sustainable SOP production, according to the company.

Although the process plant is still in the commissioning phase, the production of "Prime High K Standard" SOP (53% K₂O and <1.0% chloride), after years of effort, represents a "significant proof of the operating ability of the system", Sev.en said.

"This important step confirms the capability of the SO₄ team to conceptualise, design, construct, and operate the SOP mining and production facilities and achieve world-class SOP quality parameters. We are proud of the entire team, who have demonstrated a high level of commitment and endurance to reach a key milestone," said Mark Sykes, Australian country manager for Sev.en Global Investments.

The Lake Way plant has an annual SOP design capacity of more than 200,000 tonnes. Having faced and overcome several complex operational challenges, Sev.en says it is looking forward to bringing the project to full production and becoming a significant Australian and global SOP supplier.

MOROCCO

OCP selects Chemetics sulphuric acid technology

OCP has given notice that it will award Worley Chemetics the contract for three new sulphuric acid plants at the company's Mzinda Phosphate Hub (MPH) in Morocco. The notice of award is conditional on the subsequent signing of a contract.

As specified by OCP, Worley Chemetics will agree to supply proprietary sulphuric acid technology and equipment alongside detailed engineering, procurement and advisory services. The company will deliver the contract from Canada through its offices in Vancouver and specialised fabrication plant near Toronto.

Worley Chemetics' sulphuric acid technology provides electrical power which is CO₂ emission-free and results in lower stack emissions. Air cooling is also used to conserve and reduce water usage.

Additionally, the company's proprietary CES-ALPHA™ System recovers low-grade heat as steam for maximum heat recovery.

The MPH project is a part of the OCP's Green Investment program. This is aiming to increase the company's annual fertilizer production capacity from 12 million tonnes currently to 20 million tonnes by 2027 using clean energy and non-conventional water sources.

TOGO

FertiStream buys Nutrisource

Global fertilizer trader and distributor FertiStream has signed an agreement to acquire Nutrisource, a Singapore-based holding company with fertilizer assets in Africa. These assets notably include a modern, large-scale fertilizer blending plant in Togo.

The newly-built 20,000 t/a capacity blending plant was designed by EMT, the leading Netherlands-based blending and bagging equipment manufacturer. The fully mechanised and automated plant will produce a range of fertilizer blends, including NPKs with high phosphate content which are in high demand in the region. It offers 60,000 tonnes of raw material storage capacity and 30,000 tonnes of storage for blended fertilizers.

The Togo blending plant, which also includes a quality control laboratory, should be well positioned to provide a local supply of high-quality fertilizers to the West Africa region. It is conveniently located 22 kilometres north of Lome, a deep-water port that can accommodate Supramax vessels. This should enable FertiStream to supply blended NPK fertilizers to neighbouring countries, including Burkina Faso, Ghana, Niger, Benin and Mali.

Dubai-based FertiStream said the purchase of Nutrisource strengthens its footprint in this emerging regional fertilizer market and underlines its overall commitment to African agriculture.

"Our mission is to connect fertilizer producers and buyers worldwide, and with this acquisition, we go even further. Not only will we be able to better contribute to African agriculture by streamlining access to high-quality fertilizer products across nitrogen, phosphorus, and potassium segments, but we will also provide locally produced NPK blends tailored to the specific needs of regional crops and soils," said Jacques Lubbe, the owner and CEO of FertiStream Holding.

CONTENTS

What's in issue 522

HIGHLIGHT 1

GPCA Agri-Nutrients Conference, Riyadh

HIGHLIGHT 2

Green fertilizers enter the fray

HIGHLIGHT 3

Medium-term market outlook

HIGHLIGHT 4

Automated process analysis

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Imane Belrhiti, the head of business development for Africa & Middle East at FertiStream, will become Nutrisource's chairman. Imane is a seasoned fertilizer professional with over 14 years' industry experience, including VP level roles at OCP. He will head up a team to ensure that the production of blended NPK fertilizers begins at the Togo plant in the fourth quarter of 2024.

Dubai-based FertiStream achieved a sales volume of more than five million tonnes in the first half of 2024, via an expanding footprint across South and Central America, Southeast Asia, China, Europe, and now Africa. The company is subsidiary of FertiStream Holding Ltd, a company owned and managed by Jacques Lubbe. So far this year, FertiStream has supplied almost 500,000 tonnes of mineral fertilizers to African markets. These include Côte d'Ivoire, Ghana, South Africa, Kenya, Togo, Senegal and Cameroon, and cover a diverse commodity portfolio (AN, AS, Urea, CAN, NOP, MOP, NPKs).

UNITED STATES

Low-carbon fertilizer pilot for corn production

CF Industries and POET have launched a pilot project to reduce the carbon intensity of corn and bioethanol production by using low-carbon ammonia fertilizers. The collaboration is highly symbolic – given that POET is the world's largest biofuels producer and CF is the largest ammonia producer globally.

Both companies are expecting greater demand for ethanol with a lower carbon intensity in future in order to meet low-carbon fuel standards.

Ammonia is commonly used as a direct application fertilizer by US corn growers. But conventional ammonia production is energy intensive, and therefore a significant contributor to the carbon footprint of harvested corn and the bioethanol produced from this. Producing ethanol from corn grown using low-carbon ammonia instead can reduce its carbon intensity by up to 10 percent, the companies said.

The first applications of low-carbon ammonia to US corn are scheduled for fall this year followed by spring 2025 application. The first low carbon corn crop should therefore be harvested in the fall of next year.

"We are pleased to collaborate with POET on this important step forward in

developing a low-carbon ethanol value chain that links low-carbon fertilizers to farmers to ethanol production," said Bert Frost, executive vice president, sales, supply chain and market development, CF Industries. "Fertilizers manufactured with a lower carbon intensity provide a quantifiable and certifiable method of decarbonizing bioethanol inputs. We look forward to demonstrating these benefits not just for ethanol production but for corn growers as well."

The two companies intend to jointly develop a low-carbon fertilizer supply chain together. This will track, validate and certify the carbon intensity of low-carbon ammonia manufactured at CF's Donaldsonville complex, Louisiana, and, subsequently, the ethanol produced at POET's plants in Bingham Lake, MN, Emmetsburg, IA, Fairmont, NE and North Manchester, IN.

Low-carbon fertilizers will be supplied via retailers to farms that produce corn for POET's bioethanol plants. There will also be monetisation opportunities for farmers who use these low-carbon fertilizers.

CF Industries recently completed the installation of a 20MW electrolyser at its Donaldsonville complex. Start-up is imminent and the company intends to purchase renewable energy certificates needed for green ammonia production once this unit is up and running. More low-carbon ammonia capacity will be available at Donaldsonville from next year when a large-scale carbon capture and sequestration project commences at the site.

Woodside to acquire Beaumont blue ammonia project

Woodside has entered into a binding agreement to acquire 100 percent of OCI Clean Ammonia Holding BV for an all-cash offer of approximately \$2,350 million.

The agreement provides Woodside with ownership of OCI's under-construction 'blue' ammonia project in Beaumont, Texas, and is inclusive of capital expenditure to complete the project's first phase (Phase 1). The Beaumont project is scheduled to begin producing conventional commodity ammonia from 2025 and low-carbon ammonia from 2026.

Woodside said it would accrue the following benefits from the cash purchase:

- The world's first ammonia plant paired with auto thermal reforming (ATR) technology and at least 95 percent CO₂ capture

- Early-mover advantage in the growing low-carbon ammonia market
- A capital allocation target of 10 percent internal rate of return (IRR)
- Free cash flow generation from 2026 and the generation of earnings per share from 2027
- Capacity to abate 3.2 million t/a CO₂ equivalent when fully developed, meeting more than 60 percent of Woodside's Scope 3 abatement target.

Meg O'Neill, Woodside's CEO, said the acquisition of OCI Clean Ammonia supports the company's strategy to benefit from advancing the energy transition:

"This transaction positions Woodside in the growing lower carbon ammonia market. The potential applications for lower carbon ammonia are in power generation, marine fuels and as an industrial feedstock, as it displaces higher-emitting fuels.

"Global ammonia demand is forecast to double by 2050, with lower carbon ammonia making up nearly two-thirds of total demand.

"This acquisition is a material step towards delivering our Scope 3 investment and abatement targets. Phase 1 has the capacity to abate 1.6 Mtpa of CO₂-e and with the addition of Phase 2 the Project has the capacity to abate 3.2 Mtpa CO₂-e, or over 60 percent of our Scope 3 abatement target."

OCI's clean ammonia project in Beaumont, Texas, is located on the US Gulf Coast – and is therefore well-positioned to serve both domestic and international customers. Phase 1 of the project has a design capacity of 1.1 million t/a and is under construction. First ammonia production is due to start next year. Lower carbon ammonia production, which combines production with sequestration by carbon capture and storage (CCS), is scheduled to commence in 2026.

The Beaumont project already has agreements in place for both its feedstocks and CCS capacity. The project's nitrogen and hydrogen feedstock requirements will be sourced primarily from a feedstock plant owned and operated by Linde. This is currently under construction and due to be completed in early 2026. In the interim, the project will source its feedstock supply from multiple suppliers, including Linde, using existing and available Gulf Coast capacity.

CCS services to the project will be provided to Linde by ExxonMobil and are expected to be available in 2026. ■

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CONTENTS

What's in issue 522

HIGHLIGHT 1

GPCA Agri-Nutrients Conference, Riyadh

HIGHLIGHT 2

Green fertilizers enter the fray

HIGHLIGHT 3

Medium-term market outlook

HIGHLIGHT 4

Automated process analysis

FERTILIZER INTERNATIONAL
ISSUE 522
SEPTEMBER/OCTOBER 2024



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People

Mark Thompson became Nutrien's executive vice president (EVP) and chief financial officer (CFO) on 26th August. Mr Thompson succeeds **Pedro Farah**, who will remain with the company in an advisory capacity until 31st December as part of a succession plan.

"Mark's impressive track record of execution, along with his proven financial and strategic acumen provides the unique ability to succeed in this position on day one. He brings in-depth knowledge of our business that will support the advancement of our strategic actions to enhance quality of earnings and cash flow," said Ken Seitz, Nutrien's president and CEO.

"On behalf of the Nutrien team, I would also like to thank Pedro for his service and commitment to Nutrien over the last five years," Seitz added.

"I've had the privilege to serve in leadership roles across the company and firmly believe in the opportunities afforded by Nutrien's strong competitive advantages and world-class asset base to deliver long-term shareholder value," Mark Thompson said in reply. "I look forward to continuing to partner with Ken and our executive leadership team on the disciplined execution of our strategy and drive a focused approach to capital allocation."

Mr Thompson has been with Nutrien since 2011, serving as EVP and Chief Commercial Officer immediately prior to his new appointment. Previously, Mark held executive and senior leadership roles across the company. These included stints as chief strategy & sustainability officer, chief corporate

development & strategy officer, and vice president of business development for Nutrien's retail business. He is a Chartered Financial Analyst (CFA) and holds Bachelor of Commerce (Finance) and Bachelor of Arts degrees from the University of Saskatchewan.

Gregory D Cameron was elected EVP and CFO of CF Industries by the company's board of directors in June. Mr Cameron will report to Tony Will, CF's president and CEO, and serve as a member of the company's senior leadership team. He succeeds **Christopher D Bohn**, who was recently promoted to executive vice president and chief operating officer (COO).

"We are pleased to welcome Greg to CF Industries," said Tony Will. "He brings proven leadership, financial and clean energy expertise, and a strong track record of developing high-performing teams that will serve our company, employees and shareholders well."

Mr Cameron most recently served as president and CFO of Bloom Energy, a global leader in solid oxide fuel cell technology. He joined Bloom Energy in 2020 as an EVP. Prior to that, Mr Cameron held a series of senior roles at General Electric during his 26 years with the company. These notably included periods as president and CEO, global operations, 2018-2019, and president and CEO, global legacy solutions-GE Capital, 2016-2018.

Brazil Potash Corp set up an advisory board chaired by **Mayo Schmidt** in July. The new board will provide the company with potash sector, in-country and

investor relations advice – as it seeks to take its under-development Autazes potash project in Brazil to the construction phase. The advisory board also includes the following notable individuals: **Kátia Abreu, Luis Adams, Helio Diniz, Maria Claudia Guimaraes, Cidinho Santos and William Steers**.

In a distinguished career, Mr Schmidt previously led Nutrien, the world's largest potash producer, during the period immediately following its formation. He retired from the Canadian fertilizer giant in 2022, having served as chairman and transitional president & CEO. In 2018, Mayo chaired the merger committee which steered the integration of Agrium and Potash Corp and led to the creation of Nutrien.

Earlier in his career, Mr Schmidt held a number of key management positions, largely in the agricultural sector, working for companies such as General Mills and ConAgra.

Stan Bharti, Brazil Potash's executive chairman, said: "Brazil Potash has assembled a very impressive advisory board with extensive depth of networks in the fertilizer sector, Brazil's government and the investment community that will contribute meaningfully to transitioning our construction-ready Autazes Project into the next major potash producer. Each advisory board member is a skilled leader with a strong network that will provide good advice and insights to our international board of directors, with majority having an on-the-ground presence in the heartland of Brazil's farming community, Mato Grosso." ■

PHOTO: NUTRIEN



US fertilizer industry update

The US fertilizer industry, ranked fourth globally in terms of total production capacity, has grown and developed alongside an increasingly sophisticated domestic agricultural sector. The Biden administration has earmarked \$900 million for investment in fertilizer assets to boost domestic production capacity and reduce input costs to farmers.

Nutrien's Geismar nitrogen production complex in Louisiana.

\$900 million boost to domestic production

The US Department of Agriculture (USDA) announced an investment of \$83 million in domestic fertilizer projects across 12 states at the end of May. The government finance will help build new fertilizer production plants, modernise equipment and install new technologies.

The investment is part of the \$900 million committed to domestic fertilizer production in 2022 by the Biden administration under the USDA-administered Fertilizer Production Expansion Program (FPEP). This is designed to boost domestic fertilizer production, increase competition and reduce costs to farmers.

The FPEP was originally started in response to the doubling in fertilizer prices in 2021-2022 triggered by the conflict in Ukraine. To date, USDA has invested \$251 million in 57 projects across 29 states through the FPEP. The leaves around \$649 million of FPEP funding still to be allocated.

The new tranche of investment announced in May includes the following grants:

- A \$25 million grant to **4420 Serrano Drive LLC** for a food waste upcycling plant in Jurupa Valley, California. The new plant will supply around 90 local customers with a total of 11,400 tons of organic fertilizers annually.
- A \$4 million grant for **Cog Marketers**, which also operates as AgroLiquid, to build and equip a manufacturing plant in Lake City, Florida. This is expected to produce two million gallons of fertilizer components annually and supply around

200 retailers in Alabama, Florida, Louisiana, Mississippi, North Carolina and South Carolina.

- **Return LLC** will use a \$4 million grant to expand its current production plant in Northwood, Iowa.

Other grants were awarded to projects in California, Florida, Hawaii, Iowa, Illinois, Kansas, Kentucky, Minnesota, North Carolina, North Dakota, Oregon and Washington. The opening by **Landus** of a new slow-release nitrogen (SRN) manufacturing plant in Boone Iowa, has been one notable beneficiary of FPEP funding (see box)

"The Biden-Harris Administration and USDA are committed to bolstering the economy and increasing competition for our nation's farmers, ranchers and small business owners," said USDA Secretary Tom Vilsack in May. "The investments announced today will increase domestic fertilizer production and strengthen our supply chain, all while creating good-paying jobs that will benefit everyone."

USDA originally announced plans for a \$250 million grant programme for additional domestic fertilizer production in March 2022. The scale of the investment was then doubled to \$500 million six months later in September 2022.

In June last year, USDA allocated an extra \$400 million for fertilizer production expansion – taking total FPEP funding to \$900 million. This was in response to level of interest in the programme's first two funding rounds. These were heavily oversubscribed, receiving applications valued at approximately \$3 billion from

350 businesses, according to USDA. The seven initial FPEP grant winners, selected from 21 shortlisted projects, were also announced in June 2023. These included:

- **Black's Valley Ag Supply Inc** – who will build a new dry fertilizer production plant and storage unit in Durand, Wisconsin. The production plant will increase the company's annual fertilizer production by 33 percent.
- **Farmer's Union Oil Company** – who will expand a fertilizer processing plant in rural Montana. This project will increase the supply of local and affordable fertilizers within a four-county region, while creating several local jobs.
- **Progressive Ag Cooperative** – who will construct a dry fertilizer plant that serves cooperative members from northern Iowa and southern Minnesota.

US industry overview

The United States is the world's fourth-largest fertilizer consuming region, being responsible for around nine percent of global consumption and ranked behind only China, India and Brazil globally (Figure 1). On an individual nutrient basis, the country is also the world third largest nitrogen and potash consumer and fourth largest consumer of phosphates (Figures 2-4).

The United States has developed a large-scale and responsive domestic fertilizer industry to satisfy the high demand generated by its equally sizeable and sophisticated farming sector.

CONTENTS

What's in issue 522

HIGHLIGHT 1

GPCA Agri-Nutrients Conference, Riyadh

HIGHLIGHT 2

Green fertilizers enter the fray

HIGHLIGHT 3

Medium-term market outlook

HIGHLIGHT 4

Automated process analysis

FERTILIZER INTERNATIONAL
ISSUE 522
SEPTEMBER/OCTOBER 2024



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New Iowa slow-release nitrogen plant

Matt Carstens, Landus president and CEO, speaking during the June grand opening of the company's fertilizer production and distribution facility in Boone, Iowa.

Landus has invested \$15 million in a 75,000 square foot fertilizer manufacturing and distribution plant in Boone, Iowa. The project was backed by a \$5 million grant from the US Department of Agriculture's Fertilizer Production Expansion Program (FPEP). This Boone manufacturing plant will produce over 100,000 gallons of foliar, slow-release nitrogen (SRN) liquid fertilizer in its first operational year and 250,000 gallons in subsequent years. It also features a freestanding building for chemical and seed storage. The opening of the new site allows Landus to manufacture its entire AcreEdge Performance Portfolio in Iowa.

This includes over a dozen adjuvants, seed treatments and foliar nutrients. "This state-of-the-art facility is more than just a building; it's a testament to our commitment to supporting our farmers and rural communities. By bringing fertilizer production closer to home, we are eliminating costly links from the supply chain, and keeping the farmer at the center as we hit the ground running with this new fertilizer production and distribution center. We're looking forward to bringing US made, sustainable and fully customizable fertilizers to our farmers across the Midwest," said Matt Carstens, Landus president and CEO.

By capacity, the country is the world's third and fourth largest phosphate and nitrogen fertilizer producer, respectively (Figures 5-6), as well as being the ninth largest potash producing nation globally.

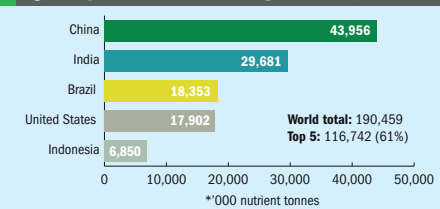
Overall, the US fertilizer industry, is ranked fourth globally, in terms of total production capacity (22.7 million nutrient tonnes), exceeded only by China (81.0 million nutrient tonnes), Russia (31.5 million nutrient tonnes) and its northern neighbour Canada (27.1 million nutrient tonnes)¹.

US fertilizer production is stable but in relative decline – with the country's capacity for phosphate and nitrogen fertilizers being overtaken by Morocco and India, respectively, in recent years.

Urea production

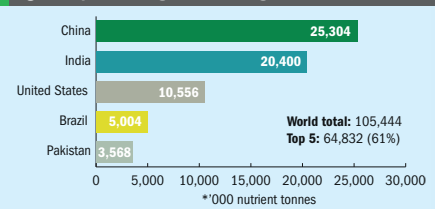
The US operates 12.2 million tonnes of urea production capacity. This is mainly in the hands of CF Industries, Nutrien and Koch industries, with these three companies combined owning 82 percent of domestic urea capacity (Figure 7). Collectively, these leading producers also operates eight of the 10 largest urea plants in the US (Figures 8 & 9). Illinois-headquartered CF industries is the largest US nitrogen fertilizer producer by far,

Fig. 1: Top five fertilizer-consuming countries*, 2022



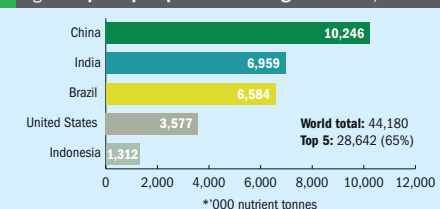
Source: Nutrien (2024)

Fig. 2: Top five nitrogen-consuming countries*, 2022



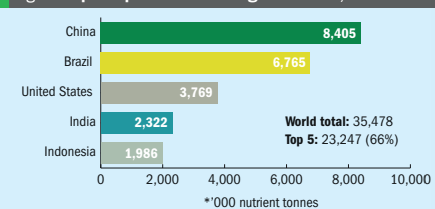
Source: Nutrien (2024)

Fig. 3: Top five phosphate-consuming countries*, 2022



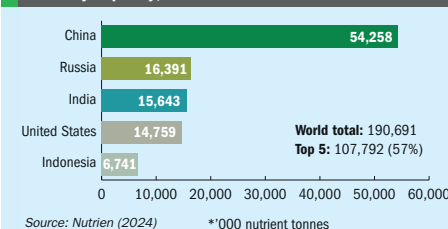
Source: Nutrien (2024)

Fig. 4: Top five potash-consuming countries*, 2022



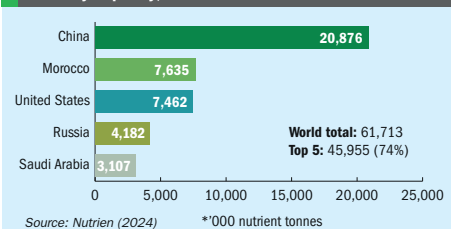
Source: Nutrien (2024)

Fig. 5: Top five nitrogen-producing countries*, by capacity, 2022



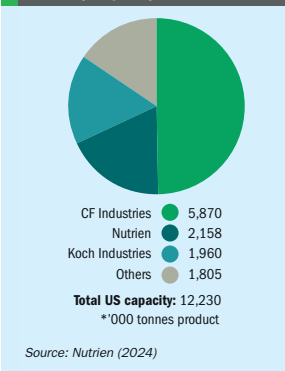
Source: Nutrien (2024) *'000 nutrient tonnes

Fig. 6: Top phosphate-producing countries*, by capacity, 2022



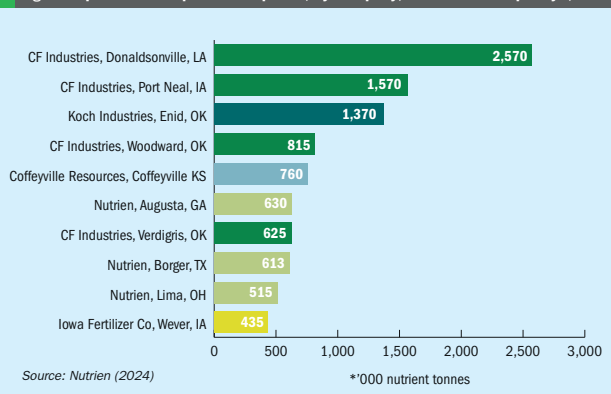
Source: Nutrien (2024) *'000 nutrient tonnes

Fig. 7: Major US urea producers, by capacity*, 2022



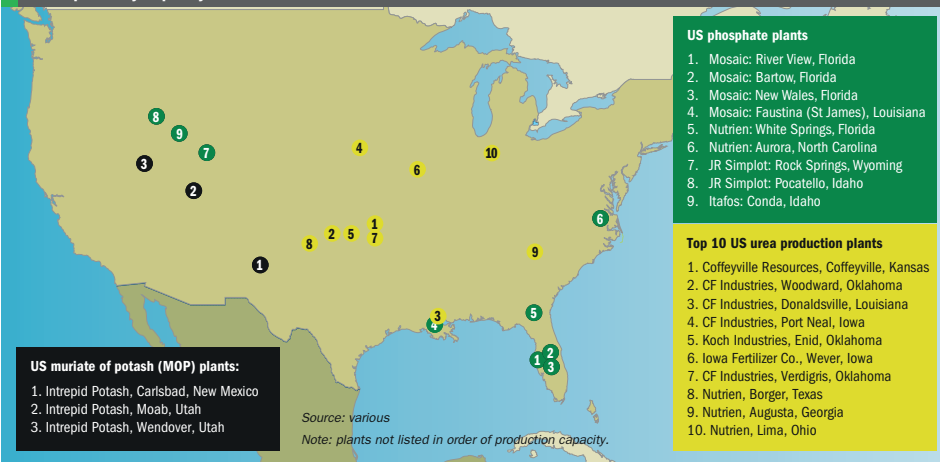
Source: Nutrien (2024)

Fig. 8: Top 10 US urea production plants, by company, location and capacity*, 2022



Source: Nutrien (2024)

Fig. 9: US fertilizer production: Location of main phosphate and potash production plants together with top 10 urea production plants by capacity



Source: various
Note: plants not listed in order of production capacity.

CONTENTS

What's in issue 522

HIGHLIGHT 1

GPCA Agri-Nutrients Conference, Riyadh

HIGHLIGHT 2

Green fertilizers enter the fray

HIGHLIGHT 3

Medium-term market outlook

HIGHLIGHT 4

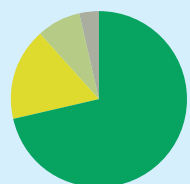
Automated process analysis

FERTILIZER INTERNATIONAL
ISSUE 522
SEPTEMBER/OCTOBER 2024



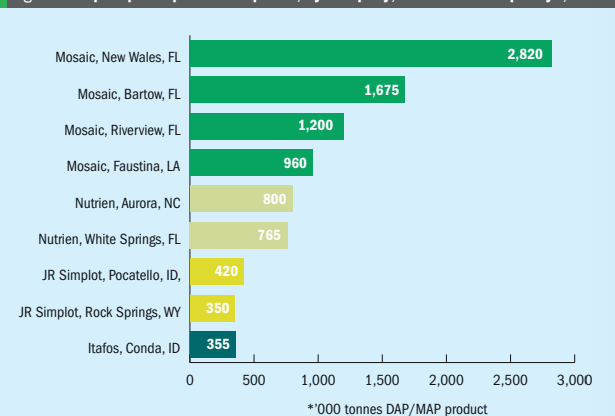
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Fig. 10: US phosphate producers, by capacity*, 2022



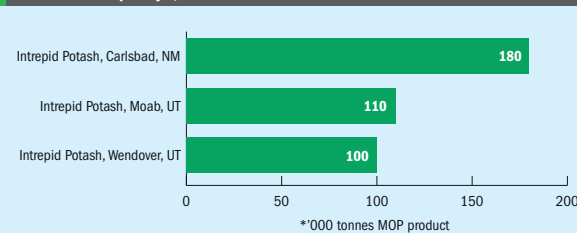
Source: Nutrien (2024)

Fig. 11: US phosphate production plants, by company, location and capacity*, 2022



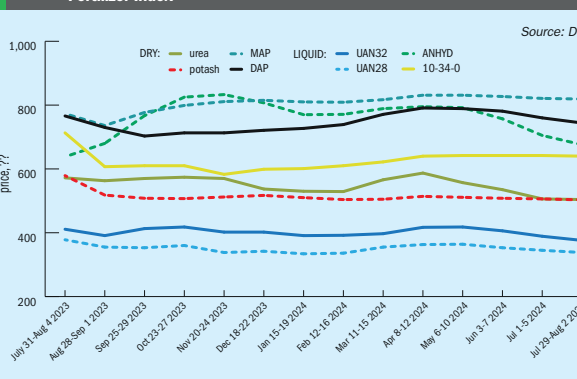
Source: Nutrien (2024)

Fig. 12: US muriate of potash (MOP) production plants, by company, location and capacity*, 2023



Source: Intrepid Potash

Fig. 13: US retail fertilizer prices over the last 12 months, compiled for the DTN Fertilizer Index



Source: DTN

with almost half (48 percent) of domestic urea capacity and operating at around three times the scale of its closest rivals Nutrien and Koch.

Phosphates production

The US can draw on 9.3 million tonnes of domestic production capacity for diammonium phosphate and monoammonium phosphate (DAP and MAP). Following several decades of consolidation, phosphate industry ownership is highly concentrated (*Fertilizer International* 496, p40) with just four companies – Mosaic, Nutrien, JR Simplot and Itafos – operating nine DAP/MAP production sites across Florida, Idaho, Louisiana, North Carolina and Wyoming (Figure 9).

Florida-headquartered Mosaic is the dominant US phosphates market player (Figure 10). It operates around 6.6 million tonnes of DAP/MAP capacity from four sites in Florida and Louisiana. This includes New Wales, the country's largest phosphates production complex (Figure 11).

Potash

Intrepid Potash is the sole US supplier of muriate of potash (MOP, KCl). The company has the capacity to produce around 365,00 tonnes of potash annually via solar evaporation from three mining sites (Figures 9 and 12):

- The HB solution mine in Carlsbad, New Mexico
- The Moab solution mine in Utah
- The brine recovery operation in Wendover, Utah.

Imports and exports

Due to its limited domestic production capabilities – versus the scale of agricultural demand – the US is the world's third largest potash importing country, after Brazil and China. The country imported 7.2 million tonnes of MOP in 2022 – albeit down from 10.2 million tonnes in 2021 – sourcing much of this from neighbouring Canada as well as Russia and Israel.

The US produced around 10.6 million tonnes of urea in 2022 supplemented by imports of 5.4 million tonnes. Indeed, the country is a major urea import market, being ranked the third largest

globally. The country's top three urea suppliers in 2022 were Qatar, Saudi Arabia and Russia. US urea exports, meanwhile, around 1.4 million tonnes in 2022, place it outside the global top 10 of urea exporting nations.

The US produced 5.4 million tonnes of DAP/MAP in 2022 and is the world's fifth largest DAP/MAP exporter (2.8 million tonnes). Major destinations include Canada, Brazil and Argentina. While remaining a next exporter, the country was also ranked as the six largest DAP/MAP importing nation globally in 2022 (1.3 million tonnes), sourcing products from Saudi Arabia, Russia and Australia.

Slight price falls

In general, average US weekly retail fertilizer prices have fallen slightly, according to the DTN Fertilizer Index, a longstanding price indicator based on a basket of four solid and four liquid products.

US ag retailers have generally reported slight year-on-year declines in the prices of both solid and liquid fertilizers so far in 2024

Six out of the eight products monitored by DTN have fallen in price over the last 12 months (Figure 13).

US ag retailers have typically reported year-on-year (y-o-y) declines in both solid and liquid fertilizers to DTN. For example, as of early August 2024:

- Potash is 13 percent lower
- Urea is 12 percent lower
- Diammonium phosphate (DAP) is three percent lower
- 10-34-0 is 10 percent lower
- Urea ammonium nitrate (UAN 28) is 11 percent lower
- Urea ammonium nitrate (UAN 32) is nine percent lower.

Monoammonium phosphate (MAP) and anhydrous ammonia were the exceptions with their prices both six percent higher y-o-y.

Sharp price falls in the first half of 2023 improved fertilizer affordability in the US, ending a trend of rising prices in 2021 and elevated prices in 2022.

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CONTENTS

What's in issue 522

HIGHLIGHT 1

GPCA Agri-Nutrients Conference, Riyadh

HIGHLIGHT 2

Green fertilizers enter the fray

HIGHLIGHT 3

Medium-term market outlook

HIGHLIGHT 4

Automated process analysis

FERTILIZER INTERNATIONAL
ISSUE 522
SEPTEMBER/OCTOBER 2024



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IFA's medium-term outlook – a supply/demand driven market

The International Fertilizer Association (IFA) recently published its annual medium-term outlook for the fertilizer market. This followed presentations by **Laura Cross** and **Armelle Gruère** of IFA's Market Intelligence Service at the Association's Annual Conference in Singapore in late May.

A favourite fixture

The long-standing market outlook session at IFA's Annual Conference is an eagerly anticipated fixture on the fertilizer industry's calendar. This highly informative and well attended once-a-year briefing is a conference highlight for hundreds of high-level fertilizer industry delegates.

This year's back-to-back demand and supply presentations in Singapore in May – summarised below – were as authoritative as ever. They were accompanied, as usual, by the publication of the *Medium-Term Fertilizer Outlook 2024–2028* report by IFA's Market Intelligence Service in July¹.

Better crop conditions

Armelle Gruère, IFA's Demand Program Manager, opened the session with an overview of the medium-term demand outlook. Global crop conditions have generally improved with the departure of El Niño, as Armelle explained:

"Grains and oil crops were affected in the centre-west of Brazil and in southern Africa. In Southeast Asia, El Niño also affected rice crops and palm oil plantations because of dry weather.

"It's not all negative as El Niño also brought some beneficial rains to Argentina and the south of Brazil. In the northern hemisphere, the conditions for winter crops and also new spring plantings are also favourable overall. Yes, there have been some heavy rains in northern Europe, but the situation is improving.



Laura Cross, Director, Market Intelligence Service, presenting the medium-term supply outlook at IFA's Annual Conference in Singapore in May.

"If we look at crop prices, well, they've fallen from a year ago, more for cereals than for oil crops. The one exception is rice, where prices have increased, but that's due to export restrictions put in place by India last year following a smaller-than-average crop."

Favourable environment on affordability

The overall picture on fertilizer affordability was favourable (Figure 1), if mixed, Gruère said:

"Fertilizer affordability improved considerably for all crops last year – indicated by a declining fertilizer price to crop price

ratio – with fertilizer prices decreasing faster than crop prices. But the cost of phosphate fertilizers did start rising again for the major crops in late 2023.

"In the first four months of 2024, nitrogen and phosphorus fertilizers were actually less affordable than at the same time last year. In contrast, potash fertilizers have become a lot more affordable for all crops."

Armelle did, however, caveat this affordability analysis:

"Firstly, it doesn't necessarily reflect the local situation. Secondly, high interest rates in a number of countries are affecting the ability of farmers to purchase fertilizers and other agricultural inputs."

PHOTO: IFA

Demand to return to record levels?

Global consumption this year (Figure 2) is projected to return to levels last seen in 2022, said Gruère:

"So, in this environment of better fertilizer affordability, we expect global fertilizer use by the end of fertilizer year [FY] 2024 to reach about 204 million tonnes, a return to the record levels of fertilizer year 2020. In that Covid year [2020], we had higher crop prices, good fertilizer affordability, an expansion in cereal and soybean area, favourable weather in key regions, and increased government support for agriculture with food security as the objective. Then we had two years of declining global fertilizer use.

"We now expect fertilizer consumption to quickly recover by four percent in fertilizer year 2023, with fertilizer prices falling from their previous peaks, and that recovery to continue with a three percent increase in 2024, this fertilizer year.

"That would bring fertilizer use slightly above the previous record of 2020. This recovery is also taking place despite the strong impacts of El Niño on specific regions."

The recovery in nitrogen and potash demand is the main factor behind improving global fertilizer use, Armelle indicated:

"The recovery in global fertilizer use in fertilizer years 2023 and 2024 is being driven equally by rising nitrogen and potash, about five million tonnes extra [nutrient tonnes] each, followed by phosphate [about three million nutrient tonnes]. As a result, nitrogen consumption is expected to be two percent above its 2020 level by the end of fertilizer year 2024, while phosphate and potash consumption is expected to be two percent below 2020 levels, with phosphate slightly behind the potash."

Looking at the regional pattern of fertilizer demand since 2020, Gruère highlighted the following:

- **Latin America:** partial recovery in fertilizer use in FY 2023 despite El Niño
- **China:** partial rebound in nitrogen use in FY 2022 and FY 2023
- **India:** stronger government support for nitrogen and phosphate leaves potash consumption behind in the short term
- **Western & Central Europe:** consumption still not recovered completely.

Fig 1: Potash fertilizers are more affordable than last year, particularly for oil crops

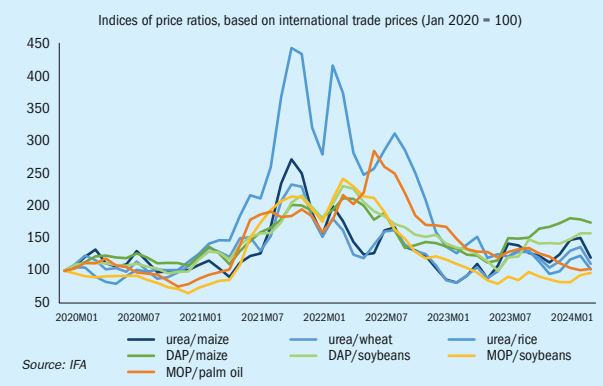
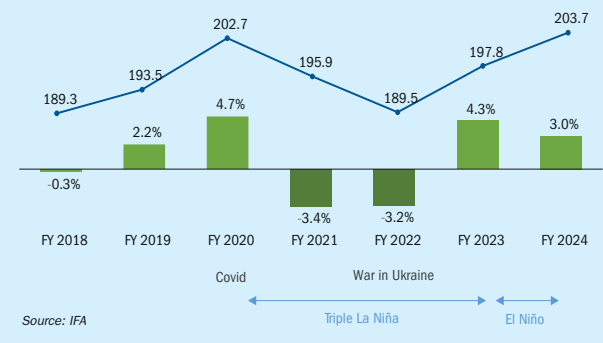


Fig 2: Global fertilizer use is expected to return to record levels



Slower medium-term growth

IFA expects demand growth to slow over the next five years, as Armelle explained:

"Over the medium term, the period from 2024 to 2028, global fertilizer use is expected to grow more slowly and at a declining rate to reach 1.5 percent [per annum] by 2028. This reflects slower growth in food production – which itself reflects a slower growing population – and increased nutrient use efficiency.

"Latin America and South Asia are expected to be the main engines of growth in the medium-term, adding between three and four million tonnes of nutrients each over that period. Major markets such as East Asia, North America and Western & Central Europe [meanwhile] are expected to grow very little.

"It's interesting to see that Africa ranks third in terms of its contribution to additional fertilizer consumption in the next five years – which is remarkable given that Africa currently only accounts for four percent of global fertilizer use. Its fertilizer use is still low and will need to rise to support increasing agricultural and food production for a growing population."

Extreme weather events represent an increasing risk to agriculture, and therefore the demand outlook, Gruère said.

"Weather variability – and extreme weather events in particular – is a major risk in this outlook. Of course, that's not new as weather has always been the wildcard in agriculture, but it is becoming an increasing concern.

"That's related to the succession of La Niña and El Niño events, but extreme

What's in issue 522

GPCA Agri-Nutrients Conference, Riyadh

Green fertilizers enter the fray

Medium-term market outlook

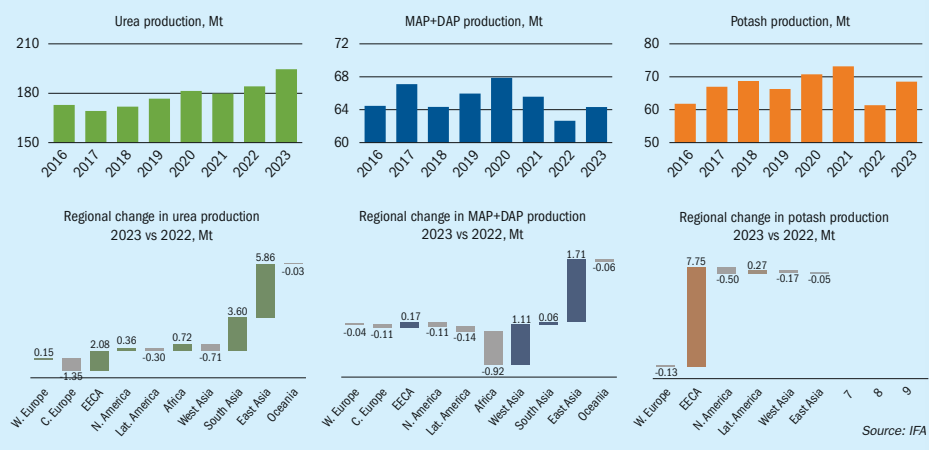
Automated process analysis

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ISSUE 522
SEPTEMBER/OCTOBER 2024



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Fig 3: N supply broke away in 2023 while P and K partially recovered



weather is also a fact, it's actually happening. As the climate warms up, there is a growing intensity of extreme weather events, whether they are floods or whether they are droughts."

The following extreme weather events, for example, have all affected fertilizer use in recent years:

- The economically devastating and deadly 2022 flooding in Pakistan prevented mid- and late-season fertilizer applications
- The 2023 La Niña-related drought in Argentina prevented crop planting
- The 2023 El Niño-related dryness in Indonesia resulted in lower fertilizer applications by oil palm plantations.

The World Meteorological Organization has also warned that the intensity of heavy rainfall events will increase in future as warmer air can hold more water vapour – about seven percent for every degree of global warming.

Commodities – a riskier business?

Laura Cross, Director, IFA's Market Intelligence Service, then presented the medium-term supply outlook:

"What I'm going to talk about is what the business environment is looking like at the moment, how the world is changing from a supply perspective – and what that means for the balance between supply and demand in the next five years."



Armelle Gruère, Demand Program Manager, Market Intelligence Service, presenting the medium-term demand outlook at IFA's Annual Conference in Singapore in May.

Fig 4: Nitrogen capacity forecast

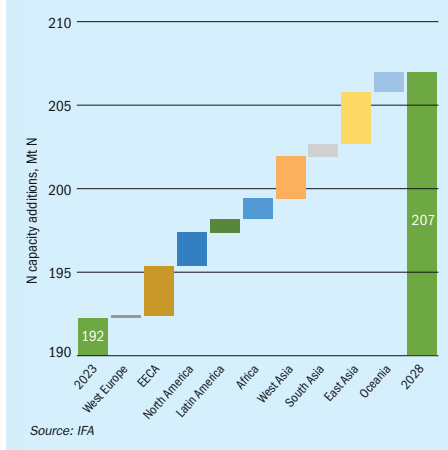
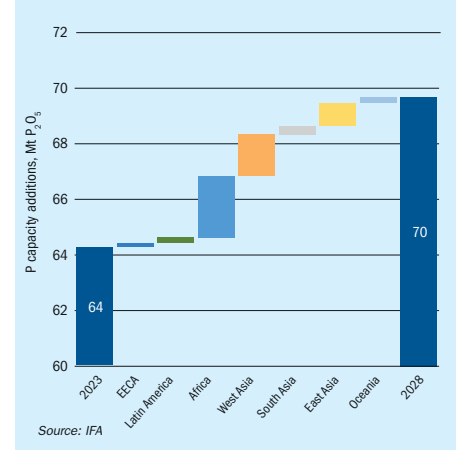


Fig 5: Phosphate capacity forecast



Laura opened her presentation by focusing on geopolitical risks and market fundamentals such as manufacturing output and investor confidence. It wasn't all bad news:

"The world is a riskier place than it was prior to 2021 – a pretty significant amount of new risk has been introduced into the market. Last year, when we first had disruptions in the Middle East, there was an initial spike in geopolitical risk – and that impacts lots of different parts of our industry.

"But I would argue that recent risks have actually become more priced-in by the market. So, actually, things are not quite as difficult or challenging as you might expect [from] the situation in the world globally.

"If we look at global manufacturing output, from the PMI index regularly produced by S&P Global, this has actually been continually improving since 2020. What's also telling from the PMI is how manufacturing production in Asian markets is breaking away from the rest of the world.

"It's also a relatively positive time from an investor standpoint – the S&P Global Investment Manager Index shows that the appetite for equity investors is actually pretty good. That index hit a two and a half year high in recent months,

again reflecting a more positive market situation."

IFA's overall conclusion is that, while the commodities business has become riskier in recent years, underlying market

“Africa ranks third in terms of its contribution to additional fertilizer consumption in the next five years – which is remarkable given that it currently only accounts for four percent of global fertilizer use.”

fundamentals continue to outperform background geopolitical sentiment. Cross gave her informed take on this:

"We've had a massive rerouting of trade away from the Suez Canal and the Red Sea – with routes going the longer distance around the Cape of Good Hope. But also don't ignore the role of the Panama Canal as well – with a slow tail off in volumes as a result of the drought conditions there.

"That's made it trickier, harder, more complex to move fertilizer products around the world. Fertilizers are one of the most exposed of the major dry bulk commodities, as shown by declining volumes going through the Red Sea-Suez Canal route.

"But actually, looking at fertilizer deliveries, we haven't seen that much of an impact in terms of availability as farmers are still receiving their shipments. These are, however, taking a much longer route.

"That may add time, it may add cost, but – as I said before – this is generally

priced-in by the market. What these longer distances do mean, though, is a negative impact on emissions."

Nitrogen supply breaks away

Looking at the current supply picture, nitrogen supply broke away in 2023 while phosphate and potash partially recovered (Figure 3), as Laura explained:

"Nitrogen production globally has continued with this year-on-year rise that we've seen over the last five years or so. A lot of that is driven by China but also by increasing domestic production in markets like India where we've had the onset of new capacity in the last couple of years.

"For phosphates and potash, it's been a little bit more mixed. Both of these markets have partially recovered – but not completely – to their pre-2022 levels with a mix of drivers behind that.

"On the phosphate side, this is pretty much market-driven and mainly about a reduced appetite for the affordability of phosphate fertilizers. For potash, one of the biggest drivers behind the 2023 recovery – hopefully this is no big surprise – was [extra] supply coming from Belarus and Russia."

Belarus is exporting far more potash than originally expected. In 2023, new routes to international markets replaced lost volumes previously exported via Lithuania. In particular, Belarus has increased exports to China by rail and to seaborne markets via Russian ports.

CONTENTS

What's in issue 522

HIGHLIGHT 1

GPCA Agri-Nutrients Conference, Riyadh

HIGHLIGHT 2

Green fertilizers enter the fray

HIGHLIGHT 3

Medium-term market outlook

HIGHLIGHT 4

Automated process analysis

FERTILIZER INTERNATIONAL
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SEPTEMBER/OCTOBER 2024



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Major port investment is taking place at the Russian port of Murmansk, for example, a potential future route for Belarusian potash exports. Cross elaborated on this:

"Belarus exported 10 million tonnes of potash through different routes last year. We can track through China customs import data that a record volume went by rail to China last year."

"It's also surprising how much of this volume went through Russian Baltic Sea ports – and this is where we've seen quite a lot of investment in port infrastructure from Belarusian companies. One example is Murmansk: this is already exporting a pretty decent amount of potash and could have 25 million tonnes of dry bulk capacity a year."

For nitrogen and phosphate, a key supply factor at play has been the much higher operating rates at existing and new Chinese plants. These are working much harder, said Cross:

"For a long time in IFA's supply and demand balance models, we've had an 80 percent utilisation rate for China with a pretty good amount of idle or unused capacity for the last 10-15 years. This is the first year in recent history that we've actually increased that to 85 percent in order for these plants to produce enough to meet domestic demand."

"The key takeaway is that, whether for exports or the domestic market, Chinese nitrogen and phosphate plants are working harder."

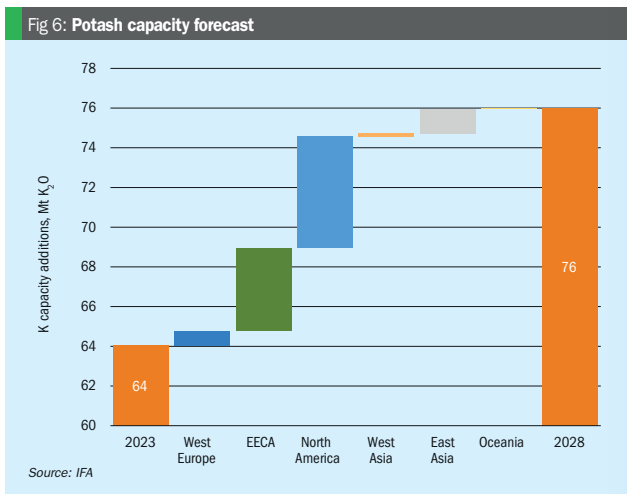
Changes to the investment cycle

Medium-term capacity forecasts for nitrogen, phosphate and potash are shown in Figures 4-6. According to IFA, the fertilizer investment cycle has changed in two main ways¹:

- Firstly, lower fertilizer prices have weakened the investment case to fund new capacity
- Secondly, the industry is becoming more sustainable, underpinned by the energy transition, which raises project costs.

Laura Cross elaborated on the causes and consequences:

"The main reason why the investment cycle is changing is the artificial peak in prices [in 2022] against a backdrop of Russian sanctions and disruption to the flow of fertilizers – rather than a cyclical



pattern that was stimulating investment in new capacity previously.

"In the historical price cycle, you're usually looking at a 3-4 year timeline to build a new nitrogen plant. For a phosphate rock mine [and complex], this calculation is more like 4-5 years, and then for potash you're looking at about on average 8-10 years for the development of a new potash mine."

"In terms of number of projects, there is quite a lot of investment interest in nitrogen capacity. The key takeaway is that we've got investment in ammonia projects with carbon capture and storage in North America, with a lot of that driven by new tax breaks from the Inflation Reduction Act. We've also got conventional ammonia capacity commissioning in Russia in the next five years, and then we've also got expansions driven by green and blue ammonia projects in places such as Saudi Arabia and Qatar."

"Phosphate is more conventional in terms of the investment cycle. A smaller number of regions are contributing to the capacity increase with mainly existing producers continuing to expand. We also have some plant additions in new countries such as Brazil, where a small investment started this year, and we've also got expansions in India and in Egypt."

"There's actually been relatively low phosphate capacity investment in the last 10 years. But we actually start to see that ramping up again by the time we get to 2026 and 2027 – showing that we're seeing more investment in the next five years."

"There are even fewer new potash suppliers but some pretty big mega projects in our five-year forecast. Laos is a country where potash supply has shot up really quickly, adding three million tonnes of new potash capacity in the last two years, with those mines forecast to continue expanding over the next five years."

"Then we've got BHP's Jansen mine in Canada, probably the most talked about potash project, which is now in our forecast for 2027. We've also projects in both Russia and Belarus in our forecast – although these may not necessarily add saleable supply in the medium-term."

Back to a supply/demand driven market

Laura Cross expects the supply/demand balance to resume its traditional role as a key fertilizer market driver:

"We've returned to a supply/demand driven market. In the last three years, most of our presentations covered what might happen in really disrupted markets. I don't want to say back to normal, but we're back to conventional market drivers – I think that's the right way to define this."

The supply/demand balance is projected to loosen for nitrogen and potash over the next five years with the phosphate balance remaining stable.

"With all of the low-carbon ammonia project announcements made in the last

couple of years, you might be forgiven for thinking there could be an oversupply of nitrogen in the next 5-8 years or so. Actually that's not the case when you look at the project delays that have taken place and also the lack of investment appetite in certain parts of the world."

"We see a relatively well balanced phosphate market in the next five years. A lot of that comes back to slowing demand growth and a lack of any sizable projects outside of existing suppliers. Very tight supply has loosened since 2021 – but it's not outpacing demand growth"

"The potash balance, which was much tighter if you go back to 2019 and 2020, loosens up as we move forward into the next five years. This still assumes relatively low utilisation rates for the mega projects in our capacity forecast because we know these take time to ramp up."

Disruptors around the corner

Laura Cross rounded off her market outlook presentation by looking at potential fertilizer market disruptors. These included the emergence of new demand centres,

a slowdown in globalisation, the use of ammonia as an energy carrier and the exponential growth of lithium iron phosphate (LFP) batteries. Paraphrasing Ernest Hemingway, she said:

"How do these big changes happen in the world? They happen gradually and then they happen suddenly."

"That's why it's really important that we make sure we're keeping an eye on all of these potential developments. Some are positive, some are negative, some we don't quite know exactly what the impact will be yet."

"Nitrogen fixing developments, biostimulants, nutrient recycling and organic fertilizers? When you look at most of these you think of a decline in fertilizer consumption – but not necessarily – and we may not see these play out uniformly either."

"Today, the production of ammonia uses the same technology it did 100 years ago. There are so many rapidly developing technologies that could potentially change the entire operating environment."

"We're going to see some of these changes coming in and really changing

the way we think about the market," Laura Cross concluded.

Further reading

1. Cross, L., et al., 2024. *Summary Report: Medium-Term Fertilizer Outlook 2024–2028*. IFA Market Intelligence Service, Paris. Publicly available at: <https://www.ifastat.org/market-outlooks>

Acknowledgements

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CONTENTS

What's in issue 522

HIGHLIGHT 1

GPCA Agri-Nutrients Conference, Riyadh

HIGHLIGHT 2

Green fertilizers enter the fray

HIGHLIGHT 3

Medium-term market outlook

HIGHLIGHT 4

Automated process analysis

FERTILIZER INTERNATIONAL
ISSUE 522
SEPTEMBER/OCTOBER 2024



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Controlled-release fertilizers for sustainable farming

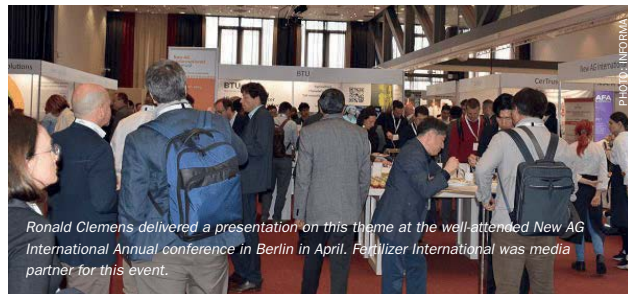
Ronald Clemens, ICL's Marketing & Portfolio Manager CRF, talks to *Fertilizer International* about the role of controlled-release fertilizers in sustainable agriculture.

Introduction

A controlled-release fertilizer (CRF) – as defined by ISO Standard 8157:2022 – is a: “fertilizer in which nutrient release is controlled, meeting the stated release rate of [the] nutrient and [meeting] the stated release time at a specified temperature.”

CRFs are coated products that essentially function by encapsulating fertilizer granules within a membrane. The release of nutrients through this membrane into the soil is consistent and predictable and largely regulated by soil temperature. CRFs offer the following agricultural benefits for field-grown crops:

- Fewer fertilizer applications
- Less impact on soil pH and salt levels in soils
- Positive effects on soil microflora
- Cut nutrient losses to the environment by up to 50 percent



Ronald Clemens delivered a presentation on this theme at the well-attended New AG International Annual conference in Berlin in April. *Fertilizer International* was media partner for this event.

- Increase nutrient use efficiency (NUE) by up to 80 percent
- Provide higher or similar crop yields at the same or reduced fertilizer application rates, respectively
- Reduce the carbon footprint of fertilizers at farm level by up to 10-12 percent.

ICL has developed a new generation of biodegradable coatings for its CRF portfolio (*Fertilizer International* 510, p24). The new coating technology is designed to meet the requirements of the EU fertilising products regulation (2019/1009) and reduce the environmental footprint of CRFs.

Fig. 1: How eqo.x biodegradable coating technology works

Working principle



Once applied in the soil, moisture penetrates the biodegradable coating and reaches the nutrient core.

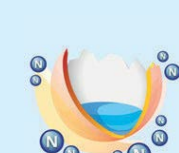
Source: ICL



Nutrient inside starts to dissolve and begins to release back into the root zone by diffusion.



Influenced by soil temperature, nutrient solution is released day-by-day through the biodegradable coating thus reducing nutrient losses to the environment.



The coating shell degrades in soil, into CO₂ and water, offering a sustainable solution for future farming.

Improving NUE and reducing nitrogen losses

There is convincing evidence that CRFs are very effective in reducing nitrogen losses from all pathways. For example, a recent paper in *Nature Food* concluded that CRFs avoided nitrogen losses from three different pathways – runoff/leaching, nitrous oxide emissions and ammonia volatilisation – based on a meta-analysis of 21 previous studies¹.

“This relatively recent publication by University of Melbourne researchers is based on a meta-analysis done across the globe comparing standard urea applications with different types of enhanced efficiency fertilizer (EEF), including urease inhibitors, nitrification inhibitors and controlled-release fertilizers. CRFs were actually the only EEF shown to be very effective at reducing nitrogen losses for all the possible pathways – ammonia volatilisation, leaching or N₂O emissions,” comments Clemens.

ICL has also been commissioning research in Hungary and Germany over the last two years. This is assessing nitrogen losses via ammonia volatilisation and denitrification in both the field and under controlled

conditions. These trials are comparing the performance of conventional urea versus controlled-release urea (eqo.x) and stabilised urea (urease inhibitors).

Carbon footprint reduction at farm level

A complete life cycle analysis is necessary to fully understand and calculate the carbon footprint of fertilizers, as production footprints alone are only part of the picture and can therefore be misleading. The carbon footprint for the production of coated urea (3.5 kg CO₂ eq/kg N), for example, is higher than that of standard commodity urea (3 kg CO₂ eq/kg N), although slightly lower than that of calcium ammonium nitrate (3.6 kg CO₂ eq/kg N).

However, the higher NUE of CRFs, plus their lower nitrogen losses, pro-

vides scope for creating a lower overall carbon footprint for fertilizer inputs, when this is measured over the whole life cycle. This is achieved by delivering the same crop yields at reduced nutrient input levels and correspondingly lower fertilizer application rates.

Indeed, ICL believes that by substituting CRFs for standard commodity urea it should be possible to reduce the on-farm use of nitrogen fertilizers by around 25 percent. By reducing the contribution at farm-level (from 6.9 to 5.2 CO₂ eq/kg N), CRFs can cut the overall life cycle carbon footprint of urea use from 10 CO₂ eq/kg N to 8.8 CO₂ eq/kg N (Figure 2).

“This is where enhanced efficiency fertilizers like CRFs can really deliver an improvement. For instance, by making it possible to reduce inputs by 20-30 percent – or keep inputs the same and increase crop yields – reductions in the carbon footprint of 10-15 percent are possible over the total life cycle,” comments Clemens.

Microbes and soil health

The effects of fertilizers on soil health are generally portrayed as negative. But is this perception warranted?

“Can controlled-release fertilizers actually have positive effects on soil health? In general, when we speak about mineral fertilizers, people have a negative view on what it does to microbial life and soil health. But is that always the case?,” asks Clemens

For example, in 2023, Shangdong Agricultural University, China, published the findings² of a long-term study on the effect of CRFs on plant-growth promoting micro-organisms (PGPMs). In this 12-year study, wheat-maize rotation lysimeter experiments were carried out over 24 seasons between 2009-2021. These investigated the effects of CRFs on the function and composition of soil microbial communities. Products used included polymer coated urea (PCU), sulphur coated urea (SCU) and, by a combining the two coatings, polymer sulphur coated urea (PSCU). The Chinese researchers concluded that:

1. The use of CRFs increased soil organic matter (SOM) content by 3.1-5.0 percent compared to conventional urea.
2. SCU and PSCU, versus PCU, were better at stimulating the growth of PGPMs while inhibiting the growth of nitro and

“There are real opportunities for developing combinations of controlled-release fertilizers and certain biostimulants, based on micro-organisms, to improve fertilization efficiency.”

“First, controlled-release fertilizers are seen as enhanced efficiency fertilizers with the ability to reduce nitrogen losses – and we have some new results to share on this. Second, how do you look at the carbon footprint of controlled-release fertilizers, not just from a production perspective but actually over the whole life cycle of their use? Last but not least – and this is a relatively new topic – how can CRFs also support healthy soils? As a company, this is a question ICL often gets asked by its customers and recently there is clear proof that CRFs can indeed contribute to soil health,” comments Clemens.

What's in issue 522

HIGHLIGHT 1

GPCA Agri-Nutrients Conference, Riyadh

HIGHLIGHT 2

Green fertilizers enter the fray

HIGHLIGHT 3

Medium-term market outlook

HIGHLIGHT 4

Automated process analysis

FERTILIZER INTERNATIONAL
ISSUE 522
SEPTEMBER/OCTOBER 2024

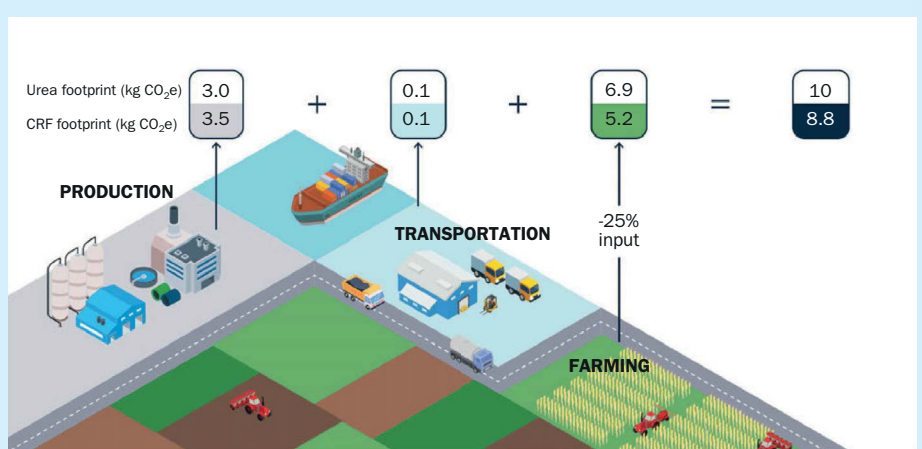
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Fig. 2: The life cycle carbon footprint of nitrogen fertilizers can be reduced from 10 CO₂eq/kg N to 8.8 CO₂eq/kg N by substituting controlled-release fertilizers (CRFs) for standard commodity urea. They can achieve this by reducing on-farm nitrogen applications – lowering inputs by 25 percent – while still delivering the same crop yields.



Source: ICL

Note: these results and the underlying data have not yet been critically assessed and validated by ISO 14040-14044.

denitrifying bacteria and plant pathogens. This promoted better wheat yields, reduced nitrogen losses and helped prevent plant disease.

3. SCU and PSCU, by significantly increasing SOM and therefore providing more substrate for the growth of PGPMS, increased wheat yield.

"The important conclusions were, first of all, that controlled-release fertilizers were able to increase soil organic matter. The sulphur coated urea (SCU) and polymer sulphur coated urea (PSCU) clearly had benefits in stimulating plant growth and promoting micro-organisms, while, on the other hand, inhibiting the growth of nitro and denitrifying bacteria and also reducing plant pathogens," comments Clemens.

CRFs have also been shown to have positive effects on the biological control of bacterial plant diseases, as confirmed by recent research at Wageningen University in the Netherlands. CRFs tested on flowering plants (Pelargonium) showed a positive effect on the microbiome – with an increase in bacterial antagonisms and a decrease in plant pathogens. The researchers concluded that:

- An abundant direct nitrogen supply can raise plant sensitivity to bacterial diseases
- The type and dose of mineral fertilizer

can have an effect on the microbiome of the fylosphere

- Applying CRFs in combination with the micro-organism *Bacillus amyloliquefaciens* had a positive effect on plants.

"This recent study on ornamental plants in the Netherlands, which ICL contributed to, showed that controlled-release fertilizers have a positive effect on the biological control of certain bacterial plant diseases. The main conclusion was that abundant direct nitrogen supply resulted in a higher sensitivity of plants to disease – and that the type fertilizers and their applied dose really has an effect on the success of flower growing," commented Clemens.

"With controlled release fertilizers, nitrogen is applied day-by-day in small quantities. CRFs had positive effects on flowering plants, by lowering sensitivity to bacterial diseases, for example, and when used in combination with plant-applied micro-organisms," he added.

In summary, ICL believes CRFs can have a positive effect on soil microbiota in the following ways:

- Higher NUE can result in higher yields, more crop residues and increased soil organic matter
- Controlled release of nitrogen, versus high nitrogen availability, can positively influence the microbiome

- Coating sources like sulphur can have a positive effect on PGPMS and depress denitrifying bacteria and plant pathogens
- This raises the option of developing hybrid coated/biostimulant fertilizer products that combine CRFs and beneficial micro-organisms.

"Coatings based on sulphur, for instance, can certainly have a positive effect by depressing plant pathogens. I think there are also real opportunities for developing combinations of controlled-release fertilizers and certain biostimulants based on micro-organisms to improve fertilization efficiency," concludes Clemens. ■

Acknowledgement

This article and conversation is based on a presentation *How can controlled-release fertilizers support sustainable farming?* delivered by Ronald Clemens at Inforna's New AG International Annual conference, Berlin, 9-11 April 2024.

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1. Lam, S., et al., 2022. Next-generation enhanced-efficiency fertilizers for sustained food security. *Nature Food*, 3, 575-580.
2. Feng, G., et al., 2023. The effect of long-term controlled-release urea application on the relative abundances of plant growth-promoting microorganisms. *European Journal of Agronomy*, 151, 126971.

Green fertilizers enter the market

The last year has seen the first shipments of low-carbon 'green' fertilizers from companies such as Yara, Fertiberia, OCI and Sabc Agri-Nutrients. Partnerships with food manufacturers and retailers are helping to grow this emerging market and drive demand.

The rush to decarbonise?

2024 looks like becoming a turning point for agricultural decarbonisation. It's been a year in which low-carbon 'green' fertilizers have finally started to enter the market – thanks to the inaugural production from the first wave of green and blue ammonia projects – with strong partnerships being forged between the world's leading fertilizer producers and global food and drink companies.

Collaborations between the food sector and new fertilizer market entrants such as Atlas Agro, FertiHy and CCm have also been on the rise¹.

"From baguettes to beer, the world's leading food and drink makers are rushing to reduce their carbon footprint by tackling one of the hidden culprits of emissions in their value chain: fertilisers," the *Financial Times (FT)* reported late last year¹, adding: "Ahead of disclosure rules for greenhouse emissions, companies including PepsiCo, Heineken and Nestlé have turned to green fertiliser[s] ... to help tackle emission levels."

Fertilizers account for around 35-40 percent and 15 percent, respectively, of the carbon footprint of bread and beer. This is something that food and drink manufacturers – and retailers – will therefore need to reduce if they are to meet their public pledges on carbon reduction.

"We're the world's biggest food and beverage company and so if we're not taking a leading position on this then what hope do the rest have?," Matt Ryan, Nestlé's head of regenerative agriculture in the UK, told *FT*.

A major impetus behind the emerging shift to low-carbon fertilizers, according to *FT*, has been a change to company report-



Yara, PepsiCo and a farmer in a potato field in the UK, one of the five countries involved in the long-term partnership between the two companies.

ing rules. Since the start of this year, EU incorporated companies are now obliged to report the carbon footprint of their entire supply chain – so-called 'scope 3' emissions. The US is also working on similar disclosure rules, *FT* said¹.

New regulations on scope 3 emissions are, however, unlikely to overcome the current price barrier – around \$200/t – between conventional commodity fertiliz-

ers and their emerging low-carbon alternatives. Consequently, low-carbon fertilizers are viewed as an expensive 'demonstration market' currently¹.

While the prices of 'green' fertilizers are likely to fall as production volumes increase, leading fertilizer producers see food sector partnerships as a vital necessity in creating the market demand to make this happen.

CONTENTS

What's in issue 522

HIGHLIGHT 1

GPCA Agri-Nutrients Conference, Riyadh

HIGHLIGHT 2

Green fertilizers enter the fray

HIGHLIGHT 3

Medium-term market outlook

HIGHLIGHT 4

Automated process analysis

FERTILIZER INTERNATIONAL
ISSUE 522
SEPTEMBER/OCTOBER 2024



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YARA INTERNATIONAL

Joining with PepsiCo and others on decarbonisation

Norway's Yara International has been at the vanguard, both when it comes to forging food sector partnerships and as an early producer of low-carbon fertilizers. This is something that Birgitte Holter, the company's VP for Green and Low Carbon Fertilizer Solutions, was passionate about when *Fertilizer International* spoke to her recently (see accompanying interview on p31).

The new long-term partnership announced between Yara and PepsiCo Europe in July this year is the latest proof of that. It follows a similar collaboration with **Simpsons Malt Ltd** in the UK, unveiled in June, which will see fossil-free fertilizers used to grow malting barley and distilling wheat.

Yara has also brokered a range of other pioneering carbon reduction partnerships across the food and drink sector dating back to 2022. These notably include commercial agreements to supply low-carbon fertilizers to:

- **Reitan Retail, NorgesSmøllene, Felleskjøpet Agri**, a complete food value chain, to produce a bread with a lower carbon footprint made from Norwegian oats.
- The flour milling company **Bindewald & Gutting Milling Group** and bakers **Harry-Brot**, two of Germany's leading food industry players, to reduce the carbon footprint of cereal production.
- **El Parque Papas**, Argentina's largest potato grower.
- **Lantmännen**, a leading northern European agricultural cooperative, to reduce the climate impacts of cereal growing.

In its latest food industry agreement, Yara will supply PepsiCo with 165,000 tonnes of fertilizer annually until 2030, covering around 25 percent of the company's European crop needs. These fertilizers will be mostly supplied from Yara's new Climate Choice portfolio. These include low-carbon fertilizers produced from two different sources: either 'green' ammonia generated at Yara's recently commissioned Herøya plant in Norway; or 'blue' ammonia generated from an under-construction carbon capture and storage (CCS) project at Yara's Sluiskil production complex in the Netherlands.

Initially, the mix of fertilizers supplied to PepsiCo will also include standard nitrate fertilizers produced from natural gas feedstocks. These already have a 50 percent lower carbon footprint compared to most non-EU nitrate fertilizers, according to Yara, thanks to the use of advanced catalytic technology.

The two partners do, however, plan to steadily shift to low-carbon fertilizers over time, as their production scales up and technologies mature, so that all of the 165,000 t/a supplied to PepsiCo will be Yara Climate Choice fertilizers by 2030.

The partnership, which spans multiple European countries, will equip participating PepsiCo farmers with best-in-class fertilizer products and crop nutrition advice, says Yara, as well as precision farming tools. The overall aim is to increase nutrient use efficiency (NUE), boost crop yields and reduce the carbon footprint of crops.

As well as sharing a desire to create a more sustainable food system, both companies say they are committed to supporting farmers facing the transition costs of decarbonisation, this being necessary to ensure that agricultural livelihoods are not adversely affected.

The Yara-PepsiCo partnership will include approximately 1,000 farms and cover a total farmed area of around 128,000 hectares across the European Union and the UK. Efforts will initially focus on potatoes, a key crop for PepsiCo, and then expand to other crops such as oats and corn. Greater adoption of regenerative agricultural practices will also be targeted as part of the new collaboration.

"This partnership with Yara aligns with our end-to-end transformation known as PepsiCo Positive (pep+) and will be critical as we transition towards the net-zero food system of the future. Targeting Scope 3 emissions is central to our pep+ agenda,

but it can be one of the most challenging areas to directly influence. Providing our farmers with fertilizers that have a lower carbon footprint and supporting them to improve crop nutrition end-to-end will allow us to make a significant step towards our target of achieving net zero by 2040," said Archana Jagannathan, Chief Sustainability Officer at PepsiCo Europe.

"To grow a nature-positive food future and transform our food system, we need to collaborate across the food value chain. We're excited to work with first

From baguettes to beer, the world's leading food and drink makers are rushing to reduce their carbon footprint by tackling fertilizers, one of the hidden culprits of emissions in their value chain, reports the Financial Times, driven by a change in company reporting rules

movers like PepsiCo to help make this a reality. Decarbonizing food production will be critical to delivering on the Paris Agreement – and farmers will play a key role in helping us get there," said Mónica Andrés Enríquez, Executive Vice President for Europe at Yara.

Yara's initial low-carbon fertilizer deliveries will be derived from green ammonia. This will be manufactured from green hydrogen generated via water electrolysis using renewable electricity at the company's newly-commissioned plant at Herøya Industrial Park, Porsgrunn, Norway (see box). By eliminating the use of natural gas feedstocks and the steam methane reforming (SMR) process, these fossil-free fertilizers have the potential to significantly reduce the carbon footprint of food and farming.

Porsgrunn will initially produce around 20,000 tonnes of green ammonia annually. This volume will then be converted into 60,000-80,000 tonnes of low-carbon nitrate-based fertilizer. These will have an 80-90 percent lower carbon footprint compared to conventionally manufactured nitrate fertilizer. Yara is using an independent assessor, DNV, to validate any carbon savings using an established and reliable product carbon footprint (PCF) method.

PHOTO: YARA



YARA OPENS HERØYA RENEWABLE HYDROGEN PLANT

Electrolyser stacks at the green hydrogen plant.

In a major milestone, Yara officially opened its renewable hydrogen plant at Herøya Industrial Park, Porsgrunn, Norway, in June.

The company has already delivered the first tonnes of fertilizers made from the renewable hydrogen and ammonia produced at the site. These have been supplied to Swedish agricultural cooperative Lantmännen (see main article).

"This is a major milestone for Yara and for the decarbonization of the food value chain, shipping fuel and other energy intensive industries," said Svein Tore Holsether, Yara's president and CEO.

The 24MW renewable hydrogen plant at Herøya, the largest currently operating in Europe, was officially inaugurated on 10th June by the Norwegian Prime Minister Jonas Gahr Støre. The hydrogen generated by the plant – via water electrolysis using renewable energy – replaces natural gas feedstocks and will cut annual CO₂ emissions at the Porsgrunn site by 41,000 tonnes.

The electrolysis plant is manufactured by ITM Power and uses proton exchange membrane (PEM) technology. It has a nameplate capacity of around 10,000 kg/d for green hydrogen. This is enough to produce 20,500 t/a of green ammonia, which can be then converted to 60,000-80,000 t/a of low-carbon fertilizer.

Yara agreed a contract with Linde Engineering for the construction and delivery of the 24MW green hydrogen plant in January 2022. This project was partly financed by a NOK 283 million (\$26.5 million) grant from Enova, part of Norway's climate and environment ministry.

"We are very pleased to have delivered the first tonnes of low-carbon footprint fertilizers to Lantmännen, a partnership which serves as a concrete example of how collaboration

across the entire food value chain is required to decarbonize. Together, we have made this important step towards decarbonizing hard to abate sectors," said Holsether.

The low-carbon fertilizers produced using green hydrogen and ammonia will form part of a new portfolio called Yara Climate Choice. These products will benefit crops, says Yara, while at the same time contributing to the decarbonisation of the food system and reducing its climate impacts.

Low-carbon fertilizers produced from 'blue' ammonia – using carbon capture and storage (CCS) – will also form part of Yara's portfolio in future, the company confirmed.

"Renewable ammonia is an important part of the decarbonization puzzle – however, developing it at scale takes time. As the world is rapidly approaching 2030, we are also working to produce low-carbon ammonia with CCS to enable the hydrogen economy and develop the emerging markets for low-emission ammonia," says Hans Olav Raen, CEO of Yara Clean Ammonia.

In 2023, Yara signed a binding carbon dioxide transport and storage agreement with the Norwegian Northern Lights project as part of efforts to reduce the CO₂ emissions from its Sluiskil ammonia production plant in the Netherlands by 800,000 tonnes. Yara says it is also evaluating world-scale CCS projects for blue ammonia in the US.

"The companies who take this seriously will have a competitive advantage. At Yara, we have already reduced our emissions by 45 percent since 2005, and with our strategy to profitably deliver decarbonized solutions quickly and at scale, produced with both renewable energy and CCS, we are uniquely positioned to deliver, both to shareholders, customers, employees and society at large," said Holsether. ■

CONTENTS

What's in issue 522

HIGHLIGHT 1

GPCA Agri-Nutrients Conference, Riyadh

HIGHLIGHT 2

Green fertilizers enter the fray

HIGHLIGHT 3

Medium-term market outlook

HIGHLIGHT 4

Automated process analysis



Hans Larsson, Yara Sweden's commercial director, and Torbjörn Wahlström, market manager for arable inputs at Lantmännen, shake hands on the new fossil-free fertilizer deal.

Food sector partnerships hold the key

Yara signed what is says was the first commercial contract to sell fossil-free fertilizers with Sweden's **Lantmännen**, a leading northern European agricultural cooperative, in January 2022 (*Fertilizer International* 506, p8). This was the culmination of a dialogue between the two companies dating back to 2019. This first-of-its-kind commercial contract was viewed as a first step in help decarbonising the food chain, while also offering consumers more sustainable food choices.

Lantmännen – through its *Farming of the Future* programme – has already reduced the climate footprint of wheat cultivation by as much as 30 percent since 2015. Now, by including low-carbon fertilizers within this programme, the partners are aiming to reduce climate impacts of cereal growing by a further 20 percentage points.

Yara also signed a memorandum of understanding to supply low-carbon fertilizers to **El Parque Papas**, Argentina's largest potato grower, in December 2022 (*Fertilizer International* 512, p8). The new agreement marked a first step towards the decarbonisation of potato production in Argentina.

Yara calculates that the use of its low-carbon fertilizers for potato crop nutrition will cut greenhouse gas (GHG) emissions at farm level by around 29 percent, versus standard fertilization practice. These fertilizers will also reduce the overall carbon footprint of



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FERTILIZER INTERNATIONAL
ISSUE 522
SEPTEMBER/OCTOBER 2024

consumer snacks such as potato chips (crisps) by around 5-10 percent.

“Most people probably don’t think about emissions when eating their chips. But there are huge opportunities to decarbonize snacks, if we find business models that enable each step of the value chain to contribute and to benefit. This is why the agreement between Yara and El Parque papas is important – we show that this can be done,” said Svein Tore Holsether, Yara’s president and CEO.

El Parque Papas is Argentina’s single biggest potato farmer. The company supplies around 14,000 tonnes of potatoes to Argentinian food processors every year. These are used to produce some of the country’s most popular potato chips.

“My mission is to introduce a completely green, emission free potato in 2024. To do that, every company in the supply chain must take climate action. Collaboration is the only way to ensure that the end-product is climate neutral. A farmer can only do so much. Yara helps us make the last piece of the puzzle emissions free – the fertilizer itself,” said Walter Hernández, the CEO of El Parque Papas.

In August last year, Yara signed an agreement with two of Germany’s leading food industry players, the flour milling company **Bindewald & Gutting Milling Group** and bakers **Harry-Brot**, to supply their cereal growers with low-carbon fertilizers (*Fertilizer International* 516, p10).

The nitrate-based fertilizers, made at Yara’s Rostock production complex in Germany, will have an 80-90 percent lower carbon footprint, being produced using Norwegian green ammonia. This, in turn, will be manufactured from green hydrogen generated by the company’s newly-commissioned Herøya plant.

The low-carbon fertilizers will be supplied to Bindewald & Gutting’s contract farmers and used to grow around 1,600 hectares of cereals in Germany from the 2023/24 growing season. Their use will reduce the CO₂ footprint of cereals by up to 30 percent, according to Yara. The project partners plan to drive down cereal emissions even further by combining low-carbon fertilizers with precision farming and site-specific fertilization.

“The avoidance and reduction of greenhouse gas emissions ... is at the core of our sustainability strategy. We are still dependent on agriculture and our suppliers when it comes to Scope 3 emissions. If we succeed, starting with fertilization, we can reduce emissions precisely where a large proportion of our supply chain emissions has always occurred,” said Norbert Löt, Harry-Brot’s managing director for production and technology.

The low-carbon fertilizers supplied to Bindewald & Gutting’s contract farmers in Germany will reduce the CO₂ footprint of cereals by up to 30 percent, according to Yara

Nearly three-quarters of German consumers would like to see the CO₂ footprint of products displayed on packaging, according to an IPSOS study commissioned by Yara. More than half of German consumers are also willing to pay extra for food with a smaller carbon footprint, the survey suggested.

This year, Yara further cemented its position as a leading decarbonisation partner for the European food industry with low-carbon fertilizer supply agreements for bread made from Norwegian oats (**Reitan Retail, Norgesmøllene, Felleskjøpet Agri**) and for malting barley and distilling wheat production in the UK (**Simpsons Malt Limited**). The latter collaboration involves a third partner **Varda** and combines the adoption of low-carbon fertilizers with precision farming methods.

The shift to more sustainable food appears to have strong consumer backing. Up to 65 percent of Norwegians said that food producers should work to reduce emissions, in a survey conducted by IPSOS on behalf of Yara, with 73 percent saying that farmers should be given incentives to implement more sustainable farming practices. Over half of Norwegians surveyed also wanted clear carbon footprint labelling on the food they buy.

Production scale-up

Yara should be well-positioned to scale-up low-carbon ammonia manufacture in future from an international portfolio of projects at existing production centres, notably Porsgrunn in Norway (see box), Sluiskil in the Netherlands, and Pilbara in Australia, as well as the United States. The company is planning to convert its entire Norwegian Porsgrunn complex to green

ammonia within the next 5-7 years and is also actively expanding its clean ammonia business internationally.

Yara approved the Yuri project to partly convert its Pilbara plant near Karratha in Western Australia to green ammonia production two years ago. The company gave the green light for Yuri in a final investment decision in September 2022 (*Fertilizer International* 511, p8). This provides the necessary go ahead for the construction of a green hydrogen plant at the Pilbara production complex.

Yuri is joint project between French utility ENGIE and wholly-owned Yara subsidiary Yara Clean Ammonia. The two partners are currently developing a new renewable hydrogen plant at the Pilbara site adjacent to Yara’s world-scale anhydrous ammonia production plant. A consortium of Technip Energies and Monford Group has been awarded the engineering, procurement, construction and commissioning (EPC) contract for the project.

Yuri includes a 10MW electrolyser, 18MW of solar photovoltaic capacity and battery storage. Once completed, the project will be one of Australia’s largest electrolysers with a green hydrogen production capacity of 640 tonnes per annum.

Construction was due to start in October 2022, with project completion and start-up scheduled for 2024. The federal Australian Government has backed the project with an AUD 47.5 million grant. The Western Australian government has also supported Yuri with AUD 2 million from its renewable hydrogen fund.

Yara has also secured a long-term supply agreement for green ammonia produced in Oman. The company signed a binding offtake agreement with Acme Cleantech subsidiary GHC SAOC in March this year (*Fertilizer International* 519, p8). This covers the supply of 100 000 t/a of green ammonia.

The ammonia will be supplied by Acme from the first phase of its green hydrogen and ammonia project in Duqm, Oman. The project, which successfully raised \$488 million in funding last July, is expected to start-up production in 2027. Acme plans to develop the project in phases to reach an ultimate green ammonia capacity of 900,000 t/a.

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YARA INTERNATIONAL

Interview with Birgitte Holter, VP, Green and Low Carbon Fertilizer Solutions, Yara International

The opening of the renewable hydrogen plant at Herøya Industrial Park, Porsgrunn, Norway, is a real landmark achievement for Yara. How significant is this moment for the company, Norway, the future of crop nutrients and the decarbonisation of food production?

Yes, the official opening [of the Herøya plant] is, of course, significant for Yara – with our Prime Minister present and for us to do the grand opening together with partners, suppliers and customers. We did already deliver [lower carbon footprint fertilizers] to Lantmännen, the company that we signed the world’s first commercial contract with in 2022, earlier in the commissioning stage.

This commercial pilot will deliver emission reductions of 41,000 tonnes of CO₂ [annually]. We also feel that it’s important now to prove – for ourselves, for the food industry and for the society – that it’s actually possible to produce renewable-based fertilizers. These will be one of the lower carbon footprint fertilizer options in our new ‘Climate Choice’ portfolio.

So, this is the first step. One of the first major industrial emissions reduction

programmes Norway has set in motion and Porsgrunn is a big plant that we plan to continue to decarbonise.

It’s also an important step for the food industry – because food production, which we all need, represents 25 to 30 percent of the world’s CO₂ emissions. It’s therefore important to prove that fertilizer producers can be a partner in reducing the climate effects of food. This, for us, is the key message to the food industry: we can help them meet their target to reduce the climate impacts of food.

Hopefully it’s also a good step for the planet, that we and other companies in the fertilizer and food industry need to take to make a tangible, positive impact.

Hans Olav Raen, the CEO of Yara Clean Ammonia, has confirmed that lower carbon footprint fertilizers produced from ‘blue ammonia’ – using carbon capture and storage (CCS) – will also form part of Yara’s portfolio in future. Why is this dual approach, one that embraces both green and blue ammonia, important for delivering decarbonisation?



Norwegian Prime Minister Jonas Gahr Støre (left) and Yara CEO Svein Tore Holsether (right) at the opening of Yara’s renewable hydrogen plant at Herøya Industrial Park, Porsgrunn, Norway.

CONTENTS

What’s in issue 522

HIGHLIGHT 1

GPCA Agri-Nutrients Conference, Riyadh

HIGHLIGHT 2

Green fertilizers enter the fray

HIGHLIGHT 3

Medium-term market outlook

HIGHLIGHT 4

Automated process analysis

FERTILIZER INTERNATIONAL
ISSUE 522
SEPTEMBER/OCTOBER 2024



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The 24MW renewable hydrogen plant at Herøya Industrial Park in Porsgrunn, Norway, is the largest of its kind currently operating in Europe.



Left to right: Svein Tore Holsether, Yara's CEO, Ole Robert Reitan, Reitan Retail's CEO, Mehmet Teknöz, local Reitan store manager, Sverre Ivar Fure, Felleskjøpet's CEO, and Jan-Eirik Eikeland, Norgsmøllene's CEO, meet up at the bread section in a Reitan store in Oslo.

Yara is launching a new lower carbon footprint fertilizer portfolio called Yara Climate Choice. What type of products will feature, will these have a price premium attached to them and how will they be marketed?

Building up this portfolio is a step-by-step process and, with this speed of development, it naturally has higher production costs in the beginning. However, we also know that, especially in Europe, the cost of not having lower carbon footprint fertilizers will increase in future.

We therefore think in the long term that lower carbon fertilizers will become [cost] competitive in the future.

On the one hand, we will see the cost of Climate Choice [renewable- and CCS based] fertilizers come down as we scale-up and as the technology develops. While, on the other hand, the costs of not decarbonising will go up due to carbon taxes.

The food industry is aware of this so we shouldn't conclude that food is going to get much more expensive. We need to target those food items where reducing carbon emissions from fertilizer production has the biggest impact on the food item itself and therefore also has the lowest cost impact. A Boston Consulting Group study, for example, estimates that the cost increase for [decarbonising] food items will be around one to four percent.

Together with the food industry, we need to develop the best strategy. All of us know two things: firstly, farmers cannot pay [extra fertilizer costs] without this being rewarded one way or the other; and,

secondly, we must be careful not raise the cost of food where it's inappropriate and shouldn't be happening.

We also need to make lower carbon footprint fertilizers attractive so farmers can contribute and be part of this [transition]. That is why we are looking for [food sector] customers that share this vision and have the ability and willingness to make this work. This is how we will go to market.

Your CEO Svein Tore Holsether has said that collaboration across the entire food value chain is the key to decarbonising the food system. Why is collaboration important and a joined-up approach so essential to food decarbonisation goals?

It's important to find crops and food value chains where lower carbon footprint fertilizers really make a difference – such as potatoes, for instance, and wheat for bread. We're also working with the food retailer Reitan Retail and three partner companies in Norway on bread made from lower carbon oats. We have the whole food chain involved, from one end to the other, so that it works for everybody – for the farmer, their distributor, the miller, the bakery and the retailer.

Also, our partners aren't all consumer-facing companies. There are other actors in the food sector driving this as well. Simpsons Malt in the UK and Bindewald & Gutting Milling Group in Germany, for example, are both business-to-business companies that also have carbon pledges – mostly through the Science Based Targets

initiative – and share the same desire to reduce the carbon footprint of food.

These B2B companies are willing to act as the integrator that sets the rules and builds the template for the whole food chain. To me, that shows that all food sector actors are potentially interested in setting up low-carbon value chains.

Yara, out of choice, has placed itself at vanguard of the fertilizer industry when it comes to decarbonising profitably, quickly and at scale. Can you explain more about this strategy and its competitive advantages?

Our competitive advantage is – because it's an industrial process – that we can audit, measure and document what we're doing with our low-carbon Climate Choice fertilizers. We're then able to hand over documents from our external auditors, DNV, for customers to use in their sustainability reports.

That information is very simple to use. So customers can make use of the lower carbon footprint in their business without a lot of effort, whether they're a business-to-business or business-to-consumer company.

Our role is to produce mineral fertilizers in ways that have the least negative impact for the planet. It's also worth noting here that we have already reduced our emissions by 45 percent since 2005. Yara is a large ammonia producer and user. So when we see that other industrial sectors in the world are now looking into [consuming low-carbon] ammonia, that gives us a great opportunity to

be able to scale-up even faster than if demand was only coming from fertilizer. Because we already have the necessary knowledge and infrastructure in place, we can also become part of these other sectors, mainly maritime and energy, and develop the use of [low-carbon] ammonia in these new fields. It's not an either/ or situation.

Taking part in these other emerging markets is extremely important, as it's kind of an extra engine in helping us scale-up on the fertilizer side. It's absolutely a win-win if we can scale-up faster on low-carbon ammonia for fertilizers because of that.

Our strategy on the fertilizer side of the business is to go beyond reducing production emissions by also using our agronomic knowledge to help reduce in-field emissions. Helping farmers to optimise their nitrogen use efficiency with tools like digital agtech, regenerative agriculture and biostimulants, to name a few.

This could in certain cases actually result in less nitrogen fertilizer use overall. We are not afraid of that. These are the steps we need to take towards growing a nature positive food future.



Yara's Birgitte Holter at a meeting with major Argentinian potato grower and potato chip manufacturer El Parque Papas. Yara has an agreement in place to supply the company with lower carbon footprint fertilizers.

FERTIBERIA

Fertiberia targets net zero by 2035

Spain's Fertiberia is another major European producer that is placing low-carbon fertilizers on the market, forging food sector partnerships and pursuing large-scale green and blue ammonia projects.

The company has pledged to reduce its emissions to net zero by 2035. The switch to fertilizer production using renewable energy will be the key to achieving this ambitious goal. Fertiberia has already partly decarbonised its Puertollano production site (see box) and plans to follow this up by decarbonising its other Spanish production plants (Palos de la Frontera, Avilés and Sagunto) in future.

Low-carbon fertilizers for M&S dairy farms

Fertiberia is supplying Marks & Spencer (M&S) with low-carbon fertilizers to help the British supermarket reduce the carbon footprint of its 27 dairy farms.

The company will supply M&S farms with Impact Zero fertilizers, a new emissions-free product range manufactured in Spain. The supermarket's UK distributor, Bartholomews Agri Food, signed an exclusive supply agreement with Fertiberia for these innovative fertilizers in July last year (*Fertilizer International* 516, p8).

M&S dairy farms will be the first to adopt Impact Zero products from spring 2024 onwards. These will be made from green ammonia at Fertiberia's Puertollano production site. This is manufactured using green hydrogen generated on-site by a solar-powered plant, previously the largest of its type in Europe (see box).

Fertiberia, by substituting green hydrogen for natural gas, has managed to drastically reduce the production emissions of its Impact Zero product range. These have been cut by as much as three tonnes of CO₂ for every tonne of ammonia generated, according to the company.

The UK dairy farms will apply a fertilizer called Tech Nergetic. This should improve nitrogen use efficiency by 22 percent, compared to a standard fertilizer, helping to reduce the amount of nitrogen applied to the land. Its properties will also cut the amount of nitrogen lost to leaching.

Cutting ag emissions with PepsiCo

PepsiCo and Fertiberia are collaborating on new ways to reduce the carbon emissions of potato growing as part of a joint pilot programme launched in June last year (*Fertilizer International* 516, p9). This will combine the use of Fertiberia's low-carbon Impact Zero fertilizers with precision agriculture.

The pilot programme is being carried out by the Garlan cooperative, PepsiCo's potato supplier for the last 30 years, in Spain's Álava, La Rioja and Burgos provinces. Growers in these regions will trial

CONTENTS

What's in issue 522

HIGHLIGHT 1

GPCA Agri-Nutrients Conference, Riyadh

HIGHLIGHT 2

Green fertilizers enter the fray

HIGHLIGHT 3

Medium-term market outlook

HIGHLIGHT 4

Automated process analysis

FERTILIZER INTERNATIONAL
ISSUE 522
SEPTEMBER/OCTOBER 2024



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Fertiberia's new Impact Zero fertilizers. Their use is expected to reduce the emissions from potato cultivation by about 15 percent, according to Fertiberia.

Potatoes will be sown on 400 hectares of land initially. The trial will then be scaled-up over the next two years and is expected to reach 1,500 hectares by 2025. PepsiCo also plans to increase its use of regenerative agriculture in Spain to 77,000 hectares by 2030.

"We are very proud to announce this green fertiliser pilot programme together with Fertiberia to reduce the emissions associated with fertilisers and, consequently, emissions from agriculture which account for a high percentage of our total emissions," said Ángel Alonso, PepsiCo's agricultural director for Southwest Europe.

Green and blue ammonia projects

Fertiberia has joined forces with Nordion Energi and Lantmännen to develop Sweden's first fossil-free fertiliser production plant. The three partners have formed the joint venture Power2Earth to deliver the €2 billion project – said to be the largest of its kind in the Nordic region – with production scheduled to start in 2028 (*Fertilizer International* 519, p8).

The project will be located in Luleå, Sweden, and produce one million tonnes of low-carbon fertilizers per annum.

The partners have secured land for the production plant and completed several feasibility studies since the project began in 2021. An environmental permit for the project was due to be submitted in the second quarter of this year.

The Luleå plant will be based on the generation of green hydrogen via water electrolysis and renewable energy. It builds on technology previously developed by Fertiberia in Spain.

Green fertilizer production at the plant has the potential to reduce carbon dioxide emissions by around 1.6 million tonnes, according to Power2Earth, this corresponding to roughly 25 percent of Sweden's agricultural emissions.

Fertiberia joins Europe's biggest blue ammonia project

In April last year, Fertiberia also joined Barents Blue, the largest blue ammonia project in Europe, as an equal partner with its developer Horisont Energi (*Fertilizer International* 513, p9)



FERTIBERIA PIONEERS EUROPE'S GREEN AMMONIA MARKET

Puertollano green hydrogen plant, Spain

PHOTO: IBERDROLA

Fertiberia's Puertollano green hydrogen plant was officially inaugurated by Spain's King Felipe VI in May 2023. The 20MW capacity unit will produce up to 3,000 tonnes of renewable hydrogen annually.

Industrial scale-green ammonia manufacture

The new plant incorporates one of the world's largest water electrolysis systems and is powered using renewable electricity from an integrated 100MW photovoltaic solar array. The plant, previously the largest of its type in Europe, will supply the company's nearby fertilizer complex, enabling Fertiberia to produce green ammonia at Puertollano, using green hydrogen instead of natural gas.

This major project was successfully developed in partnership with the Spanish electrical utility Iberdrola. It forms the centrepiece of Fertiberia's net zero strategy and the company's ambitions to become carbon-neutral by 2035. With Puertollano's inauguration, Fertiberia became the world's first major crop nutrient company to begin carbon-free ammonia and fertilizer production on an industrial scale.

The new stake in Barents Blue advances Fertiberia's plans to become net zero by 2035. Barents Blue, located in Finnmark in the far north of Norway, is planning to become Europe's largest clean ammonia production plant. It will produce one million tonnes of blue ammonia per annum, if and when it comes online.

State-controlled Norwegian oil & gas company Equinor and Norwegian independent oil & gas operator Var Energi both exited the Barents Blue project at the end of January 2023 – immediately prior to Fertiberia coming onboard as a partner – after their co-operation agreements with Horisont expired.

Javier Goñi, Fertiberia's CEO, said the company's investment in Puertollano marked the first step towards pioneering the green ammonia market in Europe. "The milestone ... makes us the first company in the world to manufacture green ammonia and CO₂-free crop nutrition solutions on an industrial scale. The project is unique in the sector due to its sheer size," he said.

thyssenkrupp Uhde to decarbonise Puertollano

Fertiberia has also commissioned thyssenkrupp Uhde to modify and reduce the carbon footprint of its conventional ammonia plant at Puertollano. A revamp project will partially convert production at the existing Puertollano plant from grey to green ammonia by injecting green hydrogen to partly replace the natural gas currently consumed (*Fertilizer International* 520, p10).

The green hydrogen required will come from a new 50MW water electrolysis unit running on renewable energy. Its injection to replace natural gas should reduce the ammonia plant's CO₂ emissions by up to 40 percent. ■

Barents Blue plans to produce blue ammonia derived from North Sea gas reserves at a site near Hammerfest, the world's most northerly town. The carbon generated from the ammonia production process (steam methane reforming) will be captured, transported and stored in an underground North Sea geological reservoir – as part of an associated venture known as the Polaris carbon capture and storage (CCS) project.

Barents Blue is backed by a NOK 482 million (\$48.5 million) EU grant, secured under the important projects of common European interest (IPCEI) scheme. Horisont said this funding is unaffected by the changes to the consortium. ■

OTHER ENTRANTS CROWD THE FIELD

OCI supplies COMPO EXPERT with blue ammonia

In April, Netherlands-headquartered OCI Global made its first delivery of blue ammonia to COMPO EXPERT for use in NPK production in Germany (*Fertilizer International* 520, p11).

OCI, a leading nitrogen, methanol, and hydrogen producer, has been supplying COMPO EXPERT, a German producer of high-quality specialty fertilizers and biostimulants, with ammonia for more than a decade.

Under a new supply agreement, COMPO EXPERT will initially replace 25 percent of the 'grey' ammonia it uses at its Krefeld production plant in Germany this year with lower carbon 'blue' ammonia. The company then plans to raise the percentage of OCI-supplied blue ammonia used at Krefeld over the next two years.

The blue ammonia is sourced from OCI's ammonia production facilities in Texas in the United States and is imported via the company's ammonia terminal and distribution hub at the Port Of Rotterdam. It is guaranteed to have a carbon footprint 60 percent lower than the industry standard (2.6 kg CO₂e/kg NH₃).

OCI's Texan plant has been certified for lower carbon ammonia production and the carbon footprint calculation used has been verified by third party auditors SCS global.

SABIC Agri-Nutrients ships low-carbon urea to New Zealand

SABIC Agri-Nutrients Company (SABIC AN) made its first ever global shipment of low-carbon urea in July last year. The 2,700-tonne urea consignment was successfully delivered to the Ravenston, the farmer-owned agricultural co-operative, at Timaru, New Zealand.

SABIC AN produced the urea using blue ammonia. The company's low-carbon ammonia production has been independently certified by TÜV Rheinland, a leading independent testing, inspection, and certification agency. This guarantees that a significant part of the CO₂ associated with the manufacturing process has been captured and used downstream.

OCF launches carbon-free fertilizer subsidiary

In April, OCP Group announced the formation of a new subsidiary company, OCP Nutricrops, to manufacture carbon-free, customised fertilizers (*Fertilizer International* 520, p10). The new venture plans to capitalise on the production and distribution capabilities of its parent company. According to OCP, it will offer innovative products that preserve soil health, increase crop yields, combat climate change and help protect the natural environment.

OCP Nutricrops plans to produce and supply completely carbon-free products, as part of a company target to reach carbon neutrality for Scope 3 emissions by 2040.

By manufacturing bespoke nutrient formulations – tailored to crops, climate and soil – OCP is aiming to boost farm productivity and raise farmer incomes by helping growers preserve

and enhance their soils. It will also provide training in precision agriculture and '4Rs' principles to ensure that crops get the right nutrients, at the right rate, in the right place, at the right time, while also minimising costs to the farmer.

The launch of OCP Nutricrops in April coincided with the announcement of a 50:50 joint venture (JV) between OCP and Fortescue Energy to supply green hydrogen, ammonia and fertilizers to Morocco, Europe and international markets. This includes establishing large-scale integrated green ammonia and green fertilizer production capacity in Morocco based on renewable energy and water electrolysis (*Fertilizer International* 520, p10).

The formation of the new JV followed the award of a €100 million (\$106 million) loan to OCP by the International Finance Corporation (IFC) in October 2023. This will finance the construction of two large-scale solar power plants dedicated to green ammonia and low-carbon fertilizer production.

The two solar photovoltaic (PV) plants will have a combined capacity of 400 megawatts (MW) and a storage capacity of up to 100 megawatt-hours. They will be located in the phosphate mining areas of Khouribga and Benguerir.

This is the second green loan secured by OCP from IFC. It follows a similar €100 million IFC loan granted in April 2022. This was earmarked for the construction of four solar plants with a combined capacity of 202MW in the same two mining areas.

In June 2023, OCP announced plans to invest \$7 billion in a green ammonia production plant in Tarfaya in southern Morocco, using hydrogen generated from renewable electricity sources such as solar. This plant could produce 200,000 t/a of green ammonia by 2026, increasing to one million t/a by 2027, and ultimately three million t/a by 2032, Reuters have reported.

The investment in green ammonia is part of an overall \$13 billion strategy by OCP to shift to renewable energy and construct a domestic supply chain for ammonia. The aim is to increase OCP's green fertiliser production and fully convert its production operations to renewable power. The strategy's other goals are to achieve full carbon neutrality within the business by 2040 and reach a water desalination capacity of 560 million m³ in 2026. ■



Mostafa Terrab, OCP Group's chairman and CEO, shakes hands with Dr Andrew Forrest, Fortescue's executive chair and founder, at a joint venture signing ceremony in Marrakesh in April.

CONTENTS

What's in issue 522

HIGHLIGHT 1

GPCA Agri-Nutrients Conference, Riyadh

HIGHLIGHT 2

Green fertilizers enter the fray

HIGHLIGHT 3

Medium-term market outlook

HIGHLIGHT 4

Automated process analysis

FERTILIZER INTERNATIONAL
ISSUE 522
SEPTEMBER/OCTOBER 2024



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Ulexandes – the leading Latin American boron producer

We profile Ulexandes, a fast-expanding supplier of agricultural boron products with production plants in both Bolivia and Peru.

Ulexandes sources its mineral raw material, ulexite, from the Uyuni salt flat (Salar de Uyuni) in Bolivia.

Introduction

Founded 25 years ago, Ulexandes is one of South America's biggest boron suppliers and operates three production plants in Peru and Bolivia (see timeline). These source their mineral raw material, ulexite, from the Uyuni salt flat (Salar de Uyuni) in Bolivia and the Lake Salinas (Laguna Salinas) in Peru (Figure 1).

The company has invested in expanding its annual production capacity to 60,000 tonnes, with production growing at around 12 percent per annum on average – output having increased by 120 percent since 2013.

Product portfolio

Ulexandes offers ulexite products in both granular and powder form as part of its product portfolio. These are all produced using proprietary micronised granulation technology (MGT)

Granular products are suitable, firstly, for direct application to crops where applying granules may offer advantages and,

Fig 1: Ulexandes sources ulexite for its production plants from Uyuni salt flat (Salar de Uyuni) in Bolivia and the Lake Salinas (Laguna Salinas) in Peru



TIMELINE

- 1999** Ulexandes started in Antofagasta, Chile
- 2003** Began operating from Arequipa, Peru
- 2008** Opened a second production plant at El Alto, La Paz, Bolivia
- 2019** Started a production plant in Matarani, Peru
- 2023** New production plant under construction at Oruro, Bolivia
- 2024** Plans to open another production plant in Santa Cruz, Bolivia



Ulexite raw material, Salar de Uyuni, Bolivia.

secondly, for incorporating boron into blended fertilizers. They include:

- **Boron 10G:** 10 percent boron content typical with formula $\text{NaCaB}_5\text{O}_9 \cdot 8\text{H}_2\text{O}$
- **Boron 15G:** 15 percent boron content typical with formula NaCaB_5O_9

The company's powder products are suitable for: direct soil application to correct boron deficiencies in perennial plantation crops; the production of solid compound fertilizers; and the coating of compound or blended fertilizers. They include:

- **Ulex 33:** 10 percent boron content typical with formula $\text{NaCaB}_5\text{O}_9 \cdot 8\text{H}_2\text{O}$
- **Ulex 46:** 15 percent boron content typical with formula NaCaB_5O_9

The following customised ulexite products are also available:

- Ulex 46 FINEST
- Ulex 40 FINE 200
- Ulex 40 FINE 325
- Boron 15 Microgranular
- Boron 15 Forestry
- Granular Copper Sulfate

Mineral extraction at Salar de Uyuni

Salar de Uyuni is the world's largest salt flat, occupying an area of nearly 11,000 square kilometres in the Andes, southwest Bolivia.

The salt deposits at Uyuni are 120 metres deep and are a valuable source of lithium, boron, potassium, magnesium, calcium and sodium. Ulexite ore is extracted from 11 salt layers present at Uyuni with an individual thickness of 1-10 metres.

As a first step, due to the size of the salt flat, geological and technical studies are used to locate the most suitable mining areas for ulexite. After site selection, the mineral raw material is usually extracted at a depth of between 3-6 metres below ground level. Extraction of the ulexite ore is carried out using both heavy machinery and manual labour. This ensures that the raw material selected is largely free from impurities, prior to the on-site refining process.

After extraction, the raw material is refined in a washing and conditioning area to remove the remaining impurities, primarily sulphate and chloride, a process that takes around five days.

After refining is complete, the raw material is dried naturally over a 6-8 day period until its moisture content reaches the required levels for the production process. Chemical and physical quality control tests are used to verify that the raw material is suitable for onward transport by road and rail to the production plant.

Production process

Raw materials are processed to produce granulated and powdered ulexite containing boron at different specified concentrations. On arrival at the plant, laboratory analyses are carried out to correctly allocate the raw material during the production process.

Processing begins with grinding. Conveyors carry the raw material through a series of different mills for homogenisation and size reduction. Agglomeration and granulation equipment is then used to obtain a granular end-product with a particle size of 2-4 millimetres.



Granulated boron end-products.

Granules are then dried to adjust their boron oxide concentration and ensure this meets customer requirements. In the final processing stage, granules undergo particle size classification for quality compliance.

Ulexandes maintains high stock levels of ulexite at its plants and warehouse. This guarantees a sufficient supply of raw materials for at least three years of continuous production. This ensures the availability of high quality finished products to customers and provides the company with the ability to promptly deliver these at all times.

Quality control

Ulexandes produces high-quality granulated and powdered ulexite products containing different concentrations of boron. The company is committed to delivering high quality products within a guaranteed technical specification. A well-equipped quality control laboratory with highly trained staff provides customers with the confidence that delivered products will always meet the highest standards. Quality controls checks are carried out at every stage from initial extraction to final packaging. Rigorous quality control during the production process includes checks for hardness and humidity every five minutes. ■



Ulexandes warehouse.

CONTENTS

What's in issue 522

HIGHLIGHT 1

GPCA Agri-Nutrients Conference, Riyadh

HIGHLIGHT 2

Green fertilizers enter the fray

HIGHLIGHT 3

Medium-term market outlook

HIGHLIGHT 4

Automated process analysis

FERTILIZER INTERNATIONAL
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Nitrogen technology showcase

We highlight recent production advances and innovations in nitrogen fertilizer production from Casale and Stamicarbon, two global leaders in process technology.

CASALE

HYPER-U – a novel high efficiency self-stripping urea process

Matteo Fumagalli

Since the 1970s, the ammonia or self-stripping process has offered an alternative to the CO₂-stripping process for urea synthesis, and is valued for its competitive energy consumption and operational costs.

The CO₂-stripping process decomposes carbamate at synthesis pressure using CO₂. The self-stripping process, meanwhile, relies on heating and requires purification at medium pressure (MP) due to the presence of excess ammonia in the urea solution.

The self-stripping process, although initially viewed as more complex than CO₂-stripping, was later successfully adopted because of its efficient steam consumption and ease of operation. The advantages of self-stripping process include its:

- Horizontal layout
- Smaller high-pressure equipment
- Reliable operation
- Excellent energy performance.

It does have some drawbacks, however, such as the need for dual-pressure purification stages, separate ammonia recovery, and the requirement for noble materials in the HP stripper.

The introduction of heat recovery from medium-pressure carbamate vapour resulted in a major improvement in the steam consumption of the self-stripping process. This type heat integration became standard in new and revamped plants in the 1990s. Since then, however, no significant improvements in energy optimisation have been made, with this seemingly having reached a plateau.

Modern CO₂-stripping processes include a medium-pressure purification stage as a key feature to lower their medium-pressure (MP) steam consumption. Any further improvement in the efficiency of self-stripping is a challenge as it requires further reductions in MP steam consumption in the HP stripper without destabilising the steam network. This is only possible by dramatically improving heat recovery. Indeed, heat recovery must nearly double to compete with the best CO₂-stripping processes.

Casale has now developed an improved self-stripping process, known as HYPER-U, that cuts medium-pressure steam consumption further and reduces cooling water needs. The main innovation is the introduction of an additional carbamate decomposition step before the conventional medium-pressure section.

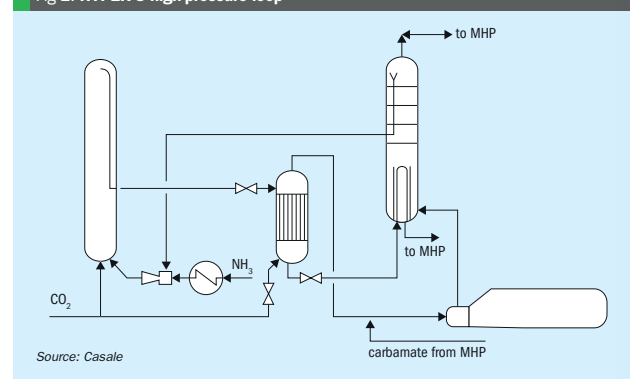
This enhances heat recovery while reducing low-pressure (LP) steam and cooling water needs.

HYPER-U process

The most innovative features of HYPER-U are the 'hybrid-stripping' and 'combi-reactor' concepts.

The HYPER-U process adopts a hybrid approach that blends the best aspects of both CO₂-stripping and self-stripping processes, resulting in much higher efficiency. A minor portion of CO₂ is fed to the bottom of the high pressure (HP) stripper. This drastically lowers the amount of ammonia that needs to be recovered at medium-

Fig 1: HYPER-U high-pressure loop



Source: Casale

CONTENTS

What's in issue 522

HIGHLIGHT 1

GPCA Agri-Nutrients Conference, Riyadh

HIGHLIGHT 2

Green fertilizers enter the fray

HIGHLIGHT 3

Medium-term market outlook

HIGHLIGHT 4

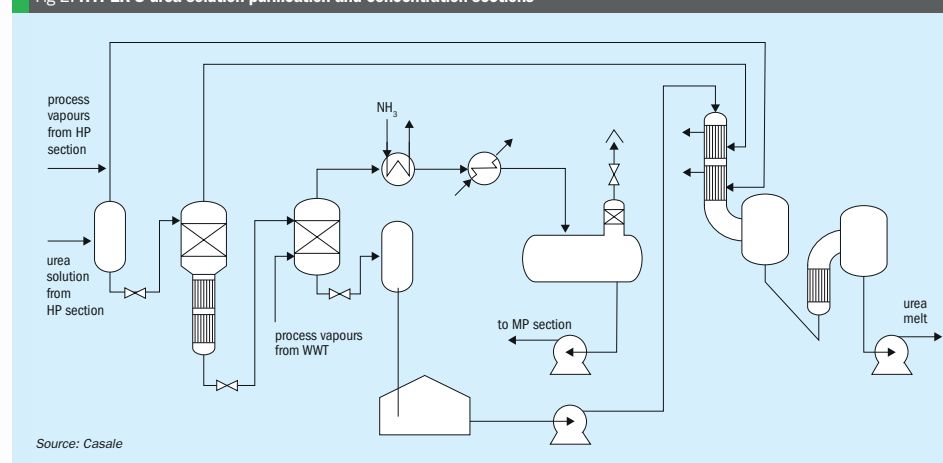
Automated process analysis

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Fig 2: HYPER-U urea solution purification and concentration sections



Source: Casale

pressure by reducing the amount of free ammonia in the urea solution leaving the HP section (simplified flowsheet, Figure 1). This in turn favours greater heat recovery by allowing the condensation of carbamate vapour at a higher temperature profile.

Vapour from the HP stripper is partially condensed in a kettle-type heat exchanger, generating steam at 5.0-6.0 barg. However, most of the condensation occurs in a vertical combi-reactor. Essentially, this is a combined HP condenser-reactor vessel that is comprised of a tube bundle and trays. The volume of the combi-reactor ensures that the conversion of CO₂ into urea begins by providing an adequate residence time. Excess heat from the condensation of high-pressure carbamate vapour is removed via direct process-process heat transfer. The heat released is then used for carbamate decomposition at 30 barg.

A critical aspect of the HYPER-U process is the inclusion of an extra carbamate decomposition stage. The urea solution from the HP stripper is first expanded to 30 barg and fed to the tube bundle (tube side) in the combi-reactor. Direct process-process heat exchange provides effective carbamate decomposition even at 30 barg. Following the 30 barg purification stage, the urea solution is then fed to the conventional medium-pressure sections for final purification.

This final carbamate decomposition stage at 3.5 barg also incorporates

another innovative concept. Instead of heating the urea solution via a shell-and-tube heat exchanger using LP steam, carbamate decomposition occurs in a column with a packed bed – with the heat of reaction provided by process vapours from the waste water treatment (WWT) section. Using the heat of condensation of WWT vapour for LP carbamate decomposition is advantageous as it offers direct heat integration. Using WWT vapour in this way has another major advantage: it avoid the use of several pieces of equipment normally required for this service.

Concentration of the urea solution – up to 96.5-99.7 weight percent depending on the product finishing technology – is carried out in a single or double vacuum evaporation section (simplified flowsheet, Figure 2). The first stage evaporator uses carbamate vapour (at 30 and 18 barg) from the medium-high and medium-pressure carbamate decomposers as a heat source. The condensation curve of the vapour at 30 barg follows a higher temperature profile than is possible conventionally. This enables the urea solution to be concentrated to up to 95 weight percent using only heat recovered from process streams without relying on steam. Consequently, HYPER-U achieves a 60 percent higher steam saving, compared to the conventional self-stripping process where MP carbamate vapours are used to concentrate urea solution to 84-85 weight percent typically.

The heat integration strategy also includes the traditional ammonia pre-heating step that captures the heat of condensation from low-pressure carbamate vapours.

HYPER-U also incorporates carbamate pre-heating: carbamate is recovered downstream of the HP loop at 110-115°C. This is in contrast to the conventional self-stripping process where carbamate solution is recovered at 80-85°C. This higher temperature, made possible by operating at 30 barg pressure, increases steam production in the HP carbamate condenser by approximately 40 kg/MT.

Steam and cooling water saving strategy

The overall heat integration strategy of HYPER-U is to maximise the use of process heat sources to replace low-pressure steam. Condensing carbamate vapour at 30 barg along an elevated temperature profile makes it possible to exploit enthalpy in a way that is impossible in the conventional self-stripping process. Consequently, overall steam demand for urea purification and concentration is drastically reduced.

The lower steam demand in downstream plant sections, by limiting the duty of the HP stripper, avoids upsetting the steam network. Reducing medium-pressure steam consumption in the HP stripper results in less 5.0 barg steam being produced in the HP carbamate

condenser. It is crucial, to balance LP steam demand and production, to minimise the steam demand for purification and concentration. The heat integration strategy achieved with HYPER-U reduces the supply of 20 barg steam to the HP stripper without needing to make up the 5.5 barg header. The consumption of 20 barg steam of the HP stripper is approximately 20 percent lower than in conventional self-stripping processes.

A notable positive side effect of enhanced heat recovery with HYPER-U is significantly lower cooling water consumption. Maximising the heat recovery for process use reduces the amount of heat wasted in cooling water. Overall, a 12-14 percent cooling water saving can be achieved.

Other advantages

HYPER-U's hybrid-stripping concept also influences the size of the HP stripper.

Conventionally, in modern self-stripping, the temperature within the HP stripper tubes follows a linear profile, ranging from 189°C at the top to 203-204°C at the bottom. Whereas in HYPER-U the bottom

temperature is kept at 195-197°C and the duty is correspondingly 20 percent lower. HYPER-U also has a positive impact on the cost of the HP stripper as maintaining the same steam pressure reduces the required surface area.

The cost of ammonia recovery equipment, such as ammonia condenser and MP absorber, is also reduced due to hybrid-stripping. This is because the free ammonia content of the urea solution leaving the HP stripper in HYPER-U is 40 percent lower. The cost of the HP ammonia pumps and their overall power consumption are also reduced as the flow rate of ammonia handled by these pumps is cut by 20 percent.

Conclusions

The HYPER-U process offers a significant improvement in energy performance compared to conventional and established self-stripping technology. Notable features include:

- **The hybrid HP stripper design** – which uses a minor CO₂ stream to lower free ammonia.

- **The 'combi-reactor'** – a combined vertical HP carbamate condenser and reaction vessel. This reactor enables direct process-process heat exchange for carbamate decomposition at 30 barg.

These features, by enabling efficient heat integration in the purification sections, offer reduced LP steam demand. Consequently, the duty of the HP stripper is reduced by 20 percent compared to conventional self-stripping processes. Similarly, the consumption of MP steam from the CO₂ compressor turbine is also lower.

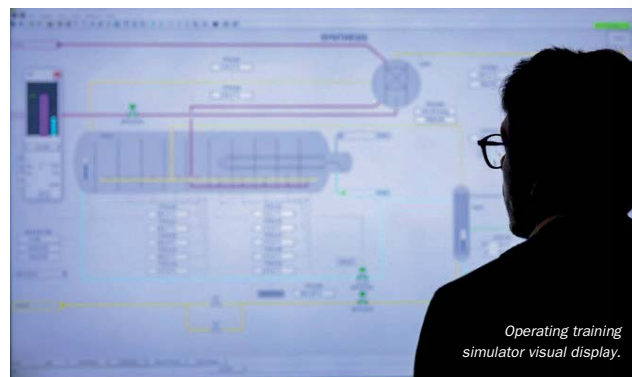
Comprehensive heat recovery in the carbamate recovery section also reduces cooling water consumption by 12-14 percent, reducing make-up water and the electricity used by cooling towers and pumps.

The overall performance of the HYPER-U process is competitive with all urea processes currently available, whether these are based on self-stripping or CO₂ stripping technology. Moreover, because fewer and smaller pieces of equipment are used, this excellent energy performance is achieved without increasing capital expenditure. ■

STAMICARBON

Operator training simulators: ensuring successful urea plant start-up

In this article, Stamicarbon's **Rahul Patil** and **Nikolay Ketov** explore how the use of digital tools – including an operational training simulator developed by Stamicarbon – enables the smooth start-up and operation of modern urea plants, thereby enhancing overall plant efficiency and safety.



Modern urea plants require successful solutions to the complex challenges they face in order to ensure efficient, safe, and cost-effective operations. The successful integration of digital tools during plant start-up and subsequent operations is therefore a landmark development that marks a significant advance for the fertilizer industry.

Notably, operator training simulators, by providing comprehensive training and preparation for plant operators, have emerged as a critical digital solution.

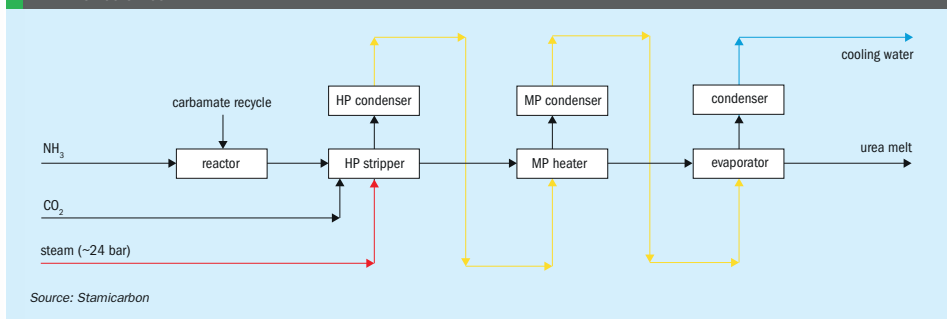
Urea technology

Stamicarbon, the nitrogen technology licensor of MAIRE S.p.A., is a market leader in urea technology globally. The Netherlands-

headquartered company is continuously innovating and introducing new solutions that extend the lifetime of urea plants, reduce emissions and lower their energy consumption.

Stamicarbon is renowned for its pioneering urea production technology, including the introduction of the CO₂ stripping process – a landmark invention – in the 1960s. Since then, the company has been

Fig. 1: Stamicarbon's Ultra-Low Energy design is highly efficient. N=3 heat integration allows high pressure steam to be used three times



improving and perfecting urea technology to optimise operational performance.

Stamicarbon's most recent breakthrough in urea technology is its Ultra-Low Energy (ULE) design. This technology significantly enhances the energy efficiency of urea production. The core improvement introduced by this innovation is that process heat – in the form of steam – is used three times in the ULE design (Figure 1) instead of two in the conventional urea process.

The primary advantage of the ULE design is the significant energy savings delivered by introducing a medium-pressure (MP) recirculation section. This section captures steam heat three times. It is configured to flash and then reheat

carbamate at medium pressure using the heat of reaction and condensation. This reheated carbamate then recovers heat via evaporation. As a result, steam consumption and cooling water consumption can be reduced by up to 40 percent and by about 16 percent, respectively, compared to traditional CO₂ stripping. This process configuration also achieves an impressively low steam consumption of less than 560 kg per tonne (kg/t) of urea, versus approximately 870 kg/t in traditional CO₂ stripping processes.

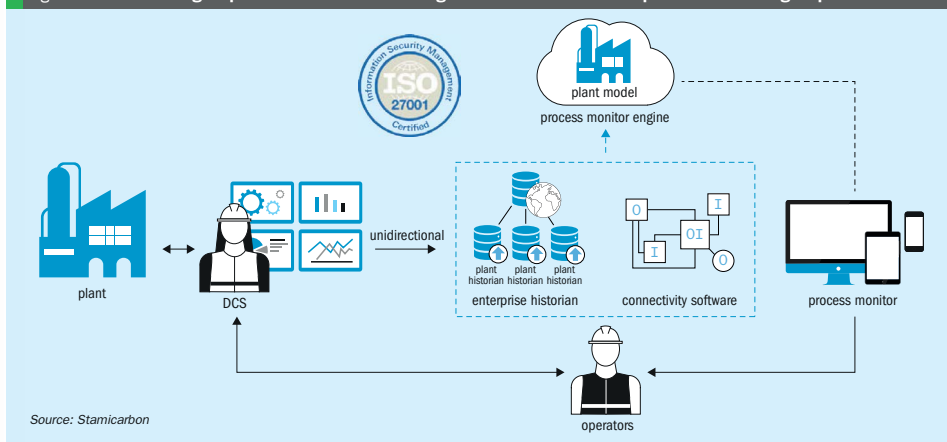
Alongside Stamicarbon's extensive experience in designing new plants, the ULE concept can also be used to revamp existing urea plants, regardless of the original technology provider.

Stami digital suite

Stamicarbon, building on decades of pioneering urea technology, has developed a suite of digital services that enhance operational effectiveness and boost productivity at urea plants – as well as supporting employee training. Creating a realistic digital model of a urea plant requires extensive experience and specialised knowledge to accurately simulate the complex physics of urea and carbamate mixtures.

Stamicarbon's process monitor tool is one of the key technologies featured in this digital portfolio. This monitor offers superior prediction capabilities by using a knowledge-driven mathematical model of the urea plant.

Fig. 2: Stamicarbon digital process monitor tool is configured to feed real-time urea plant data into a digital plant model.



CONTENTS

What's in issue 522

HIGHLIGHT 1

GPCA Agri-Nutrients Conference, Riyadh

HIGHLIGHT 2

Green fertilizers enter the fray

HIGHLIGHT 3

Medium-term market outlook

HIGHLIGHT 4

Automated process analysis

FERTILIZER INTERNATIONAL
ISSUE 522
SEPTEMBER/OCTOBER 2024



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The model behind the process monitor is actually very similar to those used to design urea plants and, for example, includes mass and heat transfer equations, reaction kinetics, vapour-liquid equilibria, and hydrodynamic criteria that cover the entire plant. In total, the plant model consists of more than 5,000 linear and non-linear equations. A process flowsheet programme – developed in-house and based on these equations – then ensures fast solutions to large and complex operational problems.

The process monitor feeds real-time plant data into the digital plant model (Figure 2). This then calculates key performance indicators (KPIs), such as plant load, energy consumption and emissions, as well as soft sensor key variables, such as equipment efficiency, load, and reactor conversion. The processed data generated is then made available to plant operators and others via an intuitive dashboard.

The Stami digital process monitor has already demonstrated its effectiveness by improving decision-making and operational excellence at urea plants since the first references were installed in 2020. These have delivered higher plant loads and reduced plant energy consumption.

Operator training simulator

Another digital tool developed by Stamicarbon, an operator training simulator (OTS), instructs plant operators on start-up and shutdown procedures, day-to-day plant operations, and various other operational scenarios. This high-fidelity simulator is an efficient training tool that helps operators understand the dynamic behaviour of urea melt and granulation plants. It also provides effective preparation for emergencies by simulating 'upset' conditions for plant operators in an entirely safe digital environment.

A significant advantage of the OTS is its ability to offer bespoke and tailor-made training to personnel, as it uses thermodynamic and kinetic models that are specific and unique to individual urea plants. The simulator provides plant operators with comprehensive training on the urea process and the dynamic behaviour of urea plants.

OTS training covers standard operating procedures including normal operation, plant start-up, blocking-in, restarting and draining. As already indicated, the models used by the OTS can

safely simulate upsets at the plant. This allows operators to practice, as part of their training, bringing the urea plant back to normal operation in response to upset conditions.

The OTS can be configured to precisely replicate Stamicarbon's Ultra-Low Energy urea plant design. This includes the process equipment, plant control, interlocking systems, and the safety trip system (STS). The simulator's distributed control system (DCS) interface mimics the exact look and feel of an actual operations room. Additionally, it trains operating staff to run the plant at maximum capacity, while minimising steam consumption and ammonia losses. It also allows new and modified operating procedures to be properly tested before these are subsequently implemented. The resulting improvements in staff knowledge and experience lead to safer and more stable urea plant operations. By providing operators with a thorough understanding of urea plant dynamics, the OTS also helps to reduce plant start-up delays by avoiding unwanted start-up trips.

OTS – plant start-up case studies

One of the benefits of Stamicarbon's Ultra-Low Energy design is its ease of operation compared to traditional plants. In particular, the design is more operationally stable by incorporating a MP recirculation section. This new design helps mitigate disturbances that can occur in traditional CO₂ stripping plants when liquid is discharged directly from the stripper into the low-pressure section. Additionally, the safety and efficiency of Ultra-Low Energy plants can be further improved by OTS training to prepare operators for a variety of operational scenarios.

The 2,334 t/d capacity urea plant at Jinjiang Xinlianxin in China was the first facility to operate with Ultra-Low Energy technology following its successful start-up in February 2021. Stamicarbon comprehensively trained the plant's staff using its OTS prior to start-up. Consequently, having provided a thorough understanding of expected reactor and plant behaviour, the start-up went very smoothly without any issues from the first attempt.

Initially, the Jinjiang Xinlianxin plant operated at a turndown capacity. Then, after securing the feedstocks, the plant's capacity was increased to more than 100 percent during the first week of opera-

tion. Notably, the plant was commissioned and entered production during the challenging Covid-19 lockdown period in China. Yet, thanks to the OTS, the staff were able to be trained remotely – allowing the plant's start-up to proceed normally without the need for on-site support from Stamicarbon.

The training of operators at Gemlik Gübre's urea melt and granulation plant in Gemlik, Turkey, is another example of the successful use of the OTS. The Gemlik plant is another Ultra-Low Energy design and has a production capacity of 1,640 t/d for urea and 500 t/d for urea ammonium nitrate (UAN).

Gemlik Gübre's OTS is a tailor-made simulator that incorporates a high-fidelity, real-time model of the urea plant and is more than 98 percent accurate in simulating improvements in staff knowledge and experience lead to safer and more stable urea plant operations. This OTS provides operators with comprehensive training and in-depth knowledge of plant behaviour – with this helping them to deliver:

- Faster start-ups
- Rapid recovery from plant upsets
- Higher plant on-stream time
- Increased plant safety
- Lower emissions
- Substantial operational cost savings over the plant's lifetime.

Conclusion

Stamicarbon offers technological solutions, products, and services for urea plants that are tailored to the specific requirements of customers. The company's solutions for urea synthesis – such as its Pool Condenser, Pool Reactor and Ultra Low Energy designs – result in increased plant efficiency, reduced operating and maintenance costs, and lower plant emissions. Adopting a full life cycle philosophy, Stamicarbon partners with its clients to design, build and operate urea plants, while continuously seeking improvements and providing support.

Stamicarbon, by leveraging its extensive expertise in nitrogen technology, in collaboration with sister companies from MAIRE S.p.A., offers a digital toolbox to optimise plant operations – both in urea production and other chemical processes. The Stami Digital portfolio includes a wide suite of digital services and is backed by proven track record of effective improvements in plant load and reductions in energy consumption. ■

phosphates & potash

INSIGHT

23

Tessenderlo – leading on liquids and a solubles success

25

Automated process analysis and sorting

CONTENTS

What's in issue 522

HIGHLIGHT 1

GPCA Agri-Nutrients Conference, Riyadh

HIGHLIGHT 2

Green fertilizers enter the fray

HIGHLIGHT 3

Medium-term market outlook

HIGHLIGHT 4

Automated process analysis

FERTILIZER INTERNATIONAL
ISSUE 522
SEPTEMBER/OCTOBER 2024



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Tessengerlo – leading on liquids and a solubles success

TKInt's new Thio-Sul[®] production plant at Geleen in the Netherlands

Tessengerlo Kerley International (TKInt) is a major global supplier of water-soluble sulphate of potash plant nutrition and the leading producer of thiosulphate-based fertilizers. In an exclusive interview, we speak to **Nicolas White** the company's Portfolio & Knowledge Director, about recent strategic developments. These include major investments in new production, transshipment and storage capacity, production offtake agreements, and product sales and marketing rights.

Tessengerlo Kerley International (TKInt) was formed in 2017. The new Tessenderlo Group business unit brought together the strongly-growing Kerley International business, responsible for marketing liquid thiosulphate-based fertilizers (notably Thio-Sul[®], KTS[®] and CaTs[®]) outside the US and Canada, and the well-established SOP Plant Nutrition business with its market leading granular (GranuPotasse[®]), soluble (SoluPotasse[®]) and foliar (K-Leaf[®]) sulphate of potash (SOP) products (*Fertilizer International* 484, p29).

Strategic strengthening

TKInt operates a large-scale SOP plant at Ham, Belgium, supplying countries globally, and liquid thiosulphate plants outside of the US. This includes production units for potassium thiosulphate (KTS[®]) and calcium thiosulphate (CaTs[®]) located next to the SOP plant in Ham. A new ammonium thiosulphate (Thio-Sul[®]) plant also opened in Rouen, France, in 2017, this being

well-positioned to supply the large French urea ammonium nitrate (UAN) market. Additionally, a Turkish operation in Izmir serves the Middle Eastern markets with KTS[®] and tailored liquid fertilizers.

TKInt is currently finalising the construction of a new Thio-Sul[®] production plant at Geleen in the Netherlands. This is expected to become operational in the third quarter of 2024.

"With the new plant in Geleen, which will be our second Thio-Sul[®] plant in Europe, we are further expanding our local presence in the liquid fertilizer market for precision farming. The Geleen branch will respond to the growing demand for liquid fertilizers from the European market. These fertilizers supplement sulphur nutrients and help limit nitrogen losses," explained Geert Gyselinck, TKInt's Executive Vice President.

The new Geleen plant strengthens TKInt's position in the Western European liquid fertilizer market and assists with sustainability goals by bringing liquid fertilizers closer to

its customers. Output from the Geleen plant will partially flow through Tessenderlo Kerley Fleuren, a tank storage and transshipment company located in the Port of Cuijk that was acquired by Tessenderlo Group in 2022.

In 2021, TKInt entered into a partnership with Kemira of Finland with a long-term offtake agreement to market and distribute premium SOP. This made the company the largest global supplier in the premium water-soluble SOP market.

Last year, TKInt also entered into an agreement to acquire the marketing and sales rights for ammonium thiosulphate (ATS) fertilizers produced by Esseco Srl in Treccate, Italy. Tessenderlo also bought the Secofit[®] TS and Agrifix[®] agricultural trademarks covering this product range.

"This agreement confirms Tessenderlo Kerley International's commitment to the ammonium thiosulphate fertilizer market. Thanks to the production capacity of Esseco Srl, we will have additional volumes of ammonium thiosulfate fertilizers available," said Geert Gyselinck. "In addition to cooperating with a company which shares

the same mindset towards continuous improvement in terms of both product and process, this agreement will also improve the service we offer to our customers."

Fertilizer International sat down with Nicolas White, TKInt's Portfolio & Knowledge Director, earlier this year to discuss these strategic developments and more.

Operating globally, advising locally

Nicolas, when we last spoke, your EVP, Geert Gyselinck, emphasised the importance of knowledge to the business by saying, "Tessengerlo Kerley International, although a globally connected business, still works and acts locally." Is connecting growers with knowledge still central to the company's approach?

That's the model we've continued to follow – and have taken one step further now. In some countries, where the market is growing, we're starting to recruit technical sales advisors which, we believe, will get us even closer to the market and growers.

These are people who have dual role, coupling agronomy knowledge with sales skills. In Mexico now, for example, where we have quite a big team, we have technical sales advisors operating at a local level supporting customers very closely.

To be clear, our role remains not to sell products [directly] to the end-user. Instead, our aim is to work with distributors and assist in sales creation – that's really the role of technical sales advisors.

Transmission of knowledge ensures our global strategy, the way we want to develop products, cascades down into local markets. That makes sure the way we're developing a product like Thio-Sul[®] in France is similar to the approach taken in countries like Bulgaria and Romania, for example.

We create information globally about our products and their use on crops. But that knowledge will always have to be tailored to the local needs of the market, the climate, the soil type, fertilization practices etc. So part of the challenge is providing our local teams with a toolbox they can use and adapt to the growers in their particular countries.

Moving into new markets

Is TKInt continuing to successfully expand its liquid fertilizer portfolio in new countries – I was thinking of the recent introduction of liquids into the Ukrainian market.



Geert Gyselinck, TKInt's Executive Vice President

You're absolutely right: it was a key part of our strategy to develop [our portfolio] eastwards. The potential for Thio-Sul[®] in some eastern European countries is huge, simply because of the areas of field crops. Unfortunately, the conflict between Russia and Ukraine has made that more complicated.

That said, the Ukrainians have been very resilient. We have our own staff on the ground in that country now, including a technical sales advisor, and they've been getting on with business as usual, or as usual as it can be.

In Western Ukraine, we've been able to move volumes of Thio-Sul[®] into the market. Our chosen partners are working with us to develop Thio-Sul[®] in combination with urea ammonium nitrate (UAN) and that's going very well.

We have high aspirations for Thio-Sul[®] because it is used in the field crops. That obviously represents a very big area, particularly in Europe. This is why we've gone ahead with the building of the second Thio-Sul[®] plant in Geleen which should come on stream quite soon now.

In the other countries, where the emphasis is more on cash crops, we're focusing on [marketing] calcium thiosulphate [CaTs[®]] and potassium thiosulphate [KTS[®]]. That work is progressing nicely as well – even though it's still in its infancy in certain new markets.

In countries like South Africa and India it took more time to obtain the homologation

[official approval] to place products on the market. That normally involves field trials which take one or two years. It's only when that initial groundwork was done that we could really start to push products into these markets. We're very actively involved in that [process] right now and getting good results.

Thiosulphates – the soil activator

As with SoluPotasse[®], our water-soluble SOP product, KTS[®] is principally going into the drip irrigation, fertigation market. The opportunity for our teams is to, firstly, sell the benefits of liquid fertilizers – and there are numerous benefits – and, secondly, to sell the benefits of applying sulphur in thiosulphate form.

Thiosulphate is a uniquely different and a much more active form of sulphur, if you compare it to sulphur-bentonite or sulphate [fertilizers]. We've heard a lot [at the New AG International conference back in April] about the importance of micronutrients. Well, some of my colleagues refer to thiosulphate as a soil activator because it can help make both micronutrients and phosphate more available to the plant under certain conditions.

You're not just getting the benefit of sulphur – which is present in two forms in thiosulphate and released throughout the season. One form is quickly converted to sulphate and made available to the plant, while the transformation of the other form takes longer giving a regulated release effect. Additionally with thiosulphates the effect of these processes is to help liberate soil micronutrients too through a redox effect.

The best of both worlds?

One of the perceived strengths of TKInt is that you're able to use SOP's global product coverage to help introduce liquid fertilizers to new markets, while also taking advantage of locally embedded liquid fertilizer expertise to the benefit of SOP sales. Has this 'best of both worlds' concept been working well?

Yes, combining two product portfolios does help us to create and maintain a larger team on the ground. That said, the two parts of the portfolio are at very different stages in the life cycle, with thiosulphates being relatively new to the market and SOP more well known. So, when it comes to development work, a lot of our effort is

CONTENTS

What's in issue 522

HIGHLIGHT 1

GPCA Agri-Nutrients Conference, Riyadh

HIGHLIGHT 2

Green fertilizers enter the fray

HIGHLIGHT 3

Medium-term market outlook

HIGHLIGHT 4

Automated process analysis

FERTILIZER INTERNATIONAL
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focused on thiosulphates – because these products need to be explained to growers and distributors.

We're recognised in the market as a preferred partner when it comes to SOP. There are cheaper, inferior alternatives. But customers won't get the consistently high quality, a reliable product supply and the agronomic support we pride ourselves on. As always, you get what you pay for!

Improving affordability spurs demand

We've seen unprecedented market conditions since 2019. How has TKInt adapted and continued to do business in the volatile circumstances which have become the new reality in recent years?

Recently, we've had a levelling out of prices and, as affordability becomes better, growers start to go out and buy fertilizers with confidence. We have seen that [trend] reflected in the market – particularly in the water solubles segment – from the end of 2023 and into 2024.

This year, there's been a rapid rise in demand for water-soluble fertilizers which at the moment are going very strongly. In fact, demand probably outstrips supply – which brings with it additional challenges.

If you look at our liquid products, which as you know are in a high value market segment, then in terms of volume they've not been as affected [by market volatility] as commodity fertilizers.

Astute investments, smart agreements

Over the last couple of years TKInt has successfully pursued investment in new production capacity, transshipment and storage assets, and secured production offtake agreements, as well as product sales and marketing rights. Are these moves part of a conscious strategy to bolster your market position and respond to demand for products like water-soluble SOP and Thio-Sul®?

We've always been recognised as market leader in the water-soluble SOP segment. We have a product at the top end of the range when it comes to quality, plus a very good position in most markets.

We've also seen competition increase over the last decade. So, of course, we will take steps to defend our position.

So, yes, it is a strategy to secure and strengthen what we believe is already a solid position.

In that context, it made sense for us to link up with production from Kemira at Helsingborg, Sweden, because they, like us, have a very good quality product. That provides us with a degree of flexibility and allows us to have more product in our hands in what is a consistently growing market.

If you look at the thiosulphate portfolio, the other high-volume product for us is Thio-Sul®. A lot of our bets for the future, therefore, are on both solid potassium sulphate and liquid thiosulphate. Hence that's why you're seeing a very conscious effort to invest in Thio-Sul® as a brand, Thio-Sul® as a product, the new Thio-Sul® production unit in Geleen, and the marketing agreement for ammonium thiosulphate supply with Esesco in Italy.

Again, these moves give us a good footprint across markets plus a degree of flexibility. That's very important for liquids when you want to deliver those to different points in the market and countries across Europe.

Linking up with urea ammonium nitrate (UAN)

Are the investments in Thio-Sul® linked to the strength of the UAN market within Europe as well?

Everybody now is talking about improving nitrogen use efficiency. Many countries are limiting when and how much nitrogen can be applied, meaning growers are having to look for more technical solutions for applying nitrogen – including UAN.

We believe that UAN combined with ammonium thiosulphate, which is a great concentrated source of liquid sulphur, will help make a difference because the nitrogen/sulphur balance is very important in many crops. You also see in scientific publications many reports of ammonium thiosulphate acting as a nitrogen stabiliser with the ability to inhibit urease and nitrification reactions.

That's recognised in the literature and we are in the process of trying to get these effects homologated [officially authorised] in certain European countries – which will then allow us to develop that [nitrogen stabiliser] use with UAN manufacturers and suppliers. ■

So, in future, not only will Thio-Sul® bring concentrated liquid sulphur, we should also be able to capitalise on its inhibition properties.

Sustainability matters

Is TKInt prioritising sustainability, given its overarching importance now?

You can't ignore sustainability as in the future it will become a license to do business for fertilizer manufacturers. Our production colleagues are therefore examining very closely how we can improve the sustainability of both our thiosulphate and SOP production.

For SOP, we've now converted many of our Mannheim furnaces from heavy fuel to gas, a much more efficient source of energy. We're also investigating alternative carbon neutral/free energy sources for the furnaces. Our Ham production site in Belgium also generates enough low-carbon electricity, from a sulphuric acid plant, for more than 30,000 households.

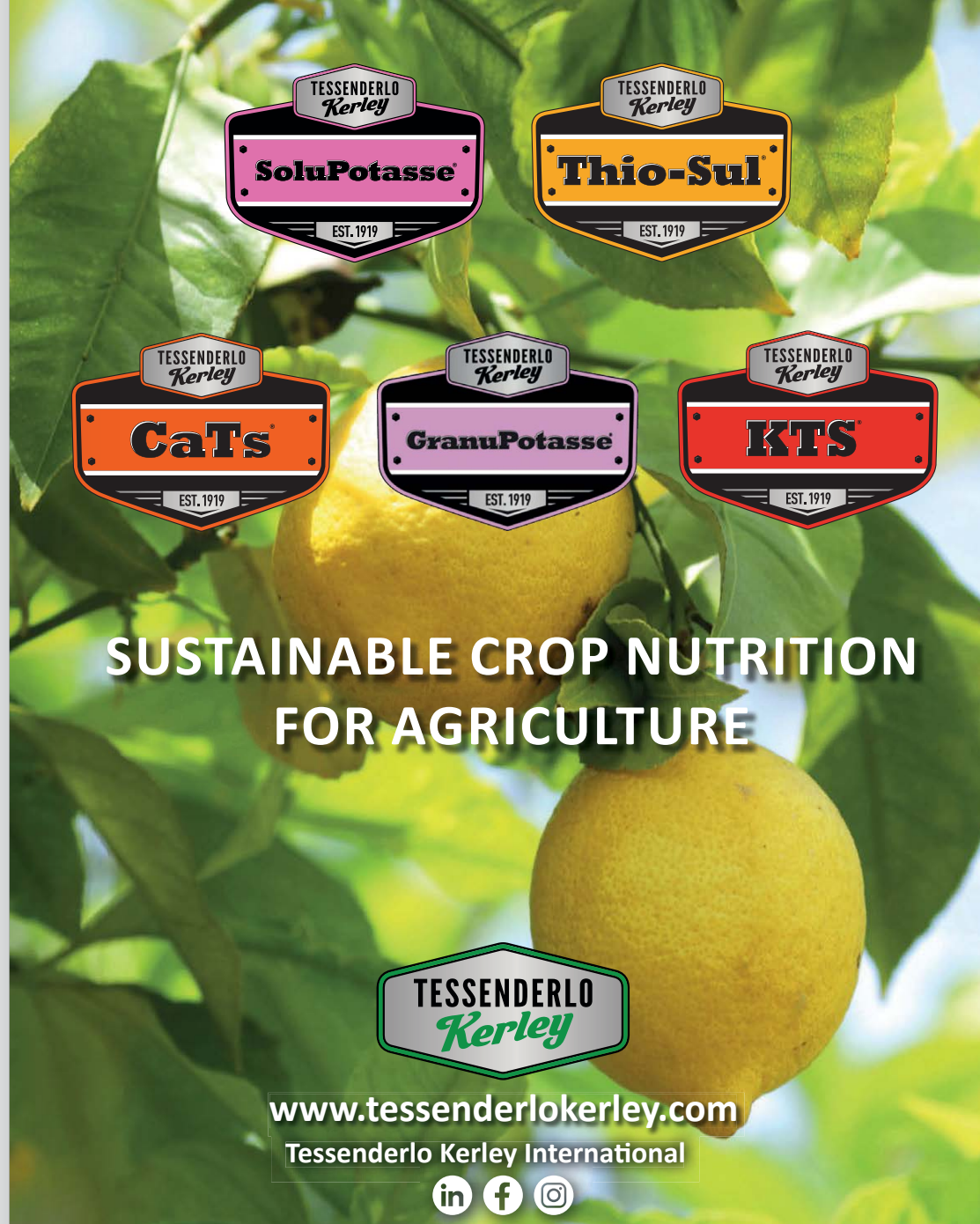
For the total carbon footprint, there's production emissions and agricultural emissions from when products are used on farms. I think what's important for the industry is to calculate carbon footprints in exactly the same way.

There are standard carbon footprint methods out there now and companies that will audit and accredit carbon calculations. We've invested a lot of time and effort over the last year in doing just that for our SOP production.

If you use the same methodology, following the recognised rules, we're confident our carbon footprint for SOP production at Ham is good – with our Mannheim process certainly no worse than many other processes – and that we can likely improve on that footprint in the future. Also, at farm level, SOP remains a very good product for sustainable agriculture.

SOP is nitrate-free, meaning that you don't have the potential problems associated with nitrate leaching, nitrification and the release of greenhouse gases. The fact that it's essentially chloride-free also means that SOP can be used in regions of the world at risk from salinity.

These are key features that our whole portfolio shares and – we believe – very important attributes for more sustainable types of fertilizer. ■



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CONTENTS

What's in issue 522

HIGHLIGHT 1

GPCA Agri-Nutrients Conference, Riyadh

HIGHLIGHT 2

Green fertilizers enter the fray

HIGHLIGHT 3

Medium-term market outlook

HIGHLIGHT 4

Automated process analysis

FERTILIZER INTERNATIONAL
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SEPTEMBER/OCTOBER 2024



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Automated process analysis and sorting

Sophisticated control of phosphates production is now possible thanks to the availability of real-time process analysers. The emergence of laboratory robots is also improving process efficiency and delivering cost savings.

Optimising production, driving down costs

Cost reduction and revenue generation have become increasingly important imperatives in the manufacture of phosphate fertilizers.

Producers are operating on relatively tight and volatile margins. In the second-quarter of this year, for example, North American producer Mosaic achieved an adjusted gross margin of £91/t on an average diammonium phosphate (DAP) selling price of \$575/t. That compares to a margin of £129/t for the same period in 2023.

Today's operating environment means there is now more pressure than ever for phosphate producers to cut their operating costs. This, in turn, requires a much greater degree of process control. Yet fine tuning the phosphates production process remains a challenge.

Traditional laboratory methods for analysing the grade (P_2O_5 content) of mined phosphate rock, rock concentrates and chemical plant feed materials are time-consuming and labour intensive. The length of time taken between sample collection and the delivery of results also limits their usefulness in process control at phosphate mines and beneficiation plants.

Infrequent and intermittent sampling also means that lab test results are not always representative. Because of this, lab-based analysis is generally only able to provide a fragmented, incomplete picture of the production process.

Typically, phosphate fertilizer producers can only rely on getting lab results every 4-6 hours, meaning that process stages such as phosphate rock mining, froth flotation and phosphoric acid reactors are effectively flying blind when it comes to P_2O_5 feed control.



North American Geoscan-M installation for monitoring beneficiated phosphate – with a TBM moisture analyser in the foreground.

It is therefore unsurprising that phosphate plant operators are increasingly adopting automated on-line technologies for process and feed control at mines and beneficiation plants. These generate results rapidly, often in near real-time, and deliver tangible benefits in terms of improved phosphate plant efficiency and yield.

They can also deliver surprisingly quick returns on investment. For a typical beneficiation plant, an improvement in P_2O_5 recovery of just two percent, for example, can deliver annual savings of half a million dollars, according to some calculations.

A range of automated analytical systems for process control in the phosphates industry are reviewed below. Many of these technologies are also applicable to potash mining and processing.

Laser-induced breakdown spectroscopy

Laser-induced breakdown spectroscopy (LIBS) has been developed for monitoring and control applications in mining and mineral processing. One advantage of LIBS is its ability to detect and measure light elements, unlike conventional analytical techniques such as XRF analysis. The technology can be installed to analyse dry granular materials on conveyor belts or slurry materials.

The MAYA on-line laser analyser, a LIBS-based system manufactured by LYNCS, provides direct, safe, efficient and accurate elemental analysis of phosphate and potash on conveyor belts.

LYNCIS has considerable experience in manufacturing on-line analysers for

phosphate, potash and NPK fertilizer analysis. The company's first LIBS analyser for the fertilizer industry, installed on a phosphate ore conveyor for The Mosaic Company in 2008, enabled removal of rock with high levels of impurities in real-time. Since then, the technology has proved to be widely applicable with LYNCS successfully supplying LIBS-based systems for a range of industrial materials. Advantageously, the company's state-of-the-art optical system allows the analysis of solid materials, slurries and brines with a high level of confidence.

LIBS offers the following advantages compared to other technologies, according to LYNCS:

- The use of lasers is much safer with no harmful neutron, gamma or X-ray radiation
- Maintenance costs are very low
- Their calibration remains stable over a long period of time, eliminating the need for frequent recalibrations.

LYNCIS analysers have the following applications in fertilizer production:

- Ore quality control based on elemental analysis (P, K, N, Mg, Ca, Si, Al, Fe, etc.)
- Real-time adjustment of flotation reagent dosage to increase P_2O_5 recovery
- Real-time adjustment of water dosage during the hot leaching and crystallisation of potash
- Product quality control.

In a major milestone for the company, LYNCS is supplying five LIBS analysers for BHP's massive new Jansen potash project in Saskatchewan, Canada. These will provide real-time chemical composition data throughout the potash production process from mining to final products. This real-time monitoring will enable rapid process interventions and ensure that final product quality is not compromised. Jansen Stage 1 is expected to produce approximately 4.35 million t/a of potash, once fully ramped-up. BHP is planning to double Jansen's total capacity to 8.5 million t/a under the subsequent Jansen Stage 2 expansion.

LYNCIS recently developed a second generation of slurry analysers. These incorporate technical design changes, made in response to practical field observations, that improve the stability of on-line process analysis. These next generation analysers can be adopted by any project as they are compatible with third-party samplers and multiplexers.



LYNCIS MAYA 4L LIBS-based analyser.

In general, there are two main end uses for LIBS process analysers supplied by LYNCS:

- Sorting/impurity rejection
- Real-time production process control.

This is illustrated by the following four case studies:

Phosphate ore sorting. Two LYNCS process analysers were installed on conveyors for The Mosaic Company to enable the removal of phosphate ore with high levels of impurities. Initially, these were used for real-time monitoring of phosphate content (as P_2O_5 or bone phosphate of lime, BPL), impurities (MgO , Fe_2O_3 , Al_2O_3), the minor element ratio (MER) and the insoluble phase.

Finally, after an initial period of investigation, instantaneous LIBS measurements were used to reject impure, high magnesium phosphate rock (above two percent MgO). The investment in the LIBS system had a payback time of just 2-3 months, by avoiding penalties for off-grade product shipments and obtaining better prices for high-grade products.

For this application, a special high-sensitivity LIBS system was used to analyse and detect low-quality phosphate ore. This can contain just 3-7 percent P_2O_5 due to contamination with gangue minerals. The use of a double-pulse technique with two synchronised lasers increased the strength of the emissions spectra from elements by up to eight times.

This double-pulse LIBS system is equally useful for analysing slurries –

one example being the measurement of flotation reagent dosages in phosphate beneficiation. For this application, LIBS measurements have achieved a high level of accuracy and close correlation with standard laboratory analyses ($R^2 = 0.91$, average absolute error +/-0.75%), based on the collection and analysis of 256 samples over a six month period.

Potash process control. For real-time process control at a potash plant, a LYNCS analyser was installed on a conveyor transporting wet cake after hot leaching and crystallisation. To enable continuous and automatic adjustment of the volume of water entering the process, this LIBS unit was also linked up to the water dosage system. Automatic dosage adjustments were then used to keep the concentration of the unwanted sodium chloride (NaCl) impurity in the process at exactly the permitted level. This is important as:

- Adding too little water would not remove the NaCl impurity
- Adding too much water, while producing a very clean, high-quality end-product, would lead to the unwanted loss of potassium chloride (KCl), the valuable target mineral.

In this application, the successful installation of a LIBS process analyser – for on-line detection of Na and K and automatic balancing of the process water dosage – improved the recovery of KCl at the potash plant by 0.4 percent. This translates to a cost saving of \$1-1.5 per tonne.

CONTENTS

What's in issue 522

HIGHLIGHT 1

GPCA Agri-Nutrients Conference, Riyadh

HIGHLIGHT 2

Green fertilizers enter the fray

HIGHLIGHT 3

Medium-term market outlook

HIGHLIGHT 4

Automated process analysis

FERTILIZER INTERNATIONAL
ISSUE 522
 SEPTEMBER/OCTOBER 2024



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Additionally, it eliminated the potential for penalties incurred as a result of poor product quality.

Potash quality control. LYNCS recently secured a contract to supply a LIBS analyser for a potash conveyor at a Vancouver seaport. This will be used for final product quality control checks prior to ship loading. The new installation is expected to eliminate potential customer claims by maintaining product quality and ensuring this meets specified requirements. Product quality checks are required at various stages of potash storage and transportation, starting with grade sorting at the production plant warehouse and ending with the final quality control checks before loading shipping vessels. LYNCS analysers are well suited to installation at seaports as they are robust and designed to resist corrosive, dusty and humid environments.

Polyhalite mining. LYNCS has supplied LIBS analysers to a polyhalite producer. This unique multi-nutrient mineral fertilizer ensures balanced crop fertilization and promotes crop growth by supplying potassium, magnesium, calcium and sulphur. LIBS technology has proved to be very useful for stockpile homogenisation, mining grade control and impurity rejection at the polyhalite mine. Reliable and accurate measurement of all the valuable nutrients, as well as unwanted impurities, is possible as these generate strong LIBS spectra. Maintaining ore grade at the early stages of production, using a LIBS analyser to measure and control the relative concentration of nutrients and impurities, is worthwhile for the producer, as this prevents the use of costly reagents, water and energy that would be otherwise be required to process and upgrade the polyhalite ore.

Metso offers the Courier® 8X LIBS-based analyser for on-line measurement of elemental concentrations in beneficiation plant feed, tailings, and concentrate slurries. This is the successor unit to the Courier® 8 SL originally launched in 2013.

The Courier® 8X has the capability to measure both light and heavy elements for monitoring and control in mineral processing plants, enabling the reduction of impurity levels in concentrates while maintaining the best possible recovery. Compared to the Courier® 8 SL, the new LIBS unit offers:

- Best available technology with a diode pumped laser

- Improved temperature control, robustness, and serviceability
- Doubled measurement speed and 30 percent shorter cycle time
- Next generation Courier® X software platform
- Remote support and calibration services
- Metso Metrics with KPI reporting for improved equipment availability
- Higher precision due to more stable slurry flow.

According to Metso, the Courier® 8X maximises plant efficiency, using enhanced technology to measure light elements, and improves both recovery and reduces impurity content in flotation circuits. Its benefits include:

- Accurate monitoring of changes in feed mineralogy
- Improved control of concentrate quality
- Improved recovery through early detection of process disruptions
- Reduced need for time-consuming and labour-intensive manual sampling
- More efficient use of energy and raw materials.

Phosphates processing and concentration is one of the target markets for the Courier® 8X SL. Its applications include:

- **Final concentrate quality control:** measurement of P content and Ca/P ratio
- **Flotation recovery optimisation and reagent control:** measurement of P in feed, concentrates, and tailings
- **Measurement of 'penalty' elements:** Mg and Si.

Prompt gamma neutron activation analysis

Prompt gamma neutron activation analysis (PGNAA) is a proven on-belt technology used for the real-time monitoring, bulk sorting and blending of ore materials on conveyors.

The GEOSCAN range of on-belt PGNAA analysers developed by Australia's **Scantech International** have been widely used for monitoring the quality of bulk industrial materials such as cement, coal and minerals since the 1990s. The GEOSCAN-M analyser is suitable for ore and concentrate analysis in the minerals industry, and enables operators to measure and control feed and product quality as well as improve process performance. There are more than 130 GEOSCAN analysers used in mining and processing plants

worldwide, covering 15 commodities in total including iron ore, manganese, zinc, lead, bauxite and copper operations.

More than 20 GEOSCAN units are currently operating in the phosphate sector in Africa, the Middle East and the Americas. These rapidly deliver high quality process data to leading phosphate producers. Data quality is a critical factor, based on client feedback, as it provides plant operators with confidence when making process decisions. Digitalisation of conveyed rock enables data to be used for the forward control of feed in processing, feedback to mining operations, and for ore reconciliation to improve resource modelling.

GEOSCAN-M units are installed directly on the conveyor system, with the belt passing through the instrument's analysis tunnel (see photo). Its compact design uses only one metre of belt space, enabling it to be fitted between standard idlers and avoiding any contact between the analyser and the belt or material. Three frame sizes are available to suit conveyor belt widths up to 2.4 metres and bed depths up to 0.53 metres. All material that passes through the analysis tunnel is continuously analysed and reported for a truly representative analysis. Being a fully penetrative analysis technique, it avoids many of the sampling errors and other issues associated with surface analysis methods or those which only analyse very small samples.

The segregation of materials during transport on conveyor belts commonly results in variations in quality between the top and bottom of the depth profile. This means that the results generated by sensing techniques which only measure the composition of surface materials, or those at intermediate depths, are unlikely to be representative of the composition of the whole bed. This kind of segregation on conveyors – and the resulting variation in the quality with bed depth – has been found to occur in most commodities where companies have investigated this.

The PGNAA technology in GEOSCAN-M installations emits neutrons from a californium-252 source located below the conveyor. These are absorbed by elements in the material being conveyed, with each element emitting a unique gamma ray spectrum.

The resulting spectra are captured by a sensitive detector array positioned above the conveyor and then processed using proprietary software. This generates independent multi-elemental chemical analyses (Ca, P, Mg, S, C, N, Si, Al, Fe, Ti, K, Mn, etc.)

using calibrations customised to each site installation.

GEOSCAN units then report these to the plant operator – typically every two minutes – where they are interpreted to make process decisions. Results are combined with microwave measurements which detect and report moisture content.

For materials flowing on conveyors, GEOSCAN systems provide the shortest measurement time, highest precision and the lowest detection limits of any comparable measurement technology available on the market, according to Scantech's client feedback.

The main applications and benefits of PGNAA systems such as GEOSCAN in phosphate mining and processing include:

- Measuring beneficiation feed quality for plant control
- Sorting phosphate rock received at chemical plant stockpiles
- Blending to improve feed quality and meet specification
- Blending acid reactor feed
- Controlling sulphuric acid additions to the acid reactor, based on phosphate rock feed chemistry, to maximise P₂O₅ recovery, recover Ca to gypsum, and optimise acid consumption.

Scantech supplied its first GEOSCAN unit to the phosphates industry in 2014. This followed the company's success with numerous installations for a variety of other mineral commodities, as well as test work on client phosphate samples to verify measurements and equipment performance.

The first phosphate industry analyser supplied by Scantech proved itself capable of delivering real-time phosphate process control with positive outcomes, based on frequent, high quality, reliable analysis results. Since then, Scantech has expanded into all the major global phosphate markets with more than 20 phosphate installations contributing to its total of more than 1,400 analysers in 80 countries worldwide.

A Middle Eastern customer, for example, has been able to obtain greater plant stability, and reduce the costs and delays associated with laboratory analysis, by installing a GEOSCAN unit close to the front end of their process. The delivery of PGNAA results every two minutes has enabled this production site to make process control decisions in real time.

An American phosphate complex also has a unit installed on the feed to their chemical plant. The customer uses GEOSCAN data to increase yields by actively controlling their acid reactor process, as well as controlling the phosphate feed to the plant. As a consequence, this GEOSCAN installation has enabled the company to make some very significant production gains.

Such process improvements and production cost reductions are not always widely publicised, according to Scantech, even when a 20 percent increase in throughput or more has been achieved by some phosphate producers within a month of installing a GEOSCAN unit.

PGNAA systems like GEOSCAN offer a number of advantages for on-belt analysis, suggests Scantech, relative to other automated analysis systems:

- **Comprehensive measurement:** across the full cross section continuously with 6 monthly standard calibration checks and improved accuracy as more material is measured
- **Deep penetration:** through the entire bed depth
- **Full-flow capability:** tonnages limited only by belt size and depth (from 100 t/h to around 17,000 t/h)
- **Reliable analysis:** no mineralogy or matrix effects (Ca, Fe), unaffected by layering, particle-size, dust and belt speed
- **Low maintenance:** analysis uses solid state components, is low cost, non-contact, with remote access for calibration support and troubleshooting
- **Local support:** staff located in each major region.
- **Easily combined with other sensor technologies:** for moisture analysis and PSD (particle-size distribution), also available from Scantech.

Following a successful recent evaluation, Scantech can now offer GEOSCAN-M PGNAA for slurry analysis, delivered over shorter time-scales and at higher precisions than previously available on the market. The analyser can see the whole flow through pipes with outside diameters of up to 0.5 metres.

PGNAA technology has also been developed for slurry analysis by San Diego-headquartered **SABIA**, Inc. The company manufactures two types of online analysers. 'On-belt' analysers continuously measure the elemental composition of bulk material on a conveyor while 'on-

CONTENTS

What's in issue 522

HIGHLIGHT 1

GPCA Agri-Nutrients Conference, Riyadh

HIGHLIGHT 2

Green fertilizers enter the fray

HIGHLIGHT 3

Medium-term market outlook

HIGHLIGHT 4

Automated process analysis

pipe' analysers are mounted around a slurry pipe to continuously measure the complete slurry stream.

Both types of PGNAA analyser have been installed by major North American phosphate producers and perform full stream, continuous, on-line, multi-elemental analysis. This penetrates the material flow for a completely representative analysis without the need for frequent sampling or multiplexing. This non-intrusive multi-elemental analysis allows operators to simultaneously monitor elements of interest and see percentage composition changes/trends in essentially real-time.

The technology is uniquely suitable for high throughput (t/h or kg/m³ volumes) and fast flowing (m/s) bulk materials. SABIA analysers have no moving parts and are easy to install. Their integrated electronics only require two cables – for power and network access.

Many global phosphate producers are considering installing PGNAA to optimise their downstream processing, improve mine grade control, and carry out stockpile blending more expertly. The range of applications includes:

- Run of mine (ROM) bulk sorting
- Stockpile reclaim analysis
- Monitoring of washed phosphate stockpile
- Mine loadout tracking for trains or trucks.

A number of additional applications are also under evaluation:

- Analysis of feed fertilizer and food-grade acids
- Carbonate concentrate/tailings
- Low-grade kiln feed
- Beneficiation recovery
- Flotation final products
- Chlorine/water balance
- Blending/reagent control in flotation cells.

Nuclear magnetic resonance

Massachusetts-headquartered **LexMar Global** is the world's leading provider of Nuclear Magnetic Resonance (NMR) analysers for process control. Within the industry, these installations are commonly called Industrial Magnetic Resonance (IMR) systems.

The company has installed more than 400 analysers globally in 45 countries, and operates regional service centres in Belgium, Texas, Morocco, Abu Dhabi, and China. Phosphate industry customers include major players Ma'aden, Mosaic,



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PotashCorp and OCP, as well as chemical and oil giants such as ExxonMobil, Dow and Borealis. Other markets the company is supplying include polyolefin resin manufacturing and mining.

LexMar Global produces the MagModule II IMR analyser for on-line process measurements on phosphate slurries. These are supplied with either multiplexer or metallurgical sampling systems. The advantages of NMR technology include:

- Direct analysis of phosphate content – as either weight percentage $\text{Ca}_3(\text{PO}_4)_2$ (BPL, bone phosphate of lime) or P_2O_5
- Powders, pellets, slurries and liquids can all be measured
- Non-destructive, rapid analysis with results in less than five minutes
- Stable calibration – no routine re-calibration required
- No sample preparation necessary
- Analysis is independent of particle size
- Robust instrumentation with rugged industrial design and construction
- Avoids use of radioactive materials.

MagModule II on-line phosphate analysers can be installed at different process stages. Units can be placed at the beneficiation stage, to monitor and help regulate froth flotation, further downstream in acid reactor feed control, or upstream in mining operations. The benefits of this include:

- Greater P_2O_5 recovery with consequently better usage of phosphate rock reserves and less wastage
- Increased plant efficiency and higher production rates
- Lower production costs
- Avoidance of contract penalties.

Coupling the analyser to an automated multiplexer is advantageous as it allows a single analyser to take routine measurement from multiple sample points without interrupting operations.

IMR technology is capable of delivering comparable, consistent results. Analysers are calibrated for P_2O_5 content by comparing IMR results with laboratory reference measurements over a range of different phosphate compositions. According to LexMar Global, IMR calibrations are intrinsically more stable than those required for alternative techniques such as X-Ray fluorescence (XRF).

One of the main benefits of on-line IMR analysis is that it allows more timely process decisions to be made which, in turn, leads to more consistent product quality. The



LexMar Global's MagModule II IMR analyser

resulting process improvements can deliver large annual savings and rapid payback.

"Improved process control is the primary benefit of incorporating on-line analysers into your plant," explains Dr Olaf Kohlmann, LexMar Global's NMR product manager and strategist. "On-line magnetic resonance will give you phosphate concentration readings within a few minutes. Having real-time information about the process status 24/7 allows the engineers to optimize production for a plant."

He adds: "Even if you could only improve P_2O_5 recovery by one single percent, the payback is significant, and the lifespan of your reserve is improved. The amount of material moving through your process decreases. Efficiency, production costs, opex, will all start to go in the right direction."

IMR analysis of conveyor belt feeds provides continuous real-time information on the grade (BPL) of phosphate rock, enabling precise quality control at the very start of the process. It also helps reduce waste rock.

In froth flotation, IMR analysis again provides real-time BPL data for flotation feeds, concentrates and tailings, improving P_2O_5 recovery during beneficiation and preventing the over- or under-application of flotation chemicals. When combined with an automatic multiplexer, MagModule II has the ability to sequentially sample from and analyse up to four different process streams.

IMR on-line analysers can also be installed further downstream at the reactor stage in the phosphate production process. Using the technology to monitor feedstock helps optimise reactor control and improves P_2O_5 recovery and efficiency. Other tangible benefits include reduced production costs and improved product quality and consistency.

The installation of IMR on-line analysers provides rapid payback on investment and delivers long-term profits, according to LexMar Global, even if P_2O_5 recovery is improved by just a small percentage, due to the operating cost reductions achieved and improved mine life.

The growing need for mining industry automation will open up even greater opportunities for on-line analysis in future, in Dr Kohlmann's view. "As limited global reserves are expended, but demand increases, innovative process optimisation techniques and refinement efficiencies will become increasingly necessary to compete in the global market," he concludes.

Laboratory robots

Alsys International has been developing robots, including manufacturing parts and writing software for these, for nearly 30 years, having been founded by the chemical engineer Marc van Beelen in 1992. Marc started developing robotic systems to tackle and overcome the many problems he encountered during his decade-long experience in the laboratory sector. One particular problem – eliminated by the use of robots – is the high margin of human error in extremely accurate measurements.

Alsys currently has four product lines on the market:

- Fertilizer robot
- End-group (oleochemical) robot
- Compact robot
- Soil robot.

The main benefits of these robots versus manual analysis are:

- Automated sample preparation
- Integrated analysis techniques
- Reliable analytical results
- Modern data processing
- A safe working environment
- A four-day runtime without the need for an analyst.

Alsys has specialised in building lab robots for the sample preparation and analysis of fertilizer industry raw materials and end products for 20 years. Its fertilizer robot (Alsys RB-247) analyses for phosphorus, potassium, magnesium and other key nutrients/impurities in fertilizers. This fully automated laboratory unit uses Metrohm titrators, Mettler moisture analyser and Metrohm Ion chromatography. Its main functions and operations include:



Alsys laboratory robot.

- Autonomous assessment of solid and liquid samples
- Sample dissolution in water (both cold and boiling) and acid
- Moisture analysis
- Ion chromatography
- ICP
- Flow Injection
- Spectrometry.

The unit has the ability to analyse both raw materials and processed samples. Options include:

- Titration and potentiometric determinations

Alsys robots integrate with enterprise resource planning (ERP) software, SAP and other laboratory information management system (LIMS). With a sample prepara-

ration plus analysis time of around eight minutes, they are capable of analysing around 150 samples a day.

The company's fertilizer industry customers include ICL, ICL Iberia, Iberpotash and Forbon.

"We've been working with the lab robot from Alsys International for about 14 years now and are currently running a fully digital production. Samples are taken directly from the mine to the robot for analysis. The data is integrated with LIMS and SAP. We now receive faster, more accurate and digital measurements on ore quality from the mine," said a laboratory manager at an Israeli mining operation.

The latest development from Alsys is the soil robot. By measuring soil nutrients, this will be able to give fertilization advice based on the analytical results obtained. Currently, the company is looking to offer a robot with the capacity to prep and analyse 1,000 soil samples per day. Soil analysis is a potentially lucrative, large-scale market due to the large difference in unit price between manual and robotic analysis. ■

CONTENTS

What's in issue 522

HIGHLIGHT 1

GPCA Agri-Nutrients Conference, Riyadh

HIGHLIGHT 2

Green fertilizers enter the fray

HIGHLIGHT 3

Medium-term market outlook

HIGHLIGHT 4

Automated process analysis

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CONTENTS

What's in issue 522

HIGHLIGHT 1

GPCA Agri-Nutrients Conference, Riyadh

HIGHLIGHT 2

Green fertilizers enter the fray

HIGHLIGHT 3

Medium-term market outlook

HIGHLIGHT 4

Automated process analysis

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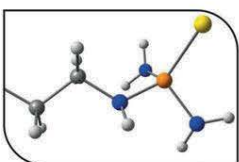
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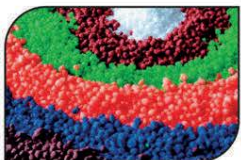
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CONTENTS

What's in issue 522

HIGHLIGHT 1

GPCA Agri-Nutrients Conference, Riyadh

HIGHLIGHT 2

Green fertilizers enter the fray

HIGHLIGHT 3

Medium-term market outlook

HIGHLIGHT 4

Automated process analysis

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