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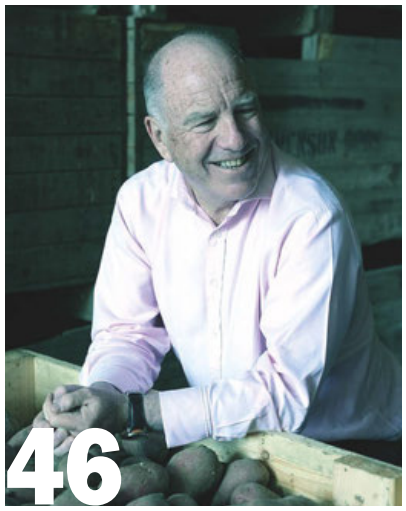

We talk partnerships with the CEO of CCm

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PHOSPHATES AND POTASH INSIGHT

REGULARS

Nourishing soils, nourishing people

Michael Twining, Vice President of Sales and Marketing, Willard Agri-Service.

PHOTO: MICHAEL TWINING

Michael Twining, Vice President of Innovation, Willard Agri-Service gave a memorable and well-received keynote at this year's International Fertilizer Association (IFA) Annual Conference in Monaco. In this guest editorial, he returns to his theme of purpose in the fertilizer industry – and our role as *the* experts at nourishing soils and therefore people.

"It has never been more important to help people understand that the nutrition on their dinner plates is the direct result of a farmer feeding their soils balanced reliable nutrients, managing healthy crop growth, and then harvesting those nutrients in the form of wholesome food."

In the northern hemisphere, fall is here! Fall is the traditional harvest season. For me, stepping outside into the cool, crisp air takes me back to the farm of my youth and the excitement of finally harvesting the crops our family had worked all season to grow. Farmers readily share stories about how much this field or that field has yielded.

There are two unfortunate truths about harvest:

First, most people have never seen a harvest or understand its link to the food they eat daily, nor are they aware of the complex food production system that provides the world with large, diverse quantities of quality foods. Most importantly, many people are unaware of the story of how nutrients used by farmers to grow crops – along with the energy crops receive from the sun and the CO_2 they absorb – ultimately reach their dinner plates. This process satisfies their hunger, supports life and health, and allows them to engage in meaningful work.

Second, the industry often uses language that most consumers find difficult to relate to or even comprehend. Whether it's farmers discussing yield in bushels or tons, or retailers and producers referring to fertilizers and inputs, we've developed a jargon based on our revenue sources. This means we might miss out on great opportunities.

The internet is full of negative claims about 'industrial' agriculture that is 'sterilising' or 'depleting' our soils. Hearing these misinformed statements, as someone who works with farmers daily, upsets me and drives me to shift the conversation from fear-based language to a solutions-focused mindset.

It has never been more important for the fertilizer industry to take the 'high ground' in helping people understand that the nutrition on their dinner plates is the direct result of a farmer feeding their soils balanced reliable nutrients (fertilizer), managing healthy crop growth, and then harvesting those nutrients in the form of wholesome food that we all can eat every day.

We (the fertilizer industry) form the backbone of **human nutrition**. In the daily rush of global commodity market analysis, production needs, shipping schedules, tonnage goals, and more, it's easy to miss some basic messages:

- We are *the* experts at nourishing soils and, consequently, people.
- The nutrients we supply farmers to replenish their soils each growing season are the same ones listed on food labels and that nourish us.
- Modern, technology-driven, regenerative farming methods improve nutrient efficiency. This creates systems that can scale globally to solve many environmental and human health problems.
- Balanced use of fertilizer is critical to the success of these systems.

Over the past year, I have pushed myself to step out of my comfort zone and publicly share the incredibly positive story we can tell the world about the future of food and farming. As I began this journey, I admit I was nervous that I might face criticism from those with agendas to promote fear and who are, frankly, misinformed.

What I have discovered is quite encouraging! Many people, far removed from agriculture, have responded with enthusiasm, commenting that they never knew how beneficial modern food production is and can be – especially when social sentiment and common-sense regulation encourage innovation in modern global agriculture and food production.

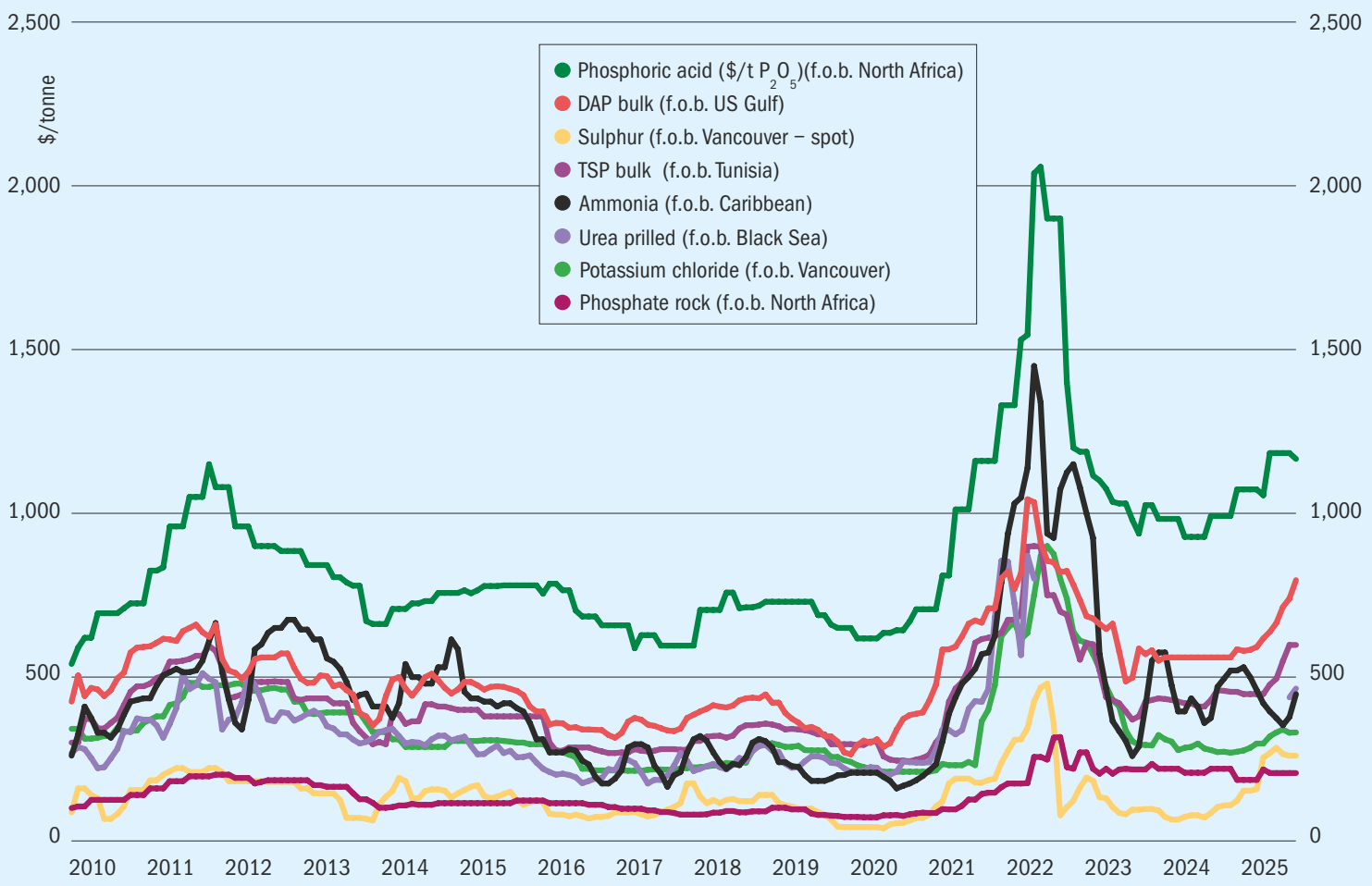
Alzbeta Klein, IFA's CEO, challenged the industry at this year's annual conference, saying, "We must move from mere input providers to true partners in sustainable food production." From my perspective as a father, an agricultural retailer, and an agricultural storyteller, I truly believe she's absolutely spot on with her focus.

We in the fertilizer industry have work to do, not only to share our past successes in solving problems, but also to innovate in ways that offer new solutions for the challenges to human health and planetary health that lie ahead! I believe people are literally and figuratively hungry to learn about the hopeful future that innovations in our industry are creating.

The future is bright. We are writing our future story today. How will your chapter read?

Market Insight

Historical price trends $/tonne



Source: CRU

PRICE TRENDS

Market snapshot, 21st August 2025

Urea slides on news China will supply India. Market sentiment reversed on yet-to-be confirmed news that additional shipments from China to India are to be allowed – with the prospect of this happening triggering a price correction. Market players see prices sliding below $500/t cfr in the next National Fertilizer Limited (NFL) India tender. That compares to $530/t cfr west coast paid by Indian Potash Limited (IPL) earlier in August.

Not all producers, however, are ready to accept the urea market slide. Pupuk Indonesia scrapped a 45,000 tonnes granular tender for September shipment after refusing to accept no-one would pay the $503/t f.o.b. asked. Iran has also struggled to secure the $435/t f.o.b. it was hoping for, with a consequent build up of 300,000 tonnes of inventory being reported.

Brazil, meanwhile, has seen piecemeal purchasing at $480-495/t cfr. Volumes are thin, as are offers, with traders pursuing better netbacks in India for September cargoes. There are growing concerns that Brazil's 2025 urea imports will fall well short of previous years, as buyers shift instead to plentiful and cheaper priced Chinese ammonium sulphate (AS).

Ammonia prices steady. Prices on both sides of Suez remain steady, except for a few upticks in some regions. All eyes are now on the next Tampa settlement, this being seen as an indicator of emerging upside pressures in coming weeks.

Market participants are currently expecting a moderate increase in the September Tampa price, with at least a 5% premium on the $487/t cfr fixed by Yara and Mosaic for August. Mosaic has been increasingly active on the spot and contract markets in recent weeks and the ammonia import line-up into Florida is strong at present. Export wise, ammonia shipments out of the US Gulf are also robust, with multiple cargoes departing or set to load from Texas and Louisiana.

East of Suez, ammonia exports continue to flow out of the Middle East at a steady rate, with no plant issues or turnarounds heard. Ma'aden said it will export 150,000 tonnes in September. Half of that total has been earmarked for delivery to India, where prices were largely stable.

Phosphate sentiment softens. DAP and MAP globally have experienced a period of relative stability in recent weeks, compared with the previous steep increases seen in 2025. While news of expanded export quotas from China has softened sentiment slightly, global availability remains tight overall, adding support to prices despite poor affordability.

Between 0.7-1 million tonnes of DAP/MAP have been allocated in China's latest export quota released on 20th August, according to sources. This total is said to comprise 550,000-600,000 tonnes of DAP and 100,000-150,000 tonnes of MAP, although other sources have indicated that DAP alone amounted to 700,000 tonnes out of a total allocation of one million tonnes.

A relative lack of supply from China has

Market price summary $/tonne – late August 2025

Nitrogen	Ammonia	Urea	Ammonium Sulphate	Phosphates	DAP	TSP	Phos Acid
f.o.b. Caribbean	448	-	f.o.b. E. Europe 265	f.o.b. New Orleans*	791	-	-
f.o.b. New Orleans*	-	433	-	f.o.b. North Africa	803	598	1,166
f.o.b. Middle East	330	495	-	cfr India	810	-	1,258
f.o.b. Black Sea	-	448	-	-	-	-	-
Potash	KCl Standard	K_2SO_4	**Sulphuric Acid**		**Sulphur**		
f.o.b. Vancouver	331	-	cfr US Gulf 163	-	f.o.b. Vancouver	270	-
cfr India	349	-	-	-	f.o.b. Arab Gulf	285	-
f.c.a. Western Europe**	-	605	-	-	cfr China	285	-
f.o.b. Baltic	306	-	-	-	cfr India	283	-

*Prices are on a bulk, spot basis, unless otherwise stated. Phosphoric acid is in terms of $/t P_2O_5 for merchant-grade (54% P_2O_5) product. Sulphur prices are for dry material. n.a. = not available. *$/short ton. ** €/t*

been the key reason for tight global availability. China exported 2.18 million tonnes of DAP/MAP in January-July this year, a 32% decrease from the same period in 2024.

Key DAP import market India, meanwhile, has remained steady at $810/t cfr, as fresh deals were awaited, while downwards pressure persisted in key MAP import market Brazil. DAP prices in Pakistan also climbed on a 60,000 tonne sale by Ma'aden.

Potash prices slip in Brazil and US. Granular potash prices have fallen modestly in Brazil and the US, while remaining stable elsewhere. The Brazilian MOP benchmark dropped to $355-360/t cfr, its lowest level since early May. Prices in the region peaked at $370/t cfr in July and then held at $360-370/t cfr for the next four weeks. Now, with the soybean season closed, prices have begun to decline on weak demand. In the US, potash activity has largely paused, with the market showing signs of softening – particularly in New Orleans, where prices have slipped to $335-340/st f.o.b.

In India, potash imports have surged, with 355,000 tonnes arriving by 20th August, marking a significant increase compared with last year. Demand, however, remains slow, and stock building at ports has seen inventories doubling to 142,000 tonnes in just two weeks.

In China, domestic potash prices have risen, despite weak demand and rising NPK stocks, with port prices averaging RMB3,240/t ($451/t) fca.

Bullish sulphur market. The Middle East sulphur spot price was assessed at $280-290/t f.o.b., up by $20/t in a week. The increase in regional pricing follows a rise in Asian demand, with firm offers currently at around $300/t cfr. While yet to be confirmed, the final award price for the latest QatarEnergy Marketing tender could be above $290/t f.o.b., according to sources.

China's sulphur port prices also surged to RMB 2,520-2,540/t fca ($351-354/t), supported by Indonesian tenders, relatively high phosphate operating rates and limited availability. This range indicates a delivery price of $301-304/t cfr.

Delivered prices into Indonesia were assessed up at $286-290/t cfr. The country's January-June sulphur imports have increased by 74% year-on-year reaching 2.59 million tonnes. Seaborne sulphur export prices from Canada also rose to $265-275/t f.o.b. on Asian demand, although little activity was reported.

OUTLOOK

Urea price direction uncertain. Strong urea demand in India was expected to trigger price escalation. Market sentiment has, however, reversed recently on yet-to-be confirmed news that additional shipments from China to India are now to be allowed. A move by China to export to India could see Middle East and Russian prices take a downturn. Affordability is also exerting downside pressure with Brazil, Europe and US showing negative margins against current price levels.

Ammonia to climb into fourth quarter. Ammonia prices look set to rise through to the end of year, before finally easing heading into 2026. The tightening in supply west of Suez has seen prices gain further ground through July and triggered a $70/t hike in the August Tampa settlement. The start of exports from new capacity in the US Gulf could, however, see the market correct downwards. Equally, a decision heavily in favour of domestic production in northwest Europe could see import appetite – and therefore cfr values – retreat.

Phosphate near their ceiling. A price ceiling may now be in sight as buyer resistance to high prices grows across the globe. Still, some further upside is possible over the coming weeks, before third quarter declines set in as supply improves. Supply tightness is, however, likely to limit any price downside. Conversely, prices may trend lower if supply, particularly from China, is stronger than expected.

Potash prices poised to fall. After months of gains, global spot potash prices have been revised slightly lower, reflecting the seasonal slowdown following contract settlements in India and China. Weak underlying demand has prompted a more bearish outlook, with prices now forecast to decline over the next 12 months. Prices could drop more sharply than expected, if demand weakens further and/or crop price declines negatively affect affordability.

Sulphur declines moderate. Sulphur price declines are expected to be less steep than previously forecast, with recent activity in Asia supporting price levels for longer. In the short term, global sulphur prices are expected to stabilise before loosening, as buyers resist the price environment and muted demand continues in most regions until later in the third quarter. Middle East prices are projected to decline from August through November, followed by a modest recovery in December and January.

CANADA

Jansen first production pushed back to mid-2027

PHOTO: BHP

The first stage of BHP's Jansen project in Saskatchewan, Canada, is now 68% complete.

BHP is now expecting first potash production from stage one (S1) of its Jansen mega project in Saskatchewan, Canada, in mid-2027. This has been pushed back by around six months from the previous end of 2026 date for initial mine production.

The start-up delay was announced in mid-July alongside a steep increase in the project's investment costs. The Australian mining giant now estimates that the Jansen project's capital cost will be between $7-7.4 billion, up from its previous estimate of $5.7 billion.

BHP blamed higher project costs on inflationary pressures, changes to the mine's design and scope, and lower-than-expected productivity.

BHP also announced it was considering delaying first production from Jansen's second stage (S2) by two years to its 2031 financial year, due to the potential for extra medium-term potash supply coming to market. This was later confirmed in BHP's annual report published in mid-August

"While consumer inflation has fallen to close to two per cent in Canada, price growth for industrial construction works has been significantly stronger, increasing by over 10 per cent in the past two years in Saskatoon," the report said. "This has placed upwards pressure on costs for Jansen."

The Jansen mine's first stage is 68% complete, according to the report, and will have a capacity of 4.15 million tonnes per annum (t/a) once complete. Jansen's second stage, meanwhile, is currently 11% complete and is expected to eventually expand potash production capacity by an extra 4.36 million t/a.

Commenting on recent developments, Saskatchewan's Ministry of Energy and Resources said: "[It] appreciates the commitment that BHP continues to make towards developing the Jansen Stage 1 and Stage 2 projects. Jansen is the largest investment in Saskatchewan's history and will be the largest potash mine in the world. Updates to scope, cost and timelines are common in the development of major natural resource projects of this scale.

"We look forward to seeing the first production from BHP's Jansen mine, now planned for 2027. This aligns with the initial timeline for first production at Jansen, before it was accelerated to 2026."

Despite the escalation in capital expenditure, BHP still expects the Jansen project to be one of the potash industry's lowest-cost mine sites globally, once production is fully ramped up. ■

MOROCCO

OCP Nutricrops surpasses 5 million tonnes of TSP

In late July, OCP Nutricrops announced that its triple superphosphate (TSP) production capacity now exceeds five million tonnes.

This was thanks to the commissioning of the first two TSP production lines – each with an annual capacity of 500,000 tonnes – as part of the strategic 'TSP Hub' programme at OCP's massive Jorf Lasfar complex. This initiative is led by the OCP Group's Manufacturing Special Business Unit (SBU) in coordination with OCP Nutricrops, OFAS and JESA.

PHOTO: OCP

OCP's TSP Hub at Jorf Lasfar is an industrial programme designed to support changing agricultural practices and address diverse fertilization needs.

These flexible production lines can manufacture tailored fertilizers that integrate nutrients and additives to match specific soil and crop needs, OCP Nutricrops said.

TSP is a concentrated fertilizer containing over 90% plant-available phosphorus and, according to the company, is ideal for nutrient-deficient soils and fertilization practices that meet 4R principles (right source, right rate, right time, right place).

OCP Nutricrops plans to expand its TSP production capacity further by adapting existing nitrogen fertilizer units. This is expected to increase the company's annual TSP capacity to more than seven million tonnes by the end of 2025.

Welcoming the launch of the TSP Hub, Youssef El Bari, the CEO of OCP Nutricrops, said: "The TSP Hub strengthens our ability to deliver high agronomic value fertilizers tailored to specific soil and farmer needs, while enhancing industrial precision and capacity."

OCP Nutricrops has also signed a commercial agreement to supply the Bangladesh Agricultural Development Cooperation (BADC) with 1.1 million tonnes of fertilizers. The deal was signed in early July during an official visit by a Bangladeshi delegation to Morocco.

"By providing tailored fertilizers and promoting their responsible use, this partnership reflects a shared vision to strengthen the foundations of a self-sufficient agricultural future for Bangladesh, grounded in science, innovation, and sustainable collaboration," BADC and OCP Nutricrops said in a joint statement.

Commenting on the partnership with BADC, Youssef El Bari said: "This agreement reinforces a long-term strategic relationship and paves the way for new collaborations in research, training, and innovation."

In reply, Ruhul Amin Khan, BADC's chairman, said: "We are very optimistic about strengthening our cooperation in various sectors of Bangladeshi agriculture through innovation, logistical support, technology transfer, training, and more."

BRAZIL

Mosaic agrees to sell Taquari potash mine

The Mosaic Company announced an agreement to sell Mosaic Potassio Mineração Ltda (MPM) to VL Mineração Ltda on 13th August.

MPM is the Mosaic subsidiary company that operates the company's Taquari-Vassouras potash mine in Rosário do Catete, Sergipe, Brazil.

VL Mineração will pay Mosaic up to $27 million in cash for the potash mine. This includes $12 million upon closing, $10 million one year after closing and $5 million over six years. The new owner will also assume responsibility for approximately $22 million in asset retirement obligations (ARO).

To ensure its continued viability, Mosaic would have needed to invest more than $25 million in the Taquari mine – capital that it says, "has more attractive uses elsewhere within the company". VL Mineração, in contrast, has expressed a strong interest in making the necessary investments to extend Taquari's operations, for the benefit of the economy, employees and the community locally.

"One of our priorities is to elevate our core business, and one way to do that is by reallocating capital to ensure we're investing where we have the greatest capacity to succeed. This sale advances progress toward that priority – allowing us to focus capital on opportunities where we have a competitive advantage and are expected to generate higher returns," said Bruce Bodine, Mosaic's president and CEO.

"This agreement allows us to contribute to the development of Brazilian agriculture, including maintaining and expanding the domestic potash supply in the fertilizer market, as we are confident the mine will be profitable and efficient under our ownership and operating model," said Daniel Moreira, CEO of VL Holding.

Mosaic expects the transaction to close by the end of 2025. The sale is, however, subject to approval by the Brazilian Administrative Council for Economic Defense (CADE) and other customary closing conditions. The company says that, from the third quarter of 2025 onwards, it will record the asset as 'held for sale' with an expected book loss of $50-$70 million.

Mosaic opens new Tocantins distribution hub

The Mosaic Company began operating its new blending, storage and distribution plant in Palmeirante, Tocantins, Brazil, in July.

The company held an inauguration ceremony with invited state and local officials on 16th July, hosted by Jenny Wang, its Executive Vice President, Commercial

The Palmeirante blending plant has the capacity to process one million tonnes of fertilizer annually – including approximately 500,000 tonnes this year – and expands Mosaic's distribution presence in the fast-growing agricultural northern region of Brazil.

It will be key contributor to Mosaic's ambitious fertilizer expansion plans in Brazil. The company is aiming to increases domestic distribution sales from less than eight million tonnes in 2024 to 13-14 million tonnes by the end of the decade.

The $84 million investment in Palmeirante was completed on time and within budget. The plant is expected to earn a margin of $30-$40 per tonne of fertilizer and generate an internal rate of return (IRR) above 20%.

"The inauguration of our new plant in Palmeirante represents meaningful progress for Mosaic," said Jenny Wang, Executive Vice President, Commercial. "Brazil is an agricultural powerhouse, and Mosaic has been a leader in the market for many years. We are providing farmers in the MATOPIBA region with more efficient access to the fertilizers they need and expanding Mosaic's presence in a key growing region."

The Palmeirante complex includes warehouse capacity, automated blending

and bagging systems, and a direct rail connection to the port of Itaqui. It is expected to reduce logistics costs and provide state-of-the-art quality control.

GERMANY

New crop-specific blending plant

The opening of a new fertilizer blending plant in August will provide farmers in northern Germany with better access to high-quality controlled-release fertilizers (CRFs), thanks to a new collaboration between ICL and Landhandel Peters.

PHOTO: ICL

A new blending plant operated by Landhandel Peters will provide famers in northern Germany with access to ICL's Agromaster controlled-release fertilizers.

The new Winsen/Luhe plant enables Landhandel Peters to produce crop-specific fertilizer mixtures on site and on demand. Whether for asparagus, potatoes, soft fruit, maize or vegetables, these blends are fine-tuned to meet the soil and crop requirements of farmers. The overall aim is to provide farmers with fast, flexible service backed by trusted technical expertise.

The new blends produced by Landhandel Peters will incorporate ICL's Agromaster CRF technology. Unlike conventional uncoated fertilizers, Agromaster delivers nutrients gradually over time, matching the uptake needs of the plant throughout its growth cycle. This means farmers can fertilize their crops less frequently, reducing the number of treatments, while confidently meeting their crop nutrient requirements over the entire growing season.

The use of CRFs also helps protect against nutrient losses through leaching, volatilisation and denitrification – making it a more efficient and environmentally responsible fertilizer choice.

The Agromaster formulations blended at the Winsen/Luhe plant will contain between 35-60% coated nitrogen, depending on crop demand. By improving nitrogen use efficiency, growers can typically achieve equal or higher yields using fewer nutrient inputs, says ICL, a win for both productivity and sustainability.

In lighter soils, Agromaster also helps to reduce potassium losses and avoid phosphorus fixation, both of which are common challenges in this region of northern Germany.

Stephanie Preller, marketing specialist at ICL Growing Solutions, said: "With faster delivery, individual nutrition specifications, and top-tier product performance, the blending plant offers a powerful new tool to support productive, sustainable agriculture in northern Germany."

UNITED STATES

Donaldsonville ready for permanent CO_2 sequestration

The carbon dioxide (CO_2) dehydration and compression unit at CF Industries' nitrogen production complex at Donaldsonville, Louisiana, is ready to start up. The unit enables the transportation

and permanent geological sequestration of up to two million t/a of CO_2 generated at the site – emissions that would otherwise enter the atmosphere.

ExxonMobil, CF's carbon capture and sequestration (CCS) partner at Donaldsonville, is responsible for transporting the CO_2 and its permanent storage. The company is currently using enhanced oil recovery to geologically store CO_2 generated at the complex.

However, once it has the necessary permits, ExxonMobil is planning to transport and store the CO_2 from Donaldsonville at dedicated permanent sites, starting with its Rose CCS project. This is one of a number of dedicated storage sites ExxonMobil is developing along the US Gulf Coast as it expands its integrated CCS network.

The US Environmental Protection Agency issued a draft Class VI permit for the Rose CCS project in July, with final permits expected later this year.

"The start-up of the Donaldsonville carbon dioxide dehydration and compression facility and initiation of sequestration by ExxonMobil is a historic milestone in our Company's decarbonization journey," said Tony Will, president and CEO of CF Industries. "By starting permanent sequestration now, we reduce our emissions, accelerate the availability of low-carbon ammonia for our customers and begin generating valuable 45Q tax credits."

As a result of its Donaldsonville CCS project, CF Industries anticipates producing approximately 1.9 million tonnes of low-carbon ammonia annually. The company also expects to qualify for tax credits under Section 45Q of the Internal Revenue Code, which provides a credit per tonne of CO_2 stored.

Beaumont NH_3 project 95% complete

The ammonia train at the under-construction Beaumont ammonia project in Texas is now 95% complete, according to owner Woodside.

The 1.1 million t/a capacity ammonia project is targeting first production of standard 'grey' ammonia in late 2025. The company will then shift to lower-carbon ammonia production in the second half of 2026 once carbon capture and storage (CCS) operations commence. The project is positioning Woodside as an early mover in the lower-carbon ammonia market.

Woodside's latest half yearly report revealed that construction on the 'Train 1' ammonia production line, which continues to be managed by former owner OCI, was 95% complete at the end of June 2025.

Completion of the Beaumont project, together with the payment by Woodside of the remaining 20% of the purchase price to OCI, is expected in 2026.

Project landmarks achieved during the first six month of 2025 include completion of the electrical substation and storage tank construction. Pre-commissioning activities also commenced during January-June this year as construction neared completion.

Woodside says it is conducting marketing activities to support ammonia sales from the project.

Pursell launches Stampede

Pursell Agri-Tech launched Stampede, its new NPK fertilizer range, at the Southwestern Fertilizer Conference (SWFC) in Nashville in July.

Featuring premium-grade NPK products, the new range is designed to efficiently deliver a well-balanced supply of nitrogen, phosphorus, and potassium – by combining ammonium and nitrate nitrogen, 100% water-soluble phosphate, and potassium in homogeneous prills.

Stampede NPKs are "ideal for improving plant health and stress tolerance, early crop growth, and root development, as well as flowering and fruiting", according to Pursell. Customised formulations with additional macronutrients and micronutrients will also be available. Key benefits include:

- Homogeneous, dust-free prills to ensure even distribution and consistent nutrient delivery
- Dual nitrogen forms: nitrate for quick uptake and ammonium for maintained feeding
- Low salt index that is gentle on sensitive plants and seedlings
- Easy, precise application for accurate calibration and uniform feeding.

The launch of Stampede follows Pursell's appointment of Richard Newman as its Director of NPK Sales in May. Mr Newman will be responsible for the company's overall strategy for NPKs and strengthening Pursell's innovative product offerings.

UNITED KINGDOM

Anglo sets out path to Woodsmith FID

Anglo American has set out three pre-conditions that would allow its UK Woodsmith polyhalite project to proceed to a final investment decision (FID). These are likely to be met in 2027 at the earliest, according to the company

The conditions were laid out in a statement accompanying the company's first half 2025 results: "First, a feasibility study would need to be completed, which requires sufficient information from the sandstone strata to confirm key assumptions. The second condition is a clear pathway to syndication for value. Finally, the group's balance sheet would need to be sufficiently deleveraged."

Anglo American announced major cuts to capital expenditure on its Woodsmith polyhalite project in May 2024 – effectively mothballing the project – with this declining to $300 million in 2025 and then to zero in 2026, as the company deleverages its balance sheet and looks for an investor/strategic partner to take an ownership stake (*Fertilizer International* 523, p32).

The Woodsmith mine is located in North Yorkshire, near Whitby, close to England's North Sea coast. An Anglo American spokesman told the *Yorkshire Post* in July that construction of the service shaft, the tunnel and other engineering activities at Woodsmith have been continuing since the announced slowdown last year.

He said there are still 1,100 people employed on the project currently, adding: "During this time we are progressing critical value-adding works – completion of critical studies and shaft sinking activities – to de-risk the overall project schedule and further optimise certain scopes of the project ahead of consideration by the board for approval and subsequent project ramp-up, which is anticipated from 2027."

While the sinking of Woodsmith's main production shaft was paused in June 2024, sinking of the service shaft through the Sherwood Sandstone formation is continuing. Tunnel boring for the project's mineral transport system (MTS), while also slowing, has continued during 2025 – and has now reached around 29.6 kilometres, approximately 80% of its total 37 kilometres length.

Speaking during an earnings call on 31st July, John Heasley Anglo American's CFO, said the company was gaining valuable information from the sinking of the service shaft into the Sherwood Sandstone, a water-bearing layer of hard rock. "These learnings are setting us up very well to continue to sink one of the two main shafts," Heasley said.

Heasley confirmed that the company was working towards meeting the three FID conditions for the UK mining project from

2027 onwards, and that discussions with a number of potential strategic partners were going well. “While Woodsmith remains a compelling opportunity and has the potential to be a flagship asset in this portfolio, we only see these three conditions being fulfilled by 2027 at the earliest,” he said.

In its first half results for 2025 released at the end of July, Anglo America reiterated that: “The expected final design capacity [of the Woodsmith mine] remains c.13 Mtpa, subject to ongoing studies and approval. Work is also continuing to identify and secure one or more strategic syndication partners for Woodsmith ahead of consideration by the Board for approval and subsequent project ramp-up, anticipated from 2027.”

Anglo American has earmarked around £300 million for capital expenditure on core infrastructure at the Woodsmith project in 2025, having spent $184 million of this during the first half of the year.

IRAQ

KBR awarded ammonia-urea project FEED contract

KBR been awarded a front-end engineering design (FEED) contract for the development of an ammonia and urea production plant by KAR Electrical Power Production Trading FZE (KEPPT) in Basra, Iraq.

Under the terms of the contract, KBR will provide FEED for the 2,300 t/d capacity ammonia production unit and a 3,850 t/d capacity urea production unit. The project’s FEED will be based on KBR’s proprietary ammonia technology. Being designed for high efficiency, low emissions, and operational reliability, this technology should help KEPPT achieve the lowest overall capex for the Basra ammonia unit and optimise the construction schedule.

“We are honored to support this pivotal project, which monetizes gas feedstock to boost the agricultural industry in Iraq,” said Jay Ibrahim, President, KBR Sustainable Technology Solutions. “Underlined by KBR’s expertise in market-leading ammonia solutions and proven FEED capability, this initiative should generate employment and reduce the dependency of fertilizer imports, while repositioning Iraq as a global ammonia producer.”

KBR has been involved in the licensing, design, engineering and/or construction of more than 260 ammonia plants worldwide.

RUSSIA

Ammonia-urea project gets funding approval

Russia’s Ammoni JSC can move to the construction phase for the Ammonia-2 plant at its Mendeleevsk complex in the Republic of Tatarstan, having now received funding approval from the regional government.

The new RUB160 billion ($1.7 billion) plant will have capacity to produce up to 1.2 million tonnes of ammonia and 1.75 million tonnes of urea. It could be operative by 2028, according to news agency reports.

Ammonia-2 will be constructed next to the company’s existing Ammonia-1 plant at Mendeleevsk. The new plant will be largely export-oriented, with around 80% of the urea produced earmarked for the global market, according to project head Alexander Osipov, despite its location in the Russia interior.

‘Friendly’ export markets such as Latin America and India will be specifically targeted, Osipov said.

In November 2023, Ammoni agreed a contract with Gazprom Mezhregiongaz to secure a gas supply of around 1.3 billion cubic metres/year for the Mendeleevsk complex for the next 30 years.■

People

The Indian Farmers Fertiliser Cooperative Limited (IFFCO) has appointed **K J Patel** as its new managing director. Patel, whose career with IFFCO stretches back nearly four decades, steps into the role with extensive experience in cooperative management and a deep understanding of IFFCO's business.

Patel joined IFFCO in 1985 as an apprentice graduate engineer. During his subsequent career, he has held several senior leadership positions at IFFCO, across various production units, including a notable stint as head of the Paradip unit in Odisha. Under his leadership, this unit underwent major improvements in operational efficiency, energy management and modernisation, earning multiple accolades for sustainability and productivity.

Patel expressed his personal gratitude to the IFFCO board and member cooperatives for appointing him. He also praised his immediate predecessor as managing director, **US Awasthi**, whose leadership was instrumental in establishing IFFCO as a global leader in the cooperative and fertilizer sectors.

"It is a privilege and a profound responsibility to follow in the footsteps of Dr Awasthi. IFFCO has always stood for the prosperity of the nation and Indian farmers, and I am committed to carrying that legacy forward with innovation, sustainability, and cooperative strength," Patel said.

Fertilizer Canada has appointed **Casper Kaastra**, the CEO of Sollio Agriculture, as the new chair of its board of directors.

Kaastra has served on Fertilizer Canada's board for more than five years and has been the association's vice-chair for the last two of these. He brings to his new role extensive experience in fertilizer distribution, specialty products and agricultural retail.

PHOTO: FERTILIZER CANADA

Casper Kaastra, the CEO of Sollio Agriculture, is the new chair of Fertilizer Canada.

"For over 25 years, I have been working to support and strengthen the agriculture industry," said Kaastra. "Farmers rely on fertilizer to reintroduce nutrients and maximise their yields. Ensuring a reliable supply and supporting product innovation is essential. This is an important time for the industry, and I look forward to working with my fellow directors and the Fertilizer Canada team to advance our sector."

Kaastra joined Sollio Agriculture in 2014 as the general manager of its crop production business, before becoming company CEO in 2021. Raised on a dairy farm near Aylmer, Ontario, he has dedicated his career to agriculture.

"Casper has been an invaluable member of the Board of Directors, providing business insights and beneficial perspectives from the retail and farm level," said Michael Bourque, president and CEO, Fertilizer Canada. "I'm pleased to see him take on this leadership position and look forward to working with him to advocate for increased competitiveness, strengthened supply chains, and greater awareness of the value of Canada's agri-food industry."

Kaastra succeeds **Lindsay Kaspick**, the regional marketing manager of Koch Fertilizer Canada, who will remain a board director.

In a coordinated move, Fertilizer Canada also appointed **James Wirth**, director, sustainable energy solutions at K+S Potash Canada, as its new vice-chair. Both the chair and vice-chair appointments have a two-year term.

Pursell Agri-Tech has appointed **Richard Newman** as its director of NPK Sales. In this role, Newman will play a key part in executing Pursell's overall strategy for NPKs and strengthening the company's product offering. Pursell recently launched its new Stampede range of NPK products in the US.

"I'm excited to join the talented team at Pursell and contribute to the continued growth and innovation of the NPK portfolio," said Newman. "There's a great opportunity to bring fresh strategy and long-term value to our customers, and I'm thrilled to be a part of it."

With almost 20 years of industry experience, Newman brings to Pursell a wealth of knowledge and a proven track record in both distribution and manufacturing. A graduate of the University of Florida, his career has focused on managing product portfolios and delivering strategic initiatives.

"Richard is already proving to be an asset to the Pursell team," said Tim Ferguson, CEO of Pursell Agri-Tech. "His background, expertise, and experience in the industry alongside his valuable strategic insights will help amplify the impact of our innovative product portfolio and optimize our collaboration with customers and partners."

Calendar 2025/2026

SEPTEMBER

15-17

TFI World Fertilizer Conference,
CHICAGO, United States
Contact: Valerie Sutton
Tel: +1 202-962-0490
Email: vsutton@tfi.org

16-18

37th AFA Technical Conference and Exhibition, BEN GUERIR, Morocco.
Contact: Arab Fertilizer Association
Tel: +202-23054464 – 67
Email: events@arabfertilizer.org

29 SEPTEMBER – 1 OCTOBER

15th GPCA Agri-Nutrients Conference, ABU DHABI, UAE
Contact: Faheem Chowdhury, Head of Events
Tel: +971 58 969 5448
Email: faheem@gpca.org.ae

NOVEMBER

3-5

CRU Sulphur+Sulphuric Acid Expoconference, THE WOODLANDS, Texas, USA
Contact: Event Client Services
Tel: +44 (0)20 7903 2444
Email: conferences@crugroup.com

DECEMBER

10-12

FAI Annual Seminar 2025, NEW DELHI, India
Contact: Secretary, The Fertiliser Association of India
Tel: +91-11- 46005204
Email: secy@faidelhi.org

APRIL 2026

13-15

CRU Phosphates+Potash Expoconference, PARIS, France
Contact: Event Client Services
Tel: +44 (0)20 7903 2444
Email: conferences@crugroup.com

AFA's 37th International Technical Conference & Exhibition

The University Mohammed VI Polytechnic (UM6P) in Benguerir, Morocco, is hosting this year's AFA Technical Conference & Exhibition.

PHOTO: UM6P

The Arab Fertilizer Association (AFA) will host its 37th International Technical Conference & Exhibition, 16-18 September 2025, at the prestigious University Mohammed VI Polytechnic (UM6P) in Benguerir City, Morocco. The theme of this year's event is 'Driving Innovation, Sustainability, and Collaboration in the Global Fertilizer Industry'.

Welcome to Morocco!

This year, AFA's International Technical Conference & Exhibition is being held in Morocco under the generous sponsorship of OCP Group and UM6P, reflecting their commitment to advancing knowledge, innovation, and sustainable practices in the fertilizer sector.

Recognised as one of the fertilizer industry's most influential gatherings, the conference regularly attracts more than 100 Chairs and CEOs from leading Arab and international companies each year, accompanied by their technical and commercial teams.

It serves as a premier platform where decision-makers, experts, and innovators exchange cutting-edge insights on the fertilizer industry's evolving landscape. The attendee profile spans the entire value chain, EPC contractors, technology providers, equipment manufacturers, catalyst and chemical suppliers, project management consultants, market analysts, and a host of other fertilizer stakeholders, making it a uniquely comprehensive networking and knowledge-sharing opportunity.

Innovation, sustainability and collaboration

This year's ambitious and diverse conference programme addresses the latest technological advances and strategic imperatives – covering nitrogen, phosphate, potash, and the emerging secondary and micronutrients essential for crop productivity.

The opening keynote will set the tone with high-level perspectives on fertilizer strategies in the face of global decarbonisation efforts, green initiatives, and increasingly stringent regulatory frameworks such as the EU's Carbon Border Adjustment Mechanism (CBAM). These discussions will explore the urgent need for producers to align operations with net-zero targets while maintaining competitiveness.

The technical sessions will cover a wide spectrum of transformative themes. Industry leaders and technology experts will delve into digital transformation, AI-driven plant optimisation, and smart process integration – showcasing how data analytics and automation are reshaping reliability, efficiency, and profitability.

Presentations will also highlight the innovative process technologies – from advanced ammonia and nitric acid production methods to breakthroughs

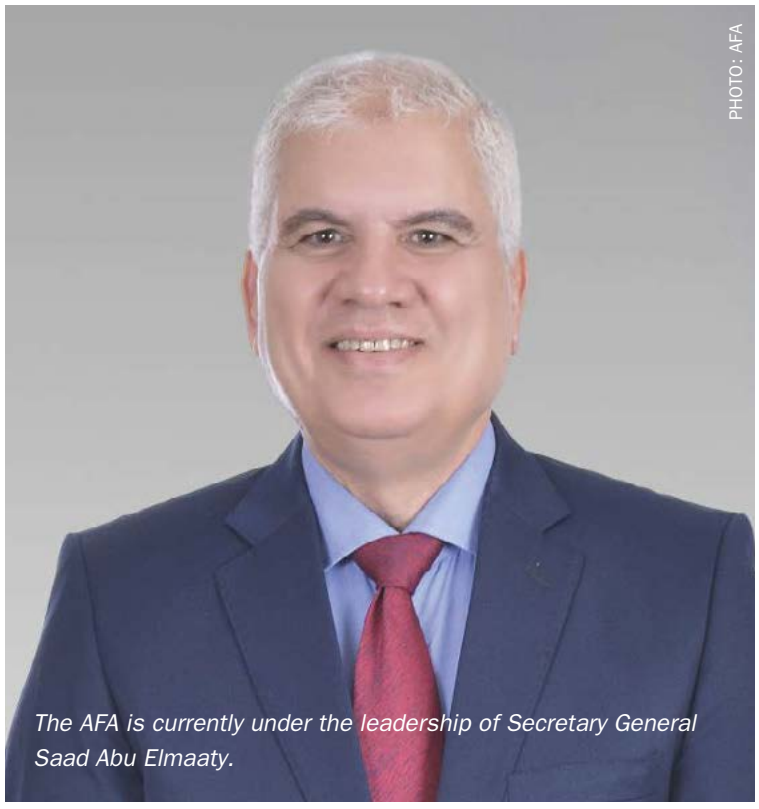


PHOTO: AFA

The AFA is currently under the leadership of Secretary General Saad Abu Elmaaty.

in sulphuric acid catalysts and CO_2 capture systems – that are redefining energy efficiency and environmental performance.

A strong focus will be placed on green innovations and process optimisation to accelerate the transition toward low-carbon fertilizers. Delegates will gain insights into resource valorisation initiatives such as metal content reduction in phosphate products, fluorosilicic acid recovery, and sustainable SOP production.

Other sessions will spotlight customised fertilizer solutions, high-purity water-soluble MAP production, and agronomic additives designed to boost nutrient efficiency while minimising environmental impact.

The conference will also address carbon capture and utilisation, with case studies on large-scale implementation at ammonia plants, post-combustion CO_2 capture feasibility, and the application of sulphur-enhanced urea to improve crop uptake and reduce emissions. The final segment will provide a global fertilizer market outlook, examining supply-demand dynamics, logistics challenges, and emerging trade flows, ensuring delegates leave with a comprehensive understanding of both technological and market trends shaping the sector's future.

Networking opportunities abound

Beyond the technical agenda, the event offers unparalleled networking opportunities through an engaging exhibition, strategic committee meetings, and a distinguished gala dinner. Together, these elements make the AFA's 37th International Technical Conference & Exhibition not just a forum for discussion, but a catalyst for actionable collaboration, inspiring participants to drive sustainable growth in the global fertilizer industry.

Register now!

AFA looks forward to welcoming sponsors, exhibitors and delegates to Morocco in September. Please register now at: arabfertilizer.org/technical-conference/registration/

Valorisation of fluorosilicic acid from phosphoric acid: a sustainable approach

In this article by **Marc Sonveaux**, Prayon's innovative approach to fluorosilicic acid (FSA) valorisation is explored, with a focus on its transformation into dicalcium phosphate (DCP) through a hydrochloric acid based process that combines FSA with sodium chloride and sulphuric acid.

Di-calcium phosphate (DCP) filtration cake generated by Prayon's new fluorosilicic acid (FSA) valorisation process.

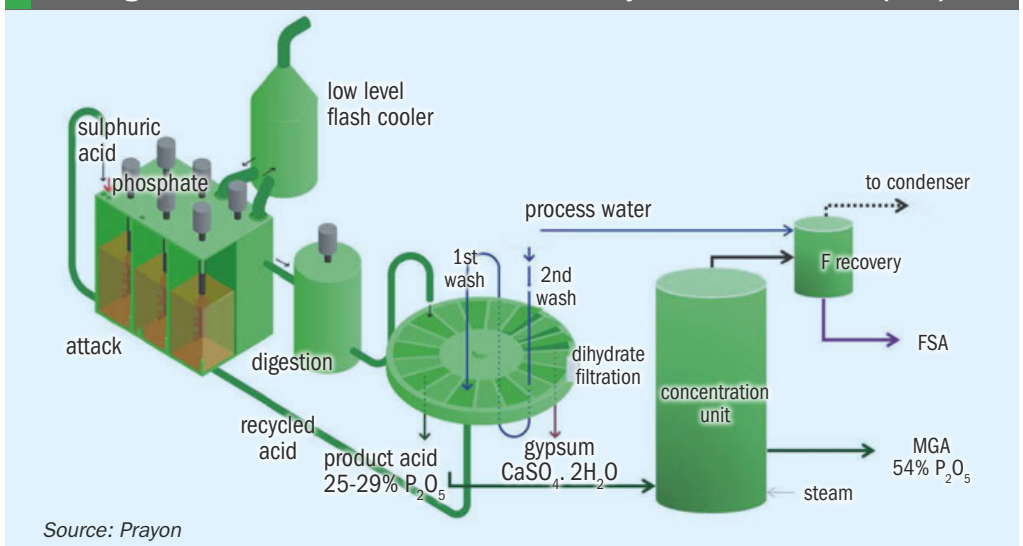
Introduction

The fluorine naturally present in phosphate rock is partially released during phosphoric acid production. These fluorine emissions need to be properly managed. In modern phosphoric acid plants, fluoride reacts with silicates to form fluosilicic acid (FSA) which can be captured using dedicated scrubbing systems.

Traditionally, the resulting FSA is typically regarded as a waste stream that usually needs to be neutralised or discarded – a viewpoint that is, however, increasingly outdated. Instead, with a growing emphasis on sustainability and the circular economy, industries are reevaluating by-products like FSA as potential resources instead.

This paper explores Prayon's innovative and circular approach to FSA valorisation, focusing on its transformation into dicalcium phosphate (DCP) through a process that combines FSA with sodium chloride and sulphuric acid.

Fig. 1: **Simplified scheme for Prayon's di-hydrate (DH) phosphoric acid plant – showing a concentration unit and fluorine recovery as fluorosilicic acid (FSA)**



Source: Prayon

FSA recovery in the phosphoric acid process

In the di-hydrate (DH) phosphoric acid process, the amounts of fluorine released during the initial reaction stage, which operates at low temperature and low acid concentration (26-28% P_2O_5), are too limited to be economically useful – and are therefore recovered in a gas scrubber to meet emissions regulations.

Instead, the majority of fluorine emissions occur during the concentration stage, being released primarily as silicon tetrafluoride (SiF_4) and hydrogen fluoride (HF). These gases are absorbed in water within fluorine recovery units, such as those designed by Prayon Technologies, forming an aqueous solution of fluorosilicic acid (H_2SiF_6), typically at 18-22% concentration (Figure 1).

Quantitatively, for every tonne of P_2O_5 produced, approximately 0.1 tons of FSA

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Balancing Productivity and Environmental Stewardship

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CRU

solution are generated. In a typical phosphoric acid plant producing 250,000 tons of P_2O_5 annually, this equates to roughly 17,000 tonnes of 100% FSA.

Rethinking FSA: from waste to value

There are several ways to remove FSA to ensure it is treated responsibly and complies with regulations.

FSA can also be neutralised with limestone or other chemicals, forming calcium fluorosilicate, which is stacked with phosphogypsum. While safer, this method incurs operational costs and requires investment in water treatment infrastructure.

FSA is also used to produce specialty fluoride products like sodium fluoride or aluminium fluoride. It can also be converted to sodium, magnesium or potassium fluorosilicates. The viability of these products does, however, depend on market demand, purity requirements, and production capacity.

But, by staying within the phosphate industry, FSA can also provide a commercially useful source of protons (acid). Valuably, this acidity can be harnessed to produce phosphate products. For example, FSA can produce dilute phosphoric acid if reacted with phosphate rock. Then, if the resulting filtrate is neutralised, di-calcium phosphate (DCP) can be produced. While such processes exist, they face challenges due to their poor filterability (linked to the presence of silicates forming gels), the high fluorine content of final products, and limited scalability.

Prayon's alternative: the HCl-based DCP process

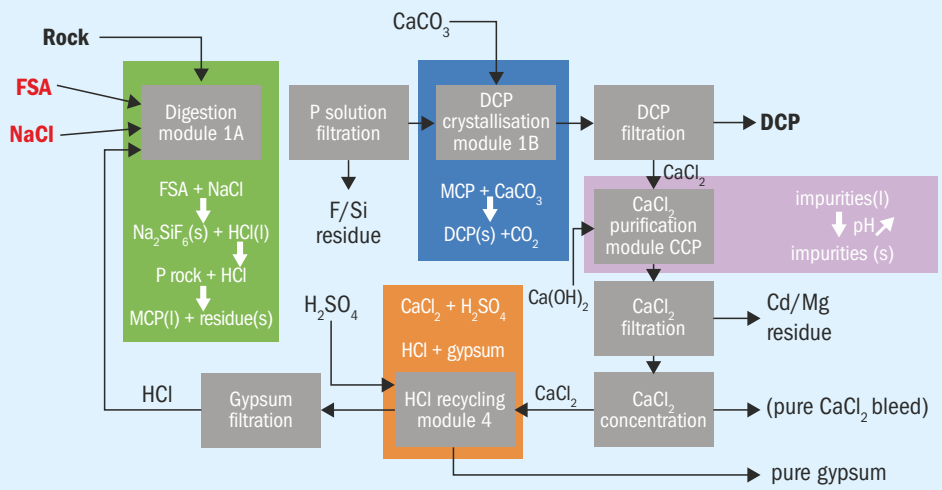
To overcome these challenges, Prayon has developed a novel process using FSA as an acid source, supplemented with sodium chloride and sulphuric acid (for hydrochloric acid regeneration), to produce high-quality DCP from low-grade phosphate rock, such as beneficiation tailings. An overview of this HCl-based DCP process is provided below.

Phosphate rocks containing 20-30% P_2O_5 were evaluated at pilot scale using the flowsheet shown in Figure 2.

The process consists of several integrated stages:

Digestion: Phosphate rock is digested using a mixture of FSA, sodium chloride (NaCl) and recycled hydrochloric acid (HCl). During this reaction:

Fig. 2: **Pilot-scale flowsheet for Prayon's HCl-based DCP process to recover FSA**



Source: Prayon

- Fluorine is removed as sodium fluorosilicate and calcium fluorosilicate.
- Insoluble materials such as silicates (sand), aluminium and iron are separated as filter cake.
- Approximately 75-95% of the fluorine and silicon introduced via FSA are removed in this stage.

Neutralisation: The filtrate resulting from digestion contains phosphate (in the form of monocalcium phosphate) and calcium chloride, along with dissolved magnesium and cadmium. Neutralisation with a calcium source (e.g., limestone) precipitates dicalcium phosphate (DCP) which is then dried. Depending on process parameters, the DCP can meet the quality specifications for animal feed applications.

HCl regeneration: To maintain process continuity and increase capacity, hydrochloric acid is regenerated from the calcium chloride stream as follows:

- The stream is purified via limestone neutralisation, removing cadmium and magnesium as solid residues.
- After optional bleeding, the purified calcium chloride solution is concentrated to balance water content.
- Reaction with sulphuric acid produces high-purity gypsum (≥99%, snow-white) and regenerates HCl – which is then recycled to the digestion stage.

Pilot-scale validation of the process was conducted at Technophos, Prayon's R&D facility in Bulgaria. This semi-industrial plant provides a processing capacity of up to 500 kg/h. Various phosphate rocks with P_2O_5 contents ranging from 20–30% were tested using the flowsheet in Figure 2.

The pilot-scale validation has shown the new HCl-based DCP process is feasible, with the following key outcome:

- **Process stability:** Smooth operation with consistent yields.
- **Efficiency:** Overall P_2O_5 yield between 75-80%.
- **Filterability:** Data collected confirmed feasibility for industrial scale-up.
- **Product quality:** DCP produced was of fertilizer quality or met animal feed standards, depending on the parameters used.

The chemical composition of the DCP obtained is shown in Table 1.

Industrial Integration and market potential

Integration of the DCP process into existing phosphoric acid plants offers multiple benefits:

- **FSA utilisation:** A plant producing 250,000 tonnes per year (kt/year) of P_2O_5 generates ~17 kt/year of FSA as 100%, which can be fully recovered and valorised.
- **DCP production:** With this FSA quantity, approximately 70 kt/year of DCP can be produced (28 kt/year P_2O_5), suitable for animal feed or used to produce high quality phosphoric acid or fertilizers.
- **Gypsum output:** ~110 kt/year of high-purity gypsum is generated, marketable for plaster, plasterboard, cement or even applications that need a very white and clean gypsum.
- **Residue management:** Digestion residues can be co-managed with phosphogypsum, simplifying waste handling.

Table 1: **Chemical composition of di-calcium phosphate (DCP) obtained from pilot testing of Prayon's HCl-based to recover FSA**

Element	Unit	Value
P_2O_5	%	41-42
CaO	%	35-37
Al_2O_3	ppm	150-200
Fe_2O_3	ppm	250-300
MgO	ppm	30-60
SiO_2	ppm	150-250
Cd	ppm	1.0-2.0
Pb	ppm	1.0-2.0
As	ppm	3-4.5
F	ppm	0.15-0.7*

**Adjusted by process setpoints*
Source: Prayon

Environmental and economic implications

As well as valorising co-products, integration of this process can also diversify the product portfolios of phosphoric acid producers. The proposed process also helps deliver key sustainability goals:

- **Waste minimisation:** Converts a hazardous by-product into valuable materials.
- **Resource efficiency:** Utilises low-grade phosphate rock, reducing reliance on high-grade reserves.
- **Circular economy:** Regenerates reagents and recycles process streams.
- **Market diversification:** Opens access to animal feed, construction, and specialty chemical markets.

Economically, the process reduces disposal costs, creates revenue streams from DCP and gypsum, and enhances plant capacity through reagent recycling.

Conclusion

In the evolving landscape of industrial sustainability, the treatment and valorisation of by-products are becoming central to strategic decision-making. One such by-product, fluorosilicic acid (FSA), is often neutralised and disposed of – an approach that not only incurs cost but also destroys potential value.

Instead of treating it as a waste stream, the valorisation of FSA through Prayon's HCl-based DCP process offers a sustainable, economically viable alternative. This approach not only recovers valuable acidity but also enables the production of high-quality products from low-grade phosphate rock.

It is important to recognise that not all phosphate rocks are equal. Each deposit has unique characteristics that influence its behaviour during processing. Full validation of each rock type is therefore essential to optimise recovery and ensure consistent product quality.

Prayon Technologies is well placed to support this validation thanks to its comprehensive technical capabilities and infrastructure. These include the company's specialised engineering teams, and its advanced research, pilot and semi-industrial facilities in Belgium and at Technophos in Bulgaria. ■

Acknowledgement

Marc Sonveaux, Prayon's Head of Industrialization, will be presenting this article at the 37th AFA International Technical Conference & Exhibition, Ben Guerir, Morocco, 17th September 2025.

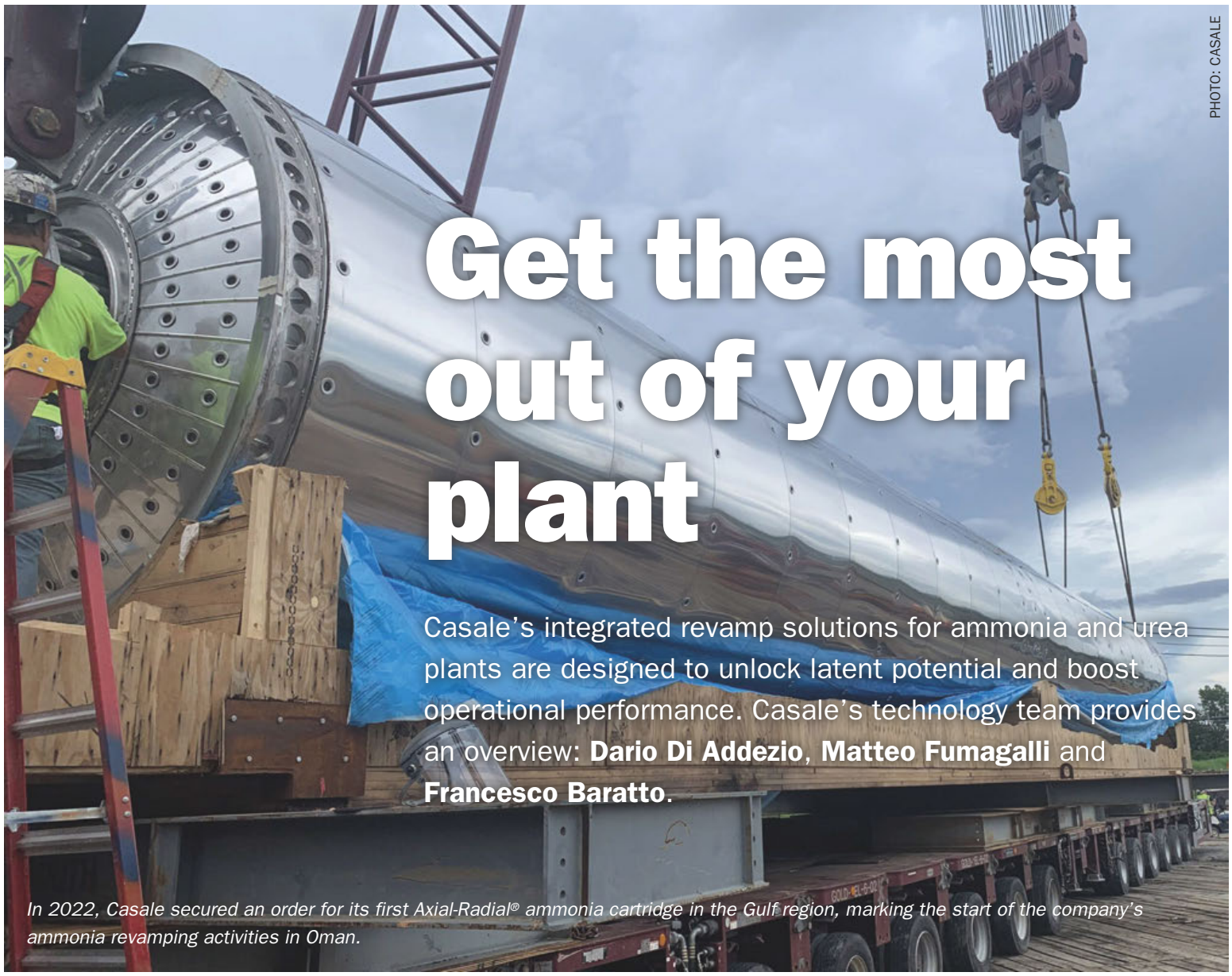


PHOTO: CASALE

Get the most out of your plant

Casale's integrated revamp solutions for ammonia and urea plants are designed to unlock latent potential and boost operational performance. Casale's technology team provides an overview: **Dario Di Addezio**, **Matteo Fumagalli** and **Francesco Baratto**.

In 2022, Casale secured an order for its first Axial-Radial® ammonia cartridge in the Gulf region, marking the start of the company's ammonia revamping activities in Oman.

A holistic revamp strategy

In the chemical industry, **ammonia** and **urea** are crucial foundational products for agricultural fertilizers and a variety of other industries. Their manufacture mostly begins with the steam methane reformer (SMR), a key piece of equipment that produces the hydrogen needed for both production processes. Although built for durability, these high-temperature, high-pressure SMRs eventually encounter challenges due to aging infrastructure and changing market demands. This often leads to reduced efficiency, higher operational costs, and increased environmental concerns.

However, modern revamping isn't just limited to the SMR either. Significant improvements are also being made to other critical sections of ammonia and urea plants – a holistic approach that ensures overall performance is enhanced across the nitrogen production complex.

Today's fertilizer producers are under immense pressure to boost capacity, drastically reduce energy consumption, and significantly shrink their carbon footprint. Building new greenfield plants is one solution, but the high capital costs, long timelines, and complex permitting often make it impractical for existing facilities. This makes **revamping** a strategic necessity.

At Casale, we know that true optimisation means looking at the **entire production chain**, not just individual units. While the SMR is a clear candidate for upgrades, due to its high energy consumption and critical role, our holistic revamp strategy focuses on synergies across the whole process. This allows us to not only modernise the SMR, but also meticulously optimise other key sections within both the ammonia and the subsequent urea plant.

This article explores Casale's comprehensive suite of innovative revamping solutions, detailing how our proprietary technologies are applied across key areas. Taking a deep dive into our revamp offerings, with illustrative case studies, we'll demonstrate how Casale's integrated approach empowers producers to unlock latent potential, enhance energy efficiency, curtail emissions, and extend the economic life of their entire complex, ensuring they far exceed, not just meet, the demands of a rapidly evolving global market.

The following sections delve into Casale's proprietary technologies and advanced methodologies – and how, through these targeted interventions, we can empower producers to achieve unparalleled levels of efficiency, sustainability, and operational longevity.

Communities

Magazines

Market-leading publications online and in print ...

Our publications offer a complete coverage of the international sulphur, fertilizer, related chemicals and raw materials industries – providing analysis, comment and statistics on world-wide production, trade, transportation, handling and consumption.

Sulphur is the market leading publication for the sulphur and sulphuric acid industries worldwide, unrivalled for its unparalleled, independent, information and extensive coverage spanning the oil and gas, chemical, metals, fertilizer and power industries. **Sulphur** magazine is noted for its in-depth technical features on the latest projects, state-of-the-art technologies and processes.

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66

Nitrogen+Syngas is the only publication to provide comprehensive global coverage of the nitrogen and syngas industries, with unequalled insight into technologies and developments for producers. **Nitrogen+Syngas** gives unique in-depth technical coverage on processes and developments worldwide.

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Fertilizer International is recognised for its coverage of the entire fertilizer industry worldwide, with a special section dedicated to the phosphates and potash industries. **Fertilizer International** is noted for its analysis of the wider economic and political factors that impact on agricultural and fertilizer markets and enjoys a high-calibre worldwide readership among industry decision-makers.

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Optimising the steam methane reformer

Casale has a unique and well-recognised licensor expertise in revamping steam methane reformers (SMRs) – with a focus on enhancing energy efficiency and performance. The company's revamping experience covers all existing SMR types and configurations that are currently available and in operation worldwide, including bottom-fired, top-fired, terrace wall, and side-wall designs (Figure 1). This extensive knowledge, combined with our experience and track record building new grass-roots syngas production plants, has significantly strengthened Casale's understanding of the key equipment for reforming reactions.

Existing furnaces often operate beyond their upper throughput limits. Consequently, many critical components, such as catalyst tubes, pigtails, intermediate tube sheets, and shield coils, are forced to operate very close to their material design limits. Over time, further limitations can arise due to component aging, mis-operation, the constraints of the original design, or new environmental emission requirements.

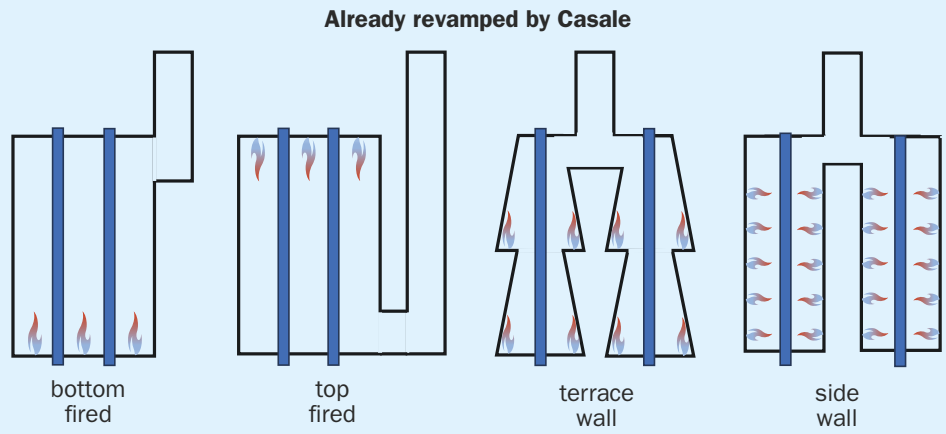
Such critical conditions can be exacerbated when revamping activities are performed without a proper licensor assessment. In our view, a **revamp assessment** is fundamental as a way of minimising risks and avoiding unexpected issues with plant consumption figures.

A licensor's assessment, drawing on a complete knowledge of the plant's background, identifies symptoms and warning signs, before the point of no return is reached, helping to avoid unplanned outages and potential risks to personnel. This is the crucial first step towards a revamping project. Based on Casale's experience, it is essential to conduct a detailed data analysis of the entire reformer. This investigation, when performed by a technology licensor with deep plant knowledge, is vital for identifying abnormal conditions, design limitations, or upset operating parameters that could impact the entire plant.

Casale's **revamping strategies** are specifically designed to address these challenges, with the goal of improving energy efficiency, increasing capacity, and reducing both the carbon footprint and emissions.

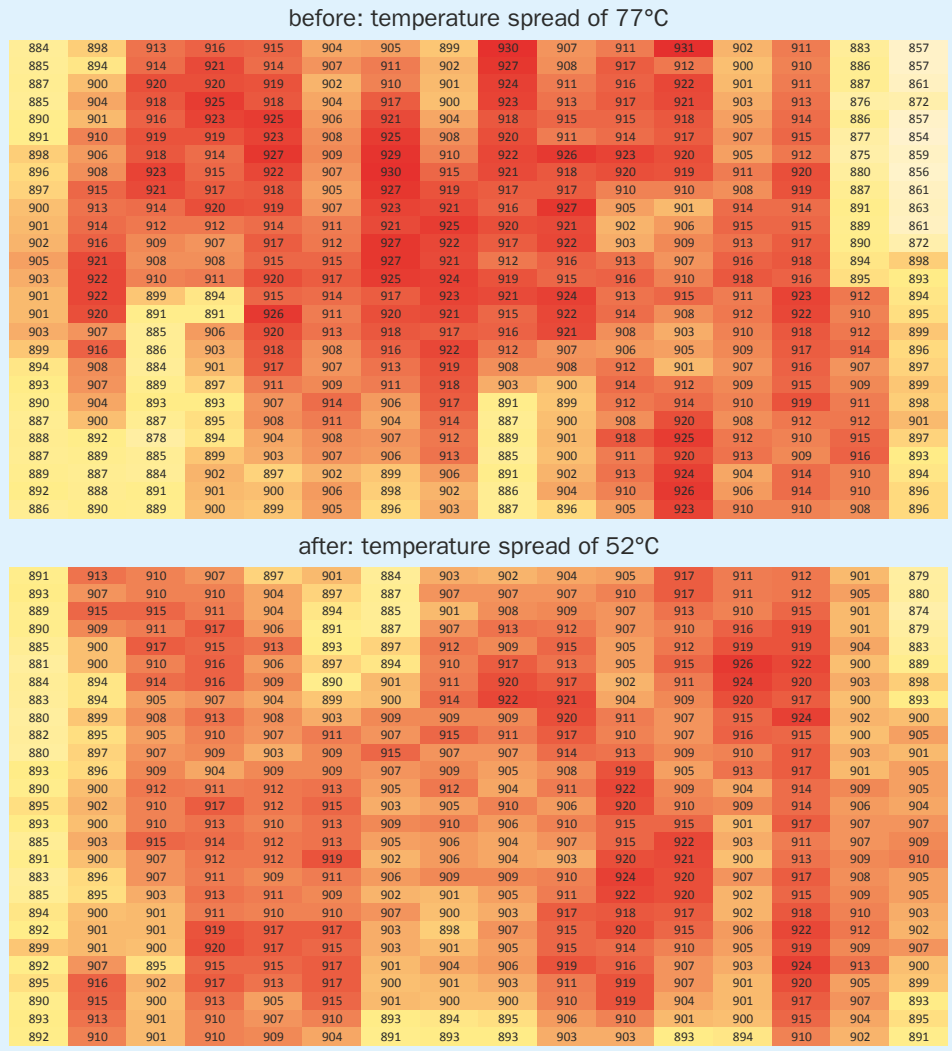
The company's expertise in primary reformer revamping is unparalleled. Our work on revamping existing plants has significantly enhanced our knowledge of key reforming equipment. In fact, Casale is the only licensor with recognised revamping expertise across all existing SMR types and configurations (Figure 1), making us a leader in the field.

Fig. 1: **Casale's revamping experience covers all existing SMR types and configurations**



Source: Casale

Fig. 2: **Temperature heat maps comparing conditions before and after the revamp of the air duct and flue gas tunnel extraction system**



Source: Casale

The scope of a primary reformer revamp typically requires a multi-faceted approach, with a range of services and supplies, as outlined in Table 1.

The radiant chamber is the most expensive and critical section of the primary reformer – incorporating materials designed

for high-temperature strength, creep resistance, and resistance to carburisation or embrittlement. Casale has accumulated experience in designing the modifications and mechanical upgrades necessary for operating plants at higher temperatures and pressures, to either improve the reaction or increase efficiency and tube life.

In many instances, modifications are not just limited to the high-alloy pressure parts, they are also carried out on the combustion air distribution system, burners, and the flue gas extraction system. Casale's assessment capabilities combine thermal primary reformer analysis jointly with mechanical analysis and computational fluid dynamic (CFD) analysis which covers the radiant chamber's heat distribution.

Figure 2 provides an example of how combustion air duct modifications and tuning a traditional flue gas tunnel extraction system have been applied successfully to the revamp of a very big SMR (16 tube rows).

Casale pays special attention to the burners during the revamping process – as these are at the heart of the primary reformer – the aim being to improve combustion efficiency, flame stability, and reduce NOx emissions. These improvements ultimately lead to a more even **heat distribution** within the reformer furnace (Figure 3). This eliminates damaging hot spots and imbalances in fuel gas flow to the burners, which are often the first signs of unexpected issues.

With a focus on the industry's future and sustainability improvements, Casale is at the forefront of retrofitting BMS burners and fuel gas systems to enable the primary reformer to switch to using low-carbon fuels, such as hydrogen. The company also has experience in revamping primary reformers with **ultra-low-NOx technology** burners operating on a fuel stream rich in hydrogen (up to 82% H_2 by volume).

This demonstrates Casale's overall capabilities and experience when it comes to managing the complex challenge of modifying heaters – including the convection section and fans – to operate with a wide range of fuels, these ranging from 100% natural gas to a lighter, hydrogen-rich fuel, as well as the various mixtures in between.

The convection section is the other main part of the primary reformer where Casale has extensive revamping experience (Figures 4-7). This includes tailor-made solutions such as:

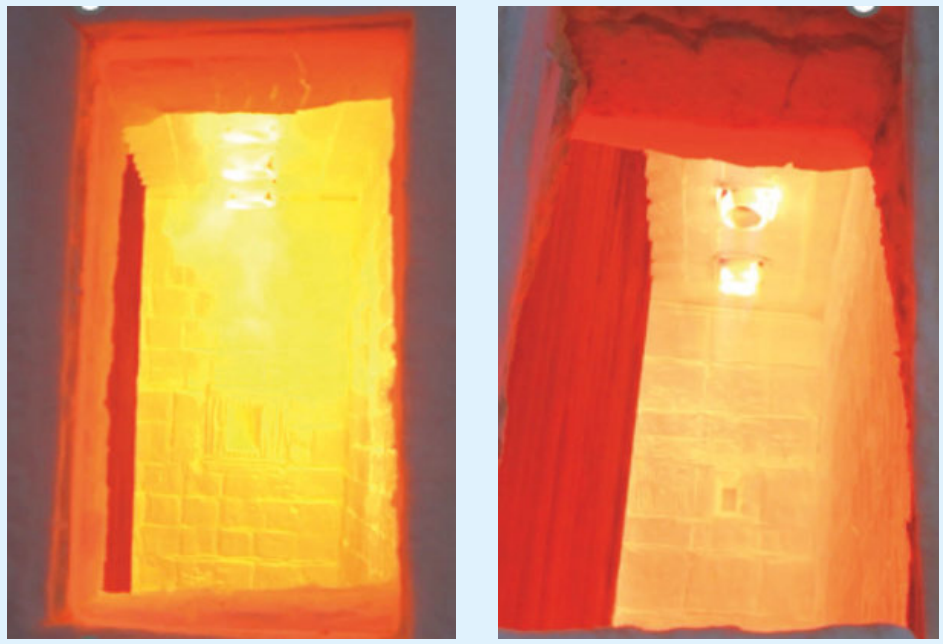
- The one-shot pull-in solution which can be provided for any convection section coil to minimise the installation time as much as possible (Figure 4).
- The coil saturator module banks to recover the heat wasted at the reformer stack making available high pressure steam that recovers wasted process condensate (Figure 6).
- APH replacement to the most efficient modern design (many rotary type APHs have been replaced by Casale).
- Conversion of the induced draft primary reformer to the balanced draft configuration (including complete coil module or even complete convection section modules). See Figures 5 & 7.

Table 1: **Summary of Casale's capabilities in steam methane reformer (SMR) revamping**

Subject	Services/supply
SMR/Fired heaters engineering	• Design of required modification • Mechanical upgrade
Catalyst tubes and inlet & outlet systems	• Modifications and supply and/or replacement in-kind
Convection section revamp	• Engineering and supply of the entire or part of the convection section
APH & Denox systems addition/modifications	• Engineering & supply • SCR & SNCR system engineering & supply
Combustion air duct and flue gas extraction system distribution assessment	• Complete modification, engineering & supply
Low and ultra-low NOx burner retrofits	• Engineering & supply • Retrofitting for low carbon fuel (hydrogen)
Safety & control improvements	• BMS and fuel gas system retrofitting • Low carbon fuel implementation (hydrogen)

Source: Casale

Fig. 3: **Burner behaviour before (left, with flame distortion) and after revamping (right, showing normal flame appearance)**



Source: Casale

Revamping other critical ammonia plant sections

Casale has established itself as a global leader in ammonia plant revamping – based on its ability to upgrade existing operations so they remain competitive with new builds in terms of capacity, efficiency, and

SOURCE: CASALE

Fig. 4: One-shot pull-in revamp solution for mixed feed coil.

environmental performance. The company always tailors its revamping approach to the client's specific objectives, with these ranging from moderate capacity increases to comprehensive upgrades, energy savings, and emission reductions.

Often, the primary goal is to boost production by **unlocking latent potential** without requiring a complete process redesign. This is achieved by optimising existing equipment while addressing key bottlenecks. For example, by developing a new burner that boosts the performance of the secondary reformer by improving gas distribution and reducing methane slip. Similarly, replacing outdated vertical waste heat boilers downstream of the reformer with double-pipe designs improves both reliability and temperature control.

Shift converters are another area of focus. Casale's proprietary axial-radial internals have been widely adopted as retrofits into existing vessels, with major pressure drop reductions (from more than 1.2 to below 0.5 kg/cm^2) reported in several installations. These internals notably offer superior catalyst protection, reduced pressure drop, and extended catalyst life.

Improving ammonia conversion is the common revamp strategy within the synthesis loop. Where feasible, Casale replaces the converter internals while keeping the existing pressure vessel. Revamping provides an opportunity to improve both reliability and conversion efficiency in older plants where the original converter has been in service for decades – often by installing a larger, more effective reactor.

SOURCE: CASALE

Fig. 6: Saturator coil installation.

SOURCE: CASALE

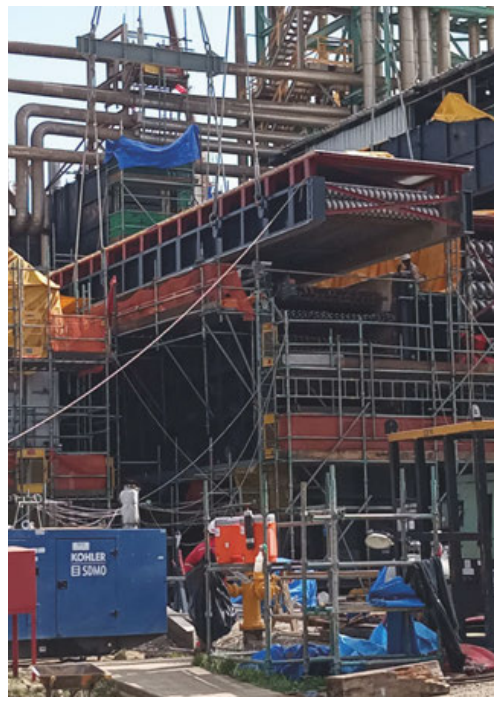


Fig. 5: Complete convection section revamping, including steam superheating coils (hot and cold) supplied as completed modules.

In many cases, the addition of a **second converter** downstream of the main converter offers the best return on investment. This increases catalyst volume and boosts per-pass conversion, without major modifications to the circulator or other loop components. Casale's axial-radial design plays a key role by maintaining low pressure drop and high catalyst utilisation. The addition of a second converter has been applied as a successful strategy in various plants, achieving capacity increases of up to 10% and raising ammonia concentration from 15-20%, while also reducing circulator outlet pressure.

Beyond capacity gains, **improving energy efficiency** is a major motivation in ammonia revamping. Casale has implemented numerous energy-saving technologies, including revamped CO_2 removal systems, natural gas saturation units (Figure 6), syngas drying sections, and advanced low-temperature heat recovery systems. In older plants, these interventions can significantly narrow the performance gap with modern operations.

Casale also supports **production stabilisation**, especially in regions with hot climates where seasonal peaks in temperature can negatively affect plant performance. This is achieved through targeted enhancements aimed at improving operating margins and reliability. Cooling capacity, for instance, can be increased by leveraging low-grade process heat. Casale

SOURCE: CASALE

Fig. 7: Recoiling the convection section reusing existing tube sheets.

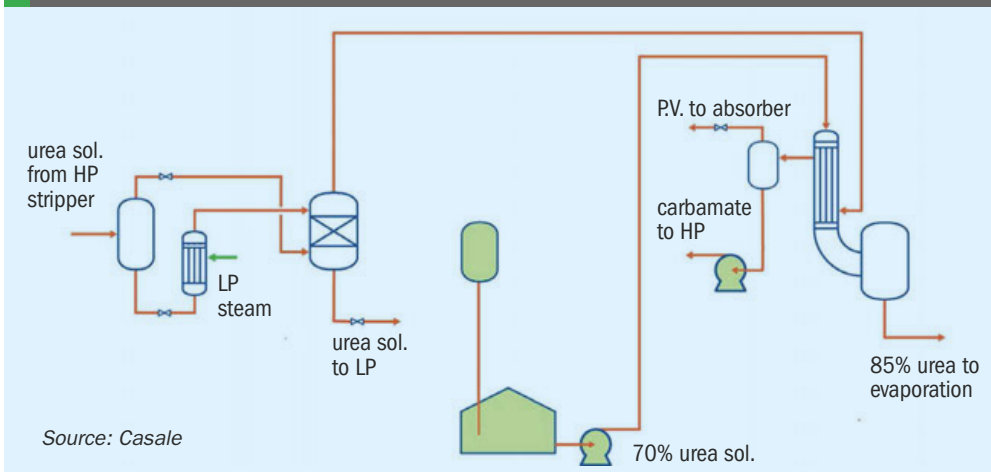
offers two proven technologies for improving cooling capacity: lithium bromide-based chilled water units and ammonia absorption refrigeration systems.

Emission reduction is another increasingly important objective – especially in jurisdictions with tightening environmental regulations or where plants are operating near their permit thresholds – and can be addressed on multiple fronts. Lowering carbon intensity requires a focus on minimising methane slip, upgrading CO_2 removal, and improving process integration to reduce fuel consumption. While, for reducing non-CO_2 emissions, replacing conventional low-pressure condensate strippers with advanced medium-pressure systems is an option. These improvements reduce the plant's environmental impact and enable compliance with stricter standards.

The cornerstone of Casale's energy optimisation strategy is the **SAVeNG concept**. This integrated revamp framework is designed to lower natural gas consumption and overall energy use by streamlining the process, reducing auxiliary steam generation, and adopting high-efficiency electric or gas turbine drivers. The energy savings achieved often make it possible to increase ammonia output without raising feedstock usage.

SAVeNG reflects Casale's 'total approach' to revamping, as it draws on proprietary technologies in both ammonia and urea production, and optimises integration between process units and offsites. It is suitable for any ammonia plant – from 600 t/d to over 2,000 t/d – and any type of urea plant, whether stripping (NH_3 or CO_2) or total recycle, even for multi-train configurations.

Fig. 8: **Addition of a medium-pressure (MP) purification section for revamping CO_2 stripping plants. New equipment shown in white**



Source: Casale

Urea production plant upgrades

Urea plant revamps typically emphasise higher throughput and sustainability improvements.

Urea plant energy consumption accounts for only a minor fraction of the entire production cycle, starting from syngas preparation via SMR. Nonetheless, there is still demand for ever more sustainable urea technology, a need that is widely acknowledged nowadays.

Thanks to stringent environmental policies, most urea plants achieve a specific consumption of ammonia very close to the theoretical stoichiometric value – the implication being that the energy consumption associated with ammonia cannot be improved in most cases. On the other hand, most urea plants (including conventional stripping plants) still require a substantial HP/MP steam supply, both as a thermal energy source and to drive machinery. Excluding ammonia, process steam represents the greatest cost variable and is responsible for the largest share of CO_2 emissions associated with urea production.

Upgrading the total-/partial-recycle urea process – or other vintage processes – to stripping technology is relatively 'easy' and, beneficially, delivers a substantial reduction in the consumption of utilities, especially steam. In particular, total-recycle (TR) processes are very well suited to upgrades to self-stripping technology. Generally, only the high-pressure synthesis section needs upgrading, as the purification sections of the total-recycle and self-stripping processes are very similar.

Consequently, by adding few new high-pressure items, a TR plant can be conveniently converted into a self-stripping plant with a production performance that is close to that of modern greenfield projects. Depending on the actual consumption of the vintage plant, the energy saving can be as high as 0.6 Gcal per tonne of urea.

Increasing the energy efficiency of conventional CO_2- or self- stripping plants isn't trivial either. Although revamping these (to achieve the same steam consumption as modern stripping plants) is extremely complex, Casale has developed process schemes that reduce process demand for steam by 10-15 %.

A common strategy is to partially shift carbamate decomposition from the high pressure (HP) stripper to a new medium-pressure (MP) purification stage (Figure 8). For CO_2-stripping plants, the new section

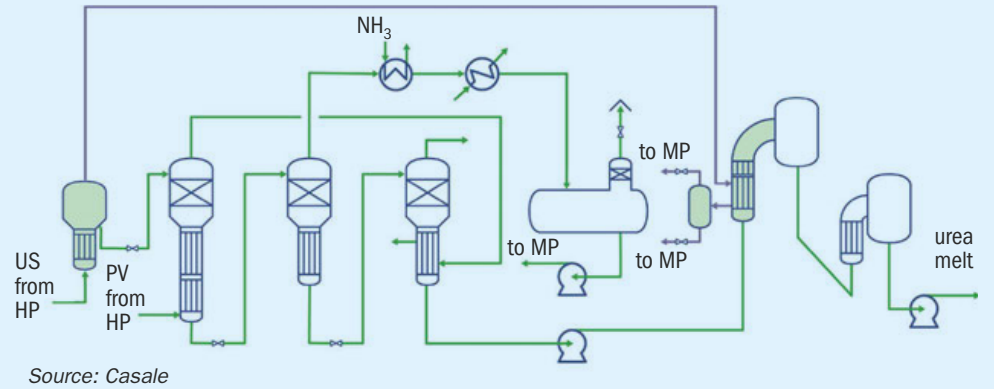
operates at about 15 barg while using internally generated low-pressure (LP) steam as heat supply. In this way, the quantity of MP steam saved in the HP stripper is matched by LP steam in the new section.

To avoid compromising the balance of the steam network, a heat-recovery strategy is also implemented. This exploits the heat of condensation of MP vapours generated during carbamate decomposition for urea pre-concentration. The steam saving achieved by the new urea pre-concentration stage is enough to balance out the consumption of the new MP carbamate decomposer and the loss of LP steam production from the HP carbamate condenser (HPCC). In this way, for a conventional CO_2 stripping plant, the specific consumption of 23 barg steam (typically from CO_2 compressor turbine extraction) can be lowered by about 150 kg/ton urea.

A MP purification stage operating at 18 barg is intrinsic to self-stripping plants, also known as ammonia-stripping plants. Unloading the HP stripper therefore requires a new purification section operating at intermediate pressure, with the range 28-32 barg being optimal. Conveniently, the stream of carbamate vapour generated by this new medium-high pressure (MHP) section (Figure 9) can also be exploited for urea concentration. At this operating pressure, the condensation curve of carbamate vapour allows heat recovery with urea solution at concentrations up to and above 90 wt. %. The saving from not using LP steam for urea concentration counterbalances the new steam consumption by the MHP decomposer (which uses 5.0-5.5 barg steam) and the lower production from the HPCC.

Given that the steam consumption of self-stripping urea plants is already more efficient than their CO_2 stripping equivalent, revamping with an MHP section achieves a saving of about 85 kg/t urea. ■

Fig. 9: **New medium-high pressure (MHP) section for revamping self-stripping urea plant. New equipment shown in green**



Source: Casale

About the authors

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Modernising urea plants

Revamping existing urea plants can deliver significant improvements – be it higher capacity, lower costs, or reduced emissions. These upgrades are essential for operating companies seeking to stay competitive, meet new regulatory standards, or make better use of existing assets. **Marc Wieschalla** of thyssenkrupp Uhde provides an overview of the main revamp options.

Revamp objectives

Urea plant revamps can deliver:

- Increased production capacity
- Cuts to operating costs (e.g., through energy efficiency)
- Reduced environmental emissions and decarbonisation of production
- Improved plant availability and reliability
- Expanded product output (e.g., AdBlue®, melamine)
- Modernised plant control systems.

Increasing plant capacity is the most frequent revamp goal – as the additional output quickly pays off the original investment. Key targets for revamps at urea production sites include melt plants, granulation units, and the CO_2 supply.

Revamp strategy – a four-step approach

A typical revamp project proceeds in four steps as follows (Figure 1):

Revamp study (1a & 1b): Initial evaluations define the process concept and provide preliminary cost estimates (1a). Early involvement of the engineering, procurement and construction (EPC) contractor can scope utilities, space, and downtime constraints to provide a more accurate cost estimate (1b).

Basic engineering (Step 2): Initial equipment (especially long-lead items) is selected and purchased, based on the process design package (PDP) and the EPC design concept.

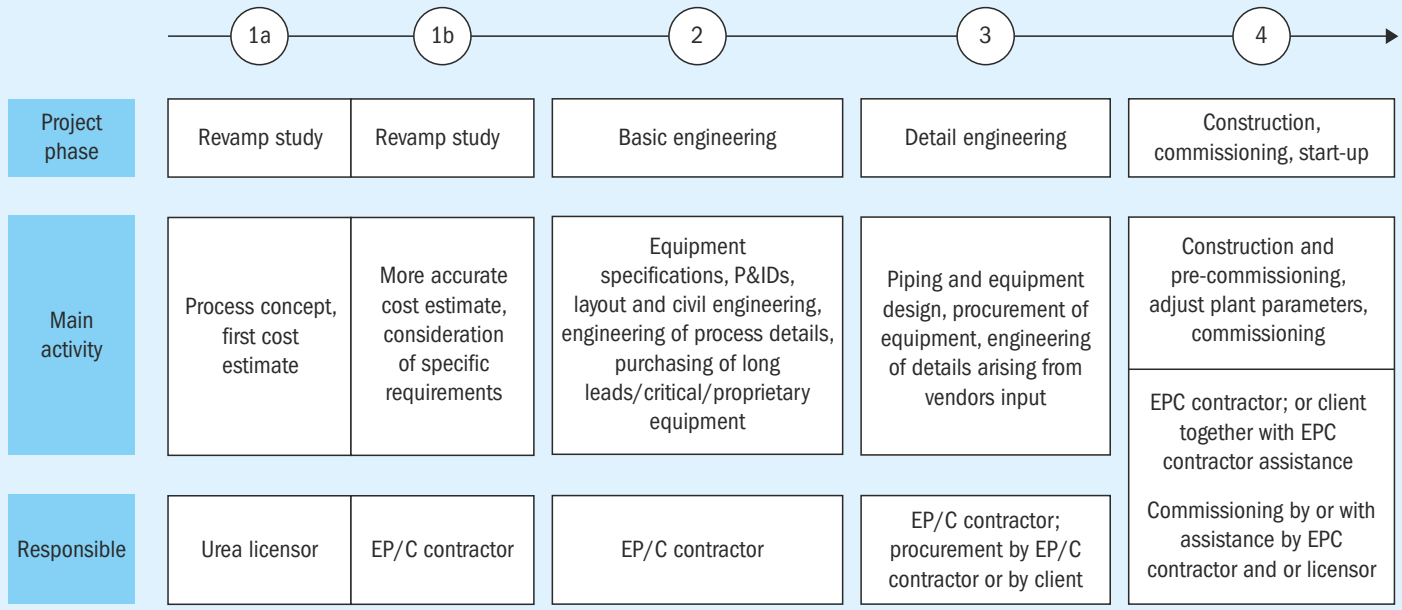
Detail engineering (Step 3): Full-scale engineering and equipment procurement are carried out. Some purchasing by the client may also occur at this stage.

Construction, commissioning & start-up (Step 4): New components are installed and tested. Commissioning services from the EPC contractor and/or licensor can range from advisory support to full-service handover.

PHOTO: THYSSENKRUPP

Yara urea plant.

Fig. 1: **Revamp execution schedule**



Source: thyssenkrupp Uhde

Revamping the melt plant

Capacity increases in the melt plant can follow five main paths – as set out in Table 1:

- Debottlenecking
- More in, more out
- New/double stripper
- Medium pressure (MP) add on
- Pool condenser.

Debottlenecking can increase capacity by up to 10%. It involves targeted upgrades to relatively minor equipment (e.g., valves, pumps) without major structural changes to the urea plant. Larger capacity increases require the involvement of the urea process licensor and significant additions to process equipment.

The other four melt plant revamp options shown in Table 1 can increase the original capacity by up to 100%.

Table 1: **Revamp activities in the melt plant for capacity increase**

Method name	Detailed activities	Achievable capacity increase
Debottlenecking	• Add CO_2 sources • Replacement of valves or their internals • Conditioning of CO_2 within CO_2 compression unit • Replacement of pumps or their impellers	up to 10%
More in more out	• Installation of efficient reactor trays • Maximum utilisation of existing design margins • Adding heating and condensation capacity in the low-pressure recirculation unit and the evaporation unit • Install adiabatic flash	10 to 30%
New/double stripper	• Parallel stripper / new bigger stripper • Installation of efficient reactor trays • Installation of parallel LP recirculation and/or evaporation unit • Improvements in desorption unit	30 to 40%
MP add-on	• Installation of efficient reactor trays • Installation of a parallel MP carbamate recirculation unit • Installation of MP CO_2 compressor or modifications at CO_2 compressor unit • Improvements in waste water treatment	30 to 50%
Pool condenser	• Replacing HPCC by Pool condenser • New or additional CO_2 compressor • Installation of a parallel HP stripper • Installation of a parallel LP recirculation unit • Installation of a parallel evaporation unit • Modifications in desorption	50 to 100%

Source: thyssenkrupp Uhde

Boosting CO_2 supply

Two strategies can provide more CO_2 for urea synthesis:

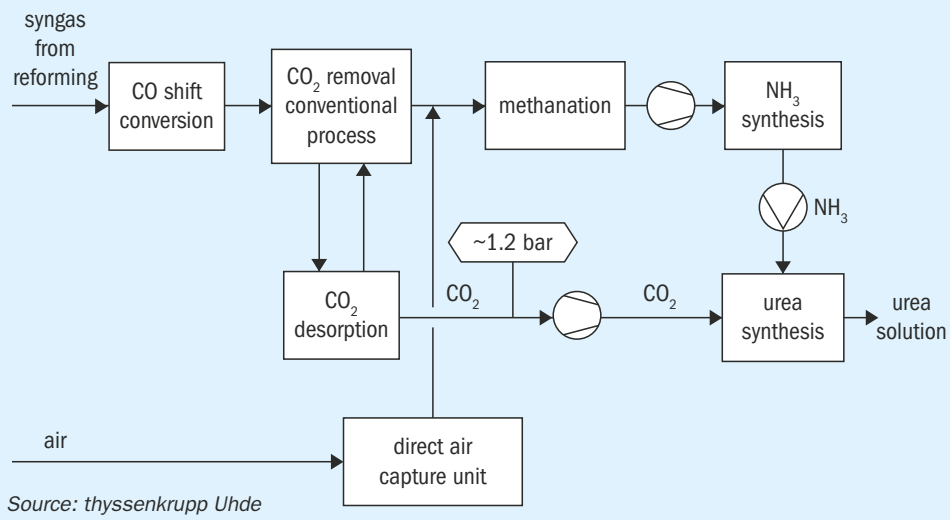
- **Ammonia plant CO_2 removal units:** These increase synthesis gas throughput and reuse fuel gas in reformers to generate more CO_2. This is cost-effective when front-end units have sufficient design margin.
- **Direct air capture:** Although currently small-scale and high-cost, this emerging technology will make green urea production an achievable goal in future. It removes CO_2 directly from ambient air for reinjection into the process (Figure 2).

Revamping the urea granulation plant

Granulation revamps fall into two categories:

- Smaller revamps that increase capacity by up to 15% and avoid major changes – new nozzles and cooling upgrades will generally suffice.

Fig. 2: **Adding CO_2 which is removed from air by means of a direct air capture process**



Source: thyssenkrupp Uhde

Table 2: **Overview of international and local emission standards for urea granulation plants**

Standard	Ammonia	Dust
IFC (World Bank, 2007)[1)]	< 50 mg/Nm³	< 50 mg/Nm³
EFMA BAT Booklet (2001)[2)]	< 50 mg/Nm³ < 50 mg/Nm³	< 0.25 kg/t < 0.25 kg/t
EU BREF LVIC (2007)[3)]	< 3 - 35 mg/Nm³	< 15 - 55 mg/Nm³
Louisiana (2012)	< 30 mg/Nm³	PM10 / PM2.5 < 8.3 mg/Nm³ < 20 % opacity
Iowa (2012)	BACT[4)]	PM2.5 < 20.96 mg/Nm³ No visible emissions

[1)] IFC: International Finance Corporation (World Bank Group)

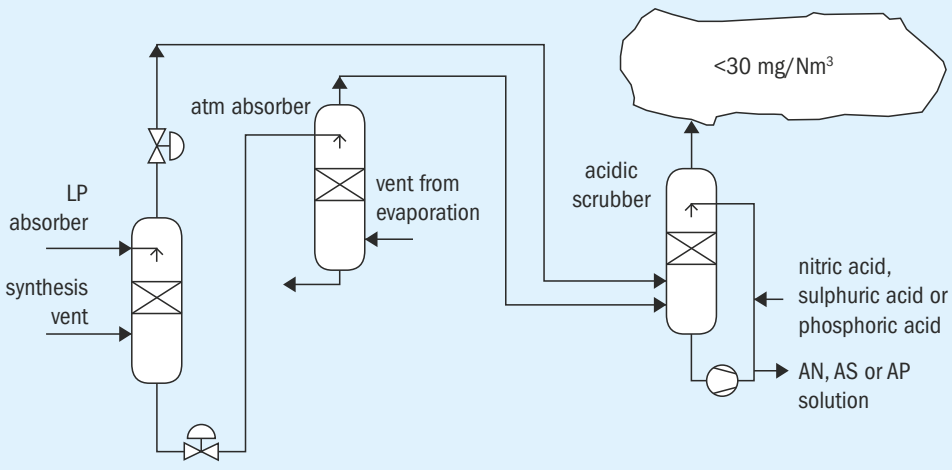
[2)] EFMA: European Fertilizer Manufactures Association (today: FE: Fertilizers Europe)

[3)] EU BREF LVIC: European Commission, Integrated Pollution Prevention and Control, Reference Document on Best Available Techniques for the Manufacture of Large Volume Inorganic Chemicals, August 2007

[4)] Best available control technology

Source: thyssenkrupp Uhde

Fig. 3: **Ammonia emissions from sources in the melt plant treated with acidic scrubbing**



Source: thyssenkrupp Uhde

- Larger revamps that increase capacity by up to 45% – and may require an extension to the granulator, new fans, added zones, and cooling system improvements.

Emission reductions are often integral. New air fans are typically required to counter the pressure drops from added abatement systems. In many cases, installing booster fans can reduce costs while maintaining flow.

Material handling upgrades also become necessary in larger revamps, although existing spare capacity can be leveraged to minimise investment.

Reducing Emissions

As regulations tighten, particularly for ammonia and dust (Table 2), even older plants must be brought into compliance. Emission points include:

- The low pressure (LP) absorber
- The atmospheric absorber
- The granulation stack.

Ammonia emissions from the absorbers are low in mass but high in concentration due to small gas volumes. Conversely, granulator emissions are higher in volume but diluted.

Scrubbing systems (Figure 3 & 4) – modern, multi-stage and acidic – can reduce emissions well below international thresholds. Options include:

- Replacing scrubber internals
- Adding dedicated acid scrubbers
- Installing combined dust and ammonia scrubbers.

In scrubbing, the **choice of acid** (nitric, sulphuric, phosphoric) depends on:

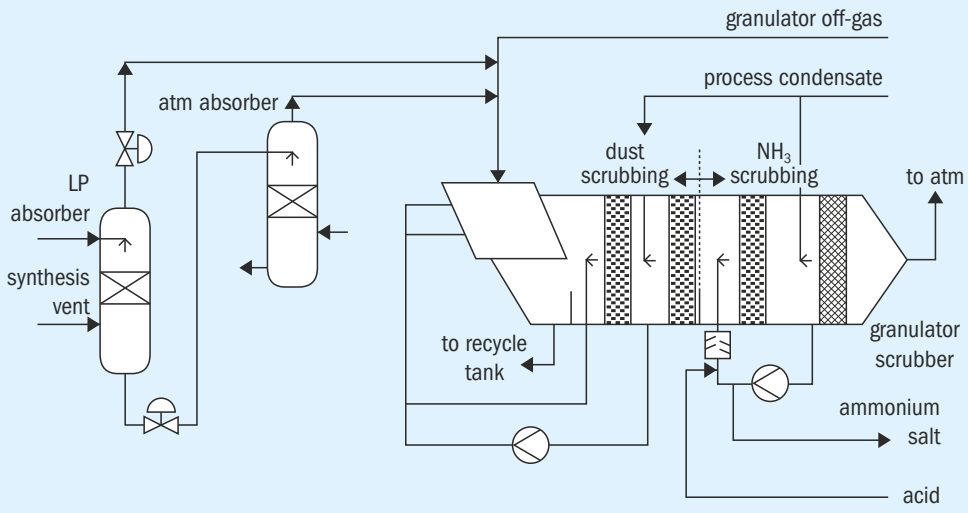
- Local availability
- Downstream processing capability
- Existing plant materials (e.g., stainless steel grades).

By-products such as ammonium nitrate or ammonium sulphate can be reused, e.g., in UAN production or granulated with urea for additional nutrient content.

Improving plant availability and contractor contributions

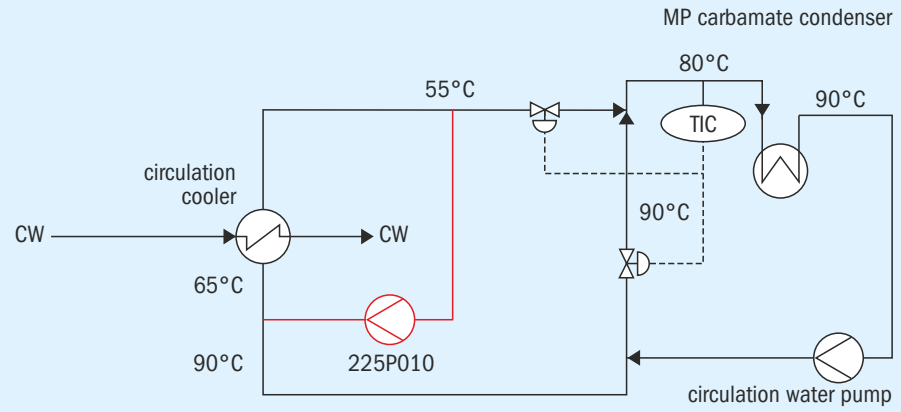
Plant availability can be significantly enhanced through modern equipment concepts. A prime example is the self-

Fig. 4: **Common treatment of the off gases from the melt plant and granulator in a state-of-the-art horizontal type scrubber**



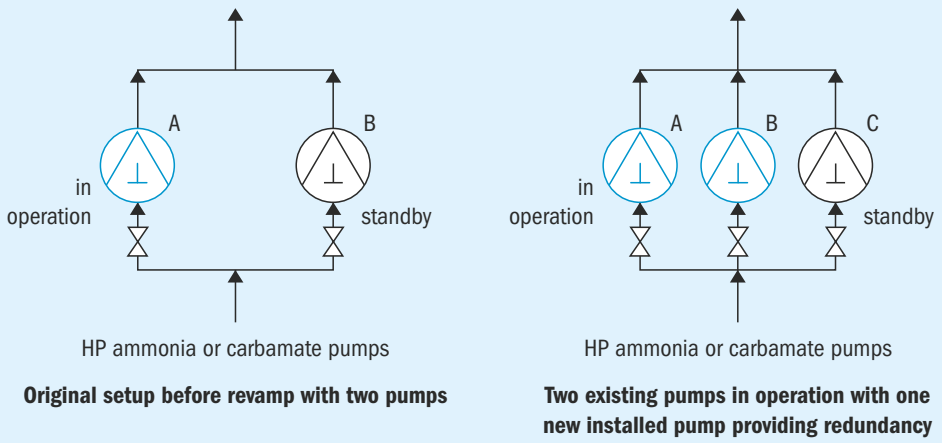
Source: thyssenkrupp Uhde

Fig. 5: **Closed cooling water loop of the medium pressure (MP) carbamate condenser with additional circulation loop (red) to reduce fouling**



Source: thyssenkrupp Uhde

Fig. 6: **Standby philosophy for high pressure pumps**



Original setup before revamp with two pumps

Two existing pumps in operation with one new installed pump providing redundancy

Source: thyssenkrupp Uhde

regulating melt pump – which operates with zero suction head (NPSH = 0 metres). This is installed just below the evaporator, allowing direct connection to the granulator's melt header.

This configuration minimises suction piping while the lower melt residence time also limits biuret formation. The pump's self-regulating nature also eliminates the need for level control or pump protection, so reducing shutdown risk – this being particularly valuable in plants with variable feed rates (e. g., those with UAN or DEF units). Uhde holds the patent for this application.

Contractors can enhance plant reliability further during detail engineering. In a medium-pressure (MP) add-on revamp, for example, Uhde has reduced fouling in the MP carbamate condenser's cooling loop by adding a secondary circulation pump (Figure 5). This reduces inlet temperatures at the plate heat exchanger, lowering the risk of scaling. The same upgrade has been applied to the high-pressure (HP) scrubber and low-pressure (LP) condenser, improving overall plant availability.

Contractors can also define pump spare part strategies – balancing capex and opex – by assessing whether to retain existing pumps, replace both, or install a third pump for redundancy (Figure 6).

Conclusion

Revamp activities are carried out to increase capacity, reduce operating costs, improve plant availability or minimise environmental impact. Early involvement of all parties is essential. With reliable data from the licensor, the contractor can assess feasibility and define required changes. thyssenkrupp Uhde combines customer experience, licensor know-how and its own engineering expertise to ensure a successful and integrated revamp. ■

Author's note

For a deeper dive into urea plant revamping, see thyssenkrupp Uhde's previous article in the May/June 2025 magazine (*Fertilizer International* 526, p34).

The company will also be presenting on 'Performance improvement at fertilizer plants by plant digitalization' at the forthcoming AFA International Technical Conference & Exhibition, Benguerir, Morocco, 16-18 September 2025. The company will also be giving an opening keynote on green fertilizer strategies and decarbonisation.

Collaborate to innovate – Anglo American's Future of Fertiliser report

The fertilizer industry must collaborate across the whole food value chain to produce the scalable sustainable products that are needed to provide future food security while reducing agriculture's impact on soils and the wider environment. This is the major recommendation from a group of global agriculture and food chain experts in a report recently published by Anglo American.

The Future of Fertiliser report[1], commissioned by Anglo American and compiled by Deloitte, interviewed 74 independent agricultural experts from around the world to better understand what needs to change in the industry, if it is to keep successfully feeding the world by 2050. With expertise drawn from academia, government institutions, NGOs, the food and fertilizer industries, as well as farmer themselves, the report is a call to action for the industry to adapt at pace and scale to the productivity and environmental challenges facing it in the coming decades.

The 74 experts envisaged a future in which governments and large companies would increasingly act to address the damage to nature, soil and the environment caused by unbalanced crop nutrition and poor chemical fertilizer practices. Evidence of this shift is already apparent in policies being developed in Europe and China in particular, they said, but also in the growth of regenerative agriculture, carbon farming and biodiversity initiatives in several regions throughout the globe. Scalable improvements in the efficiency, application, delivery and management of fertilizers are therefore urgently needed to keep up with stakeholder expectations and demands.

PHOTO: ANGLO AMERICAN

Tom McCulley, CEO of Anglo American's Crop Nutrients business (right) in discussion with a UK farmer (left).

The report was released ahead of the International Fertilizer Association's annual conference in Monaco. Its CEO, Alzbeta Klein, when interviewed for the report was asked what she believed the focus of the IFA conference would be in 25 years' time. She said: "2050 will be more than just a meeting about fertilisers. It will be a global summit on the future of humanity's relationship with food, nature and technology."

A new framework for success

To address the need for more scalable, sustainable fertilizers, the report's experts called for the industry to redefine its metrics for success (Figure 1) – to better manage competing and complex performance demands such as yield, soil health and sustainability. They said that new government regulations and environmental policies, allied to increased access to technology and innovative finance models, would incentivise the uptake of more sustainable practices and products, and that the industry should adapt accordingly.

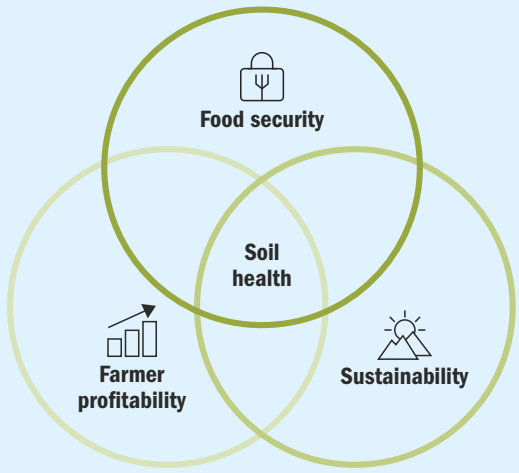
Tom McCulley, CEO of Anglo American's Crop Nutrients business, said: "There is no doubt in our minds that the future of agriculture has to be different if we are to produce more, better quality food more sustainably than we do today.

"This means that we need to work together across the sector to change the way we do things and find opportunity in this new frontier. We need to stop thinking about crop yields in isolation and create robust collaborative frameworks to measure our impact on issues like soil health, emissions, food nutrient content and nature, and find ways of delivering value for the farmer from them. It is the only way we will be able to successfully meet the growing demand for food while contributing positively to the planet."

Environmental impact – cost or opportunity?

One of the most eye-catching statements from the panel was a recommendation for the industry to internalise the environmental cost of chemical fertilizers in order to define the real value of sustainable alternatives

Fig. 1: **The Future of Fertiliser report's proposed metrics framework for a more sustainable system.**



Food security – Deliver nutrients of the right type, in the right quantities, at the right time and at a fair price to grow enough food for a growing population.

Sustainability – Deliver food and profit without destroying the environment, especially soil and ecosystem health, nor harming longterm food security and profitability goals.

Farmer profitability – Ensure a fair profit for farmers and other businesses in the agrifood system.

Soil Health – Measurement and performance at the core.

Source: Anglo American

and incentivise their use, then to collaborate with farmers and other stakeholders in the value chain to drive trust and uptake.

This issue was highlighted by Simon Inglethorpe, editor of *Fertilizer International*, who, along with other CRU colleagues, was interviewed for the research: "Around 40% of the emissions from a loaf of bread are from the fertiliser used to grow the wheat. Therefore, if food retailers are going to hit their targets for upstream Scope 3 emissions, they've got to have partnerships with their fertiliser manufacturer."

To achieve these sorts of collaborations, scalable crop nutrition solutions that efficiently use available nutrients at a low environmental cost across a broad range of crops and geographies must be developed, the report stated – an important step away from historical wasteful practices, damaged soil and unnecessary emissions. This means that lower carbon footprint fertilizers that can deliver additional nutrient performance, efficiency and additional value to the farmer will come to the fore.

PHOTO: ANGLO AMERICAN

A healthy soil rich in earthworms.

The central role of soil health

The report states that soil health considerations and the value of soils should play a central role in creating the new frameworks and products of the future, to help growers farm as productively, sustainably, and profitably as possible.

Many interviewees cited soil health as intrinsic to ensuring long-term food security, as healthier, more fertile soils are needed to improve crop yields and crop quality. Healthy soils also act as a filter for cleaner water and reduce runoff and erosion, while being vital to the fight against climate change through efficient carbon sequestration and improvements to on-farm biodiversity.

Leading regenerative farmer Ben Taylor-Davies, in his interview for the report, stated: "Everything starts and ends with soil. It's the start point, the end point and everything in between of profitability, food security, environmental security."

Future fertilizers and the nutrients they provide, while continuing to underpin agricultural success, the report said, must therefore actively contribute to the preservation of soils and precious natural resources for the long term.

The co-founder of Biome Makers, a soil microbiology analysis company, Alberto Acedo commented: "A sustainable fertiliser is a fertiliser that ensures efficiency of the nutrition of the plant, promotes or conserves biodiversity, and does not produce waste or residues on the land."

Meeting changing demands

The report states that by embracing these shifts towards more collaborative, sustainable practices, and seizing the opportunities they present, the sector can ensure that future fertiliser practices not only meet the growing demand for food but also contribute positively to the planet and future generations that will demand more and better-quality food.

"The future of fertilisers must be one where crop solutions both nourish people and sustain the planet, building on the incredible successes of food production since the mid-20th century," commented Duncan Wanblad, Chief Executive of Anglo American, who contributed the forward for the report. "Greater use of sustainable fertilisers has a vital role in increasing crop yield and resilience in parallel with protecting nature and improving soil health. But a future with an abundant, sustainable food system will not happen by accident; we must build it together."

This sentiment was echoed by all the experts interviewed, who emphasised the need for a greater spirit of collaboration, openness, and humility on the road to 2050. Real progress, they said, hinges on fostering new and genuine partnerships between previously siloed stakeholder groups, to move towards a more resilient and sustainable future. ■

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1. Anglo American, 2025. *The Future of Fertiliser – Expert perspectives on a changing landscape.* Anglo American/Deloitte, May 2025. Available from: https://uk.angloamerican.com/futureoffertiliser [Accessed 12/08/2025]

PHOTO: ANGLO AMERICAN

The Future of Fertiliser report compiled by Deloitte of behalf of Anglo American was published earlier this year. Based on interviews with 74 independent experts, it explores how the fertilizer industry needs to change if it is to continue to feed the world successfully by 2050.

IFA unveils Cultivate Challenge finalists!

Global trade body the International Fertilizer Association (IFA) has announced the finalists of its first-ever competition to find the next generation of innovative companies. The aim is to identify start-ups that can help to half the energy intensity of ammonia production, double plant recovery of fertilizer-applied phosphorus and track nutrient use efficiency (NUE) along the food chain.

The lucky thirteen

The International Fertilizer Association (IFA) unveiled the finalists of its first-ever 'Cultivate Challenge' competition at the end of July. The final 13 start-up companies were selected from more than 100 applicants in more than 40 countries. They were announced during a live online session hosted by Alzbeta Klein, IFA CEO/Director General, Patrick Heffer, Deputy Director General, and Jack Keeys, Innovation Hub Lead.

The thirteen finalists are:

- Capsber
- Ficosterra
- HydGene
- LiveGrow Bio
- Marvin
- MazaoHub
- NitroCapt
- NitroVolt
- Paul-Tech
- Peregrine
- Phospholutions
- PlasmaLeap
- Taxon.

The Cultivate Challenge competition, a key component of the newly-launched IFA Innovation Hub, showcases start-ups that are addressing critical challenges faced by the fertilizer sector and the wider agricultural and food system – notably the decarbonisation of ammonia production, a step change in the use efficiency of phosphate fertilizers, the accurate tracking of nutrient use efficiency (NUE), along with a wildcard category for 'out of the box' innovation.

Some 33 semi-finalists were evaluated, after rigorous pre-screening and due diligence conducted by SVG Ventures, EIT Food, and IFA specialists, with the top 13 then chosen for their groundbreaking approaches and scalable impacts.

PHOTO: NITROVOLT

Copenhagen-based green ammonia start-up NitroVolt is one of the 'Cultivate Challenge' finalists.

IFA 2025 CULTIVATE CHALLENGE FINALISTS

Capsber

India-based Capsber produces microbial-based biofertilizers, biostimulants, and soil health products with a track-record of field trials and early market validation. Capsber are a great fit within the challenge's phosphorus theme.

Ficosterra

Spanish startup Ficosterra utilises seaweed and microbial extracts to create biostimulants and biofertilizers, with growing market traction and a great foundation to further validate and scale with industry.

HydGene

Synthesising green hydrogen on-site using engineered biocatalysts to convert biomass waste, Australian startup HydGene shows a clear business model that unlocks improvements in emissions, efficiency and economics.

LiveGrow Bio

American startup LiveGrow Bio has developed a microbial fermentation and formulation platform enabling cost-effective manufacture of biostimulants and biopesticides. This platform is positioned as an enabling technology and delivers a strong and scalable product/solution fit.

Marvin

Offering a geospatial/AI platform for risk and compliance across land-based value chains, Brazil-based Marvin demonstrates a traceability capability which helps to meet the fertilizer industry's nutrient tracking goals.

MazaoHub

Operating in Tanzania, Kenya and Rwanda, MazaoHub has developed climate-smart software which is supported by soil sensors and AI-based agronomy advice, and is already delivering in-field impact to smallholders with a scalable delivery model.

NitroCapt

Swedish startup NitroCapt has developed a method of plasma-based nitrate fertilizer production from air, water and renewable energy, creating a step-change in energy reduction with a great opportunity to develop and refine their offering.

NitroVolt

Danish start-up NitroVolt is focused on small-scale, low-carbon ammonia synthesis on-farm for nitrogen fertilizer, combining next generation technology with a unique place-based solution.

Paul-Tech

The real-time soil nitrogen sensing and decision support system developed by Paul-Tech from Estonia has excellent commercial momentum and is already delivering positive results to customers/clients.

Peregrine

Peregrine, a US-based startup, co-produces clean hydrogen and sulphuric acid by electrolysis for fertilizer inputs. It has demonstrated rapid progress, integration potential, and promising early results.

Phospholutions

Producer of RhizoSorb®, a patented phosphorus-use efficiency enhancer, American startup Phospholutions has a well-established product tied closely to one of the challenge themes, and is poised for its next stage of growth.

PlasmaLeap

Australian startup PlasmaLeap delivers on-farm green ammonia production using plasma technology powered by electricity, air, and water. PlasmaLeap was recognised for its high impact technology with significant early-stage traction and relationship-building.

Taxon

Focusing on microbial genomics and bio-input development for soil/plant health, Argentinian startup Taxon has combined biology and technology to amplify growth across industry bio input innovations.

Winning package

The winning start-ups will each receive:

- **A year's IFA membership:** Including full access to IFA's global network, events, data resources, and the Innovation Platform.
- **Regional showcase opportunities:** The invitation to present at events such as the Thrive Impact Summit in Silicon Valley, the World Agritech Innovation Summit in London, the IFA Crossroads Asia-Pacific Conference in Bangkok, and the IFA Strategic Forum in Rabat.
- **Invitation to the grand final of the competition:** This will take place at the IFA Cultivating Tomorrow Conference in 2026.
- **Tailored business development programme:** This will connect finalists with industry-leading organisations, venture capital specialists, and fertilizer experts – with the aim of to accelerating growth, developing knowledge and network-building.
- **And much more:** Including access to IFA's wider ecosystem and alumni programme.

Industry sponsors

The competition benefited from the backing of 13 strategic partners:

- **Platinum level:** Arab Potash Company, Koch Agronomic Services, Maaden, Nutrien, OCP Nutricrops, SABIC Agri-Nutrients.
- **Gold level:** Coromandel International, Fauji Fertilizer Company, Haifa Group, ICL, Indorama Corporation, International Raw Materials, Pivot Bio.

"Our inaugural Cultivate Challenge demonstrates IFA's commitment to innovation-driven plant nutrition solutions, to help feed the world more sustainably", said Alzbeta Klein. "These 13 start-ups are working on cutting edge solutions with the potential to decarbonise fertilizer production, optimize nutrient use, and transform global food systems. I'm excited to see their progress during this first year of the Challenge."

What next?

Through the remainder of this year and into next, the finalists will deepen their connection with the fertilizer industry and the wider value chain through upcoming regional showcase events. They will also participate in the competition's grand final at the 2026 Cultivate Tomorrow event. ■

eqo.x®

We are ready for a sustainable future

ICL is proud to announce eqo.x, its biodegradable release technology that brings Controlled Release Fertilizers to a new era. This innovative technology for soil grown crops will help farmers to maximize their crops performance and reduce its footprint. It will be the release technology for our brands Agrocote and Agromaster. eqo.x is certified within the European Fertilizer legislation.

GLOBEE AWARDS Winner 2025

TITAN BUSINESS AWARDS Platinum winner 2025

Award-winning Sulvaris – Canada's technology innovator

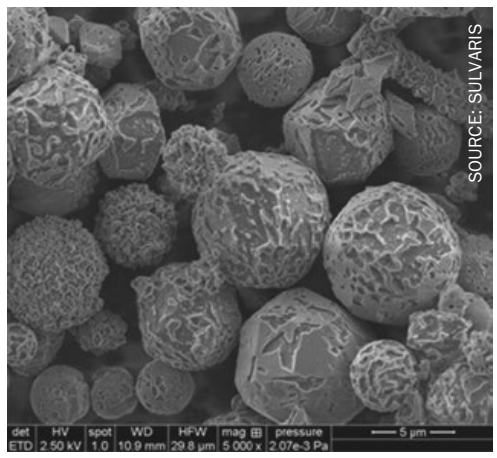
At a time when nutrient use efficiency, sustainability, and profitability are paramount, Sulvaris is aiming to transform low-value by-products into high-performance, field-ready premium nutrient products – enabled by scalable and innovative technology. **Mark Howell**, Head of Agronomy & Product Development at Sulvaris, introduces the company's technology portfolio.

Sulvaris was founded in Calgary, Alberta, Canada, with the vision of building bridges between industries by adding value to by-products that would otherwise be considered waste or a liability. Alberta, for example, is a region that generates large tonnages of elemental sulphur from its sizable oil and gas sector. Sulphur in this form can supply valuable agricultural end-markets globally – although it does require careful processing to become usable as a crop input.

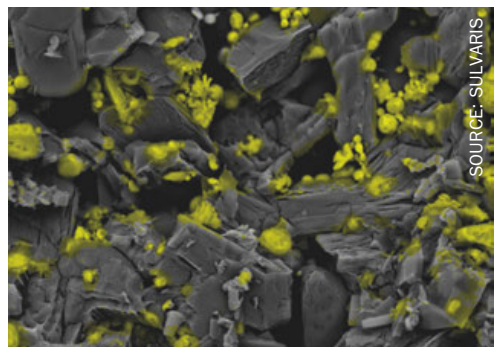
Crops are, in fact, unable to directly take up elemental sulphur. Instead, it needs to be converted into sulphate (oxidised) by soil microbes before plants can absorb it as a nutrient. The good news is that the oxidation of sulphur into plant-available sulphate can be accelerated by using finer particles to dramatically increase the surface area accessible to soil microbes. Indeed, the exposed surface area of elemental sulphur increases exponentially as particle size decreases.

Sulvaris has developed Micronized Sulfur Technology (MST®) for the crop nutrition market. This patented process engineers sulphur particles to a small and consistent size of seven microns (95% range 1-12 microns) – the smallest scale that is economically feasible in commercial fertilizers today (see black and white photo). Unlike standard elemental sulphur that oxidises very slowly, or sulphate sources that are susceptible to leaching, MST® strikes a balance by oxidising steadily as soils warm, maintaining a supply of sulphur in the root zone throughout the growing season.

In April this year, the International Fertilizer Association (IFA) presented Sulvaris with the Novel Fertilizer Award for its micronised sulphur technology (MST®).



SEM image of MST® particles (average size seven microns) at 5,000x magnification.



UreaMST® granule at 500x magnification. Image from a scanning electron microscope (SEM) in energy dispersive X-ray (EDX) mode shows MST® particles (yellow) evenly distributed throughout the urea matrix.

SOURCE: SULVARIS

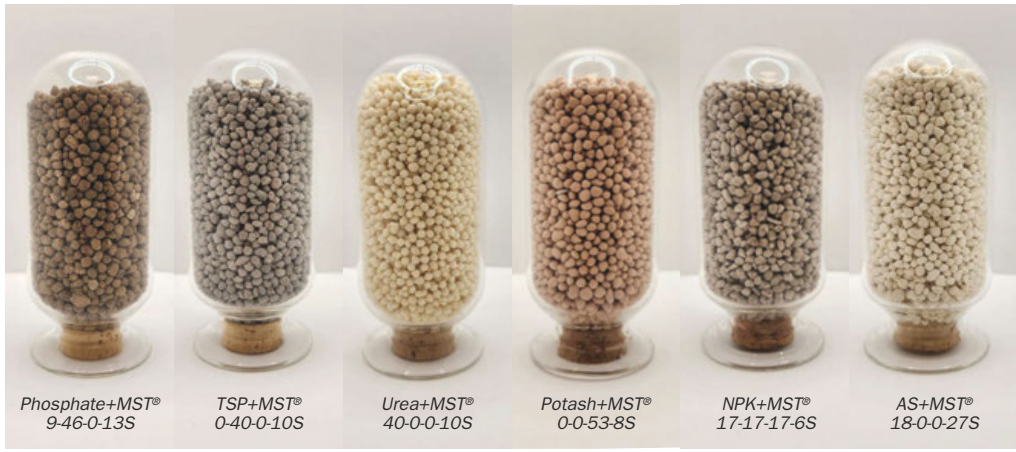


Fig. 1: Fertilizer products co-granulated with Sulvaris' Micronized Sulfur Technology (MST®) showing example nutrient analyses

Scanning electron microscope (SEM) images illustrate this vividly. These show MST® particles (coloured yellow) uniformly dispersed in a Urea+MST® granule (see photo). This homogeneity, as well as enhancing agronomic performance, also improves safety and handling. This is because the presence of dust and the related risk of combustion are eliminated by the uniform particle distribution of MST®, and by the fact that micronisation is carried out in a controlled environment.

In a key point of differentiation from other technologies, Sulvaris offers MST® to producers and distributors as an integrated production option for a full portfolio of nitrogen, phosphorus, potassium, and compound NPK fertilizers (Figure 1). Furthermore, Sulvaris has developed a liquid MST® offering for fertilizer applications. Liquid MST® also functions as an amendment for high soil pH and sodic soils. It is also an economic and effective foliar-applied fungicide.

Sulvaris technologies allow fertilizer producers and distributors to capture premium margin opportunities by enhancing agronomic value. Instead of selling commodity products, licensees can integrate Sulvaris technology into their existing production processes – boosting nutrient delivery, improving product handling, and delivering higher-return products to distributors and growers.

Sulvaris' principal technology offerings include: the award-winning Micronized Sulphur Technology (MST®), Carbon Control Technology (CCT®), and its latest Sulvaris Advanced Granulation Engine (SAGE™) platform.

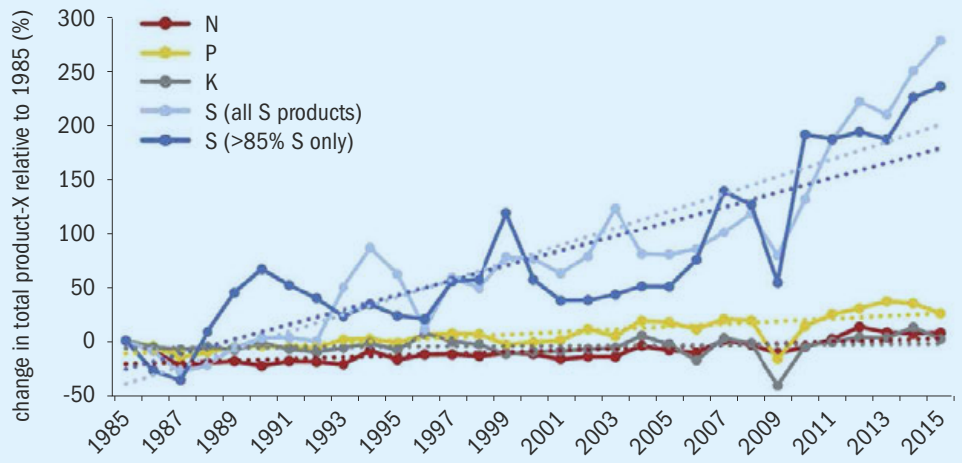
Licensing lets industry players enter sulphur markets with upgraded products without the capital burden of developing their own technology, while gaining the added certainty provided by a de-risked commercialised product. The 'bolt-on' nature of these technologies means very low capex investments and minimal production disruption, plus a small equipment footprint – with a process that is highly scalable and designed to meet the needs of a variety of clientele including producers and distributors.

Agronomic and environmental dividends

Sulphur (S) is essential for amino acid and protein formation, chlorophyll synthesis, and enzymatic processes. Yet global agriculture is increasingly confronted with sulphur deficiency. Factors such as cleaner air and declining SO_2 emissions, widespread use of high-analysis fertilizers lacking S, more intensive cropping systems, and losses to leaching have all led to a decline in sulphur supply.

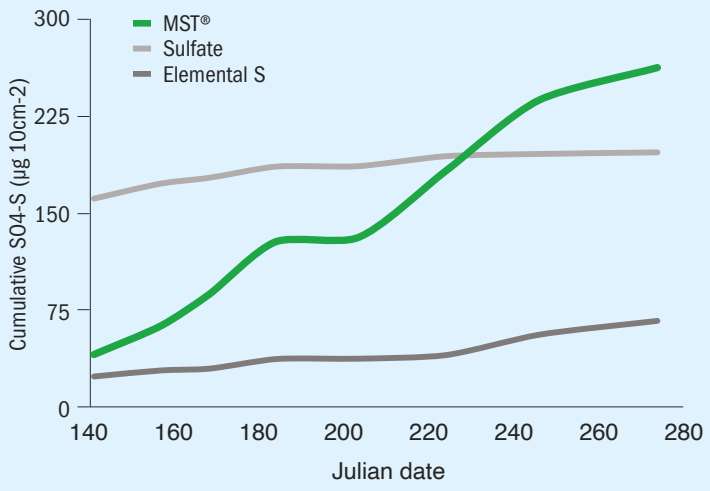
Globally, CRU estimates that only about half of the sulphur required by crops is currently supplied by fertilizers, with the largest deficits in India, Sub-Saharan Africa, and the CIS. Even in high input regions such as East and South Asia, sulphur deficits remain at 46 % and 62 %, respectively.

Fig. 2: **Sulphur fertilizer use in the Midwestern US has increased in recent decades as atmospheric sulphur deposition has declined with improved air quality**



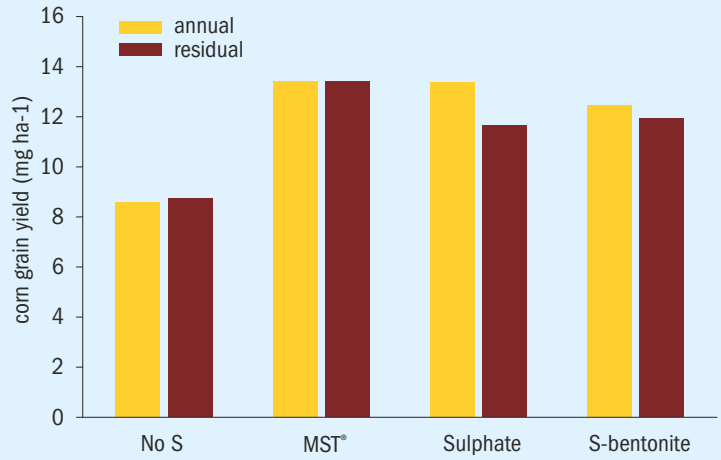
Source: Hinckley,et al. (2022)

Fig. 3: **Soil sulphate availability throughout a growing season from MST®, sulphate, and generic elemental sulphur using Plant Root Simulator (PRS™) Probes**



University of Minnesota & Western Ag Innovations

Fig. 4: **Corn grain yield in a 5-year field trial with the sulphur source applied on an annual basis In the fifth year, half the plots did not receive sulphur, relying on residual applications from previous years instead.**



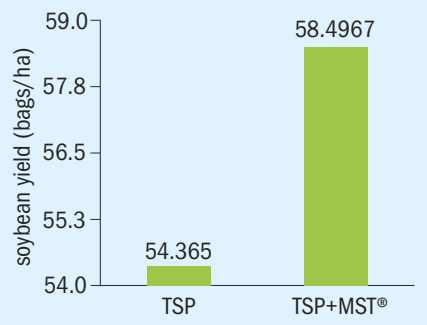
Source: University of Minnesota

In particular, declining atmospheric deposition from industry has removed what used to be a 'free' sulphur source for agriculture. To counterbalance this decline, sulphur fertilizer applications in North America have increased annually by 7.7% since 1985, versus the much lower 1-2% growth rate in nitrogen, phosphorous, and potassium applications (Figure 2).

Against this backdrop of an established need for sulphur fertilizers, MST® offers the fertilizer industry with a means of accessing growing demand – backed with positive crop yield results from independent research. One example is the long-term elemental sulphur study at the University of Minnesota (Figures 3 & 4). This has demonstrated that slow-release of plant-available sulphate throughout the growing season delivers the greatest yield, while also providing a carry-over benefit to subsequent seasons.

MST® demonstrates yield improvements, even in challenging soils with low organic matter – this confirming that small particle size is the dominant factor in sulphur nutrient delivery from elemental sulphur sources. In more than four locations in Brazil in 2024, for example, TSP+MST® increased soybean yields by between 5-16%, with applications providing sufficient sulphur release for crop uptake despite the challenging soil conditions (Figure 5). Advantageously, sulphur and nitrogen uptake are known to be biochemically interlinked in soybean, with adequate sulphur nutrition improving root nodulation, the source of nitrogen for soybeans.

Fig. 5: **Third-party field trials in the Cerrado region of Brazil in 2024 demonstrated an average 4.1 bag/ha increase in soybean yield.**



Source: Sulvaris

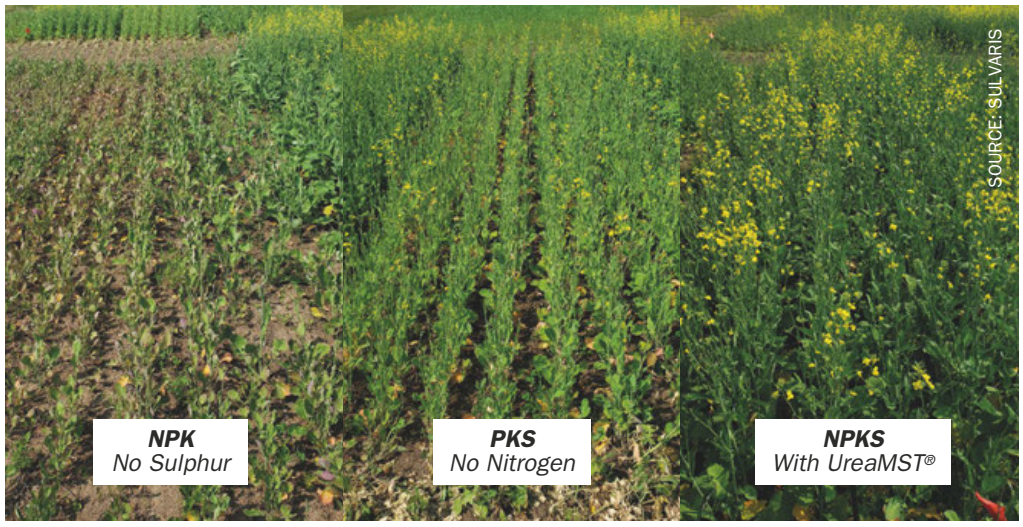


Fig. 6: Canola field trial demonstrating the significant impact of proper 4R sulphur nutrition on plant growth and nitrogen utilization at the University of Alberta Breton Plots.

When sulphur nutrition is insufficient, crops will not attain their full yield potential and, consequently, will not maximise uptake of other applied nutrients like nitrogen. This exacerbates inefficient nutrient use with negative environmental consequences, such as leaching losses to waterways and greenhouse gas emissions.

Perhaps one of the most striking examples of this is for canola (Figure 6) – where sulphur is a cornerstone nutrient and necessary to unlock protein synthesis. Consequently, a lack of sulphur can lead to poor nutrient uptake and toxic accumulations of nitrates in the crop. Long-term plots have also demonstrated that – in addition to lower yields – insufficient sulphur lowers soil organic matter accumulation and increases the potential for greenhouse gas emissions.

Milestone moment – the IFA Science Innovation Award

In April 2025, Sulvaris captured global attention by winning the inaugural International Fertilizer Association (IFA) Science Innovation Award in the Novel Fertilizers category. Selected from 22 global submissions, the award recognised MST® as a groundbreaking fertilizer technology that is a novel, practical, scalable and sustainable. Satish Iyer (co-founder) and Mark Howell (Head of Agronomy) accepted the award on behalf of Sulvaris at IFA's Cultivating Tomorrow conference in Barcelona.

This international accolade recognises MST® as a leading process option globally for producers wishing to address sulphur deficiencies.

As Alzbeta Klein, IFA's CEO, highlighted: "[Sulvaris] stood out to our judging panel because of their ability to find a robust technological solution to both sulphur deficits and losses in agricultural systems, leveraging scientific expertise with accompanying evidence of implementation and impact."

This comes at a time where IFA and The Sulphur Institute (TSI) are recognising

sulphur as the 'fourth plant macronutrient' alongside N, P, and K, having recently launched an initiative to assess sulphur deficiencies and applications globally. Sulvaris, alongside other key industry players and academia, will contribute data and expertise to a global crop nutrient database. This will help identify areas where crop quality and yields can be improved with better nutrient management including sulphur applications.

Fertilizer producers, faced with margin pressures and regulatory demands, need scalable technologies that provide product differentiation and improve nutrient use efficiency. MST® offers a simple, efficient process that integrates into existing production lines with minimal downtime, low capex, and a compact footprint (Figure 7) – making it a practical and accessible 'bolt-on' option for both fertilizer producers and distributors.

These valuable characteristics have been further validated, de-risked and commercialised in Nutrien's Smart Nutrition MAP+MST® product, currently available in the North American market. Overall, the MST® process is highly scalable and, to meet the needs of a variety of clientele, is suitable for producers looking to augment commodity fertilizer production and generate premium products at volumes from 15,000 tonnes to several million tonnes.

Building on the IFA award and the recognition it provides, Sulvaris continues to add to its intellectual property (IP) portfolio and enhance its global relevance as a technology provider. This notably includes recent patent submissions for MST® integration and CCT™ production.

Looking ahead: scaling impact with innovation

Sulvaris is building a series of innovations to meet emerging tech and sustainability imperatives in the fertilizer industry:

- **Micronized Sulfur Technology (MST®)** addresses sulphur deficiency with precision and season-long efficacy with upgraded premium fertilizers.
- **Carbon Control Technology (CCT™)**, by sequestering carbon and improving nutrient use, embeds sustainability properties within the structure of fertilizers.
- **The Sulvaris Advanced Granulation Engine (SAGE™)** offers an adaptable manufacturing system for premium products that provides balanced crop nutrition to a distributed market.

Sulvaris, through its licensing business model, has shown that providing licensees with transformative fertilizer technologies delivers high-margin potential. With MST®, the company offers the market a novel, highly functional product that seamlessly integrates into existing production systems and delivers proven yield, handling, and environmental advantages.

Now, with CCT™ and SAGE™, Sulvaris is setting the stage for a new generation of fertilizer technologies. For producers and distributors looking to migrate beyond standard commodity fertilizer offerings, this is a gateway into enhanced-efficiency, sustainable products that meet regional agronomic demands and ESG goals alike.

CCT™ – a circular economy solution

While MST® unlocks the sulphur market and provides an entry for fertilizer producers, Sulvaris is also advancing its Carbon Control Technology (CCT™), a platform that elevates the capacity to deliver multi-nutrient, sustainable fertilizers in a carbon-rich matrix. CCT™ is a patented innovation that integrates and enriches biomass by-products with crop nutrients to form a stable carbon structure.

CCT™ provides a circular economy solution by valorising biomass or crop residue waste streams as feedstocks. Generated by our Sulvaris CCT reactors, these products have demonstrated enhanced nutrient delivery with slow-release nitrogen, yield improvements and, importantly, reduced greenhouse gas emissions, while simultaneously contributing to soil organic matter. Beneficially, this turns a liability (waste biomass) into a valuable agronomic input.

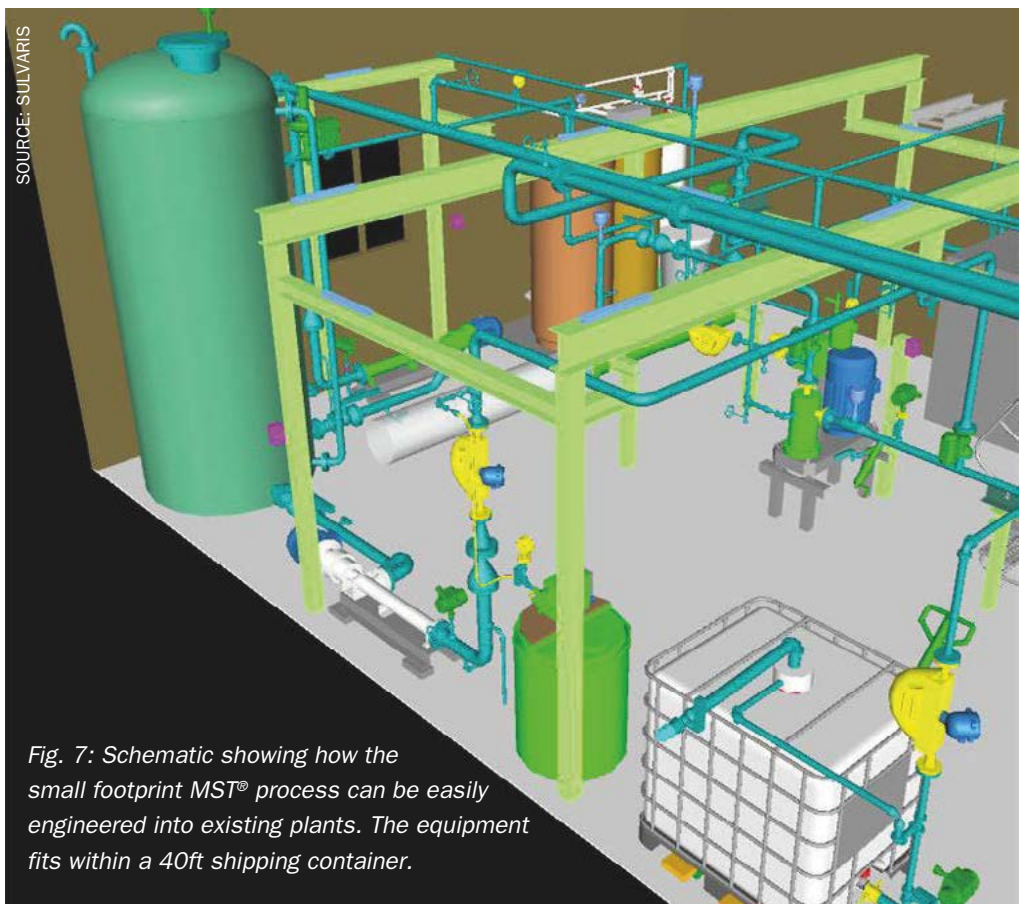

SOURCE: SULVARIS

Fig. 7: Schematic showing how the small footprint MST® process can be easily engineered into existing plants. The equipment fits within a 40ft shipping container.

SAGE™ – moving beyond MST® and CCT™

The Sulvaris Advanced Granulation Engine (SAGE™) is a new production system designed to deliver enhanced-efficiency MST® fertilizers with low capex, fast cycle time, and scalability. SAGE™ enables producers and distributors to access Sulvaris technologies in a de-risked platform designed to create high-value products, while also maintaining standard commodity output.

It offers the capability to produce co-granulated MST®-enhanced NPK granules with:

- Flexible granulometric control
- Uniform nutrient distribution
- Better performance over traditional blends
- Improved product handling
- An ability to develop market specific formulations adapted to regional needs. ■

Pioneering CCm – patents, partnerships and production

A strong driver behind the emergence of low-carbon fertilizers has been the close partnerships between start-ups and major companies looking to reduce Scope 3 emissions in their supply chains. CCm Technologies has been a particularly successful pioneer of this approach. *Fertilizer International* sat down with **Pawel Kisielewski**, the company's CEO, to talk about its innovative fertilizer technology, achievements to date and UK production scale-up.

Introduction – from patents to production

CCm Technologies is a UK-based manufacturer of low-carbon fertilizers. The company was established in 2011 by four founding directors, Professor Peter Hammond, Pawel Kisielewski, Gordon Horsfield and Richard Morse. The company was granted its first patent in 2013 for a fertilizer production process based on carbon capture, utilisation and storage (CCUS). This was followed by a series of other patents (on polymer technology, a heating unit and CO_2 power generation, for example) over the next five years.

Innovation and intellectual property (IP) are at the heart of the company. CCm's extensive library of global patents has grown to 44 granted in more than 50 jurisdictions worldwide. Of relevance to agriculture, its IP includes a technology that creates low-carbon fertilizers by capturing carbon dioxide from industrial power generation and then uses this to stabilise recovered nutrients, such as ammonia and phosphorus, from agricultural and industrial waste streams. Fibrous residues from food waste, sewage sludge and agriculture are also used as a substrate for these nutrients to improve nutrient delivery and enrich soils with added carbon.

Importantly, this fertiliser production process is 'climate positive' with an ability to capture and sequester carbon. This improves soil carbon and health – with every tonne of CCm fertilizer sequestering around 1 tonne of CO_2 equivalent. Also, by recovering secondary nutrients, emissions from primary fertilizer production are avoided.

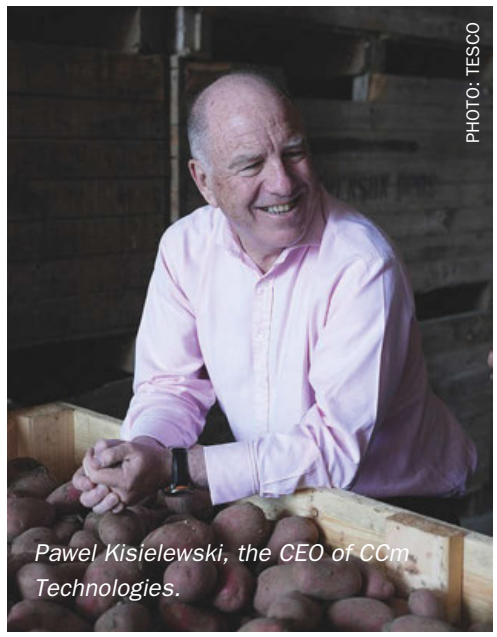


PHOTO: TESCO

Pawel Kisielewski, the CEO of CCm Technologies.

A successful Series A funding round led by Wittington Investments in 2019 was followed by a breakthrough year for CCm in 2020. This saw the launch of a project with PepsiCo/Walkers Crisps to cut carbon emissions from potato growing by 70%, and Yorkshire Water's deployment of CCm's recovery process to capture ammonia and phosphorus and convert these into fertilizers.

The company has also received a £1 million UK government grant to work with Severn Trent Water on developing commercial products from recycled wastewater and went on to secure £2 million of new funding from Innovate UK's Sustainable Innovation Fund in 2021. It has also been collaborating closely with Tesco on low-carbon fertilizers since 2022.

CCm raised more equity in the third quarter of last year through a successful Series B funding round led by Frontier Agriculture. The company is currently building two low-carbon fertilizer plants in East Anglia and is continuing to partner with leading global food and drink manufacturers and leading retailers.

CCm has been producing low-carbon fertilizers at the following UK sites:

- The Nestle/Cargill cocoa shell pilot in York
- PepsiCo potato waste digestate plant (10,000 t/a of 12-4-4)
- Bagley Biogas farm-based digestate plant (2,000 t/a of 10-2-5 and 12-4-4)
- Water utility sewage sludge plant (10,000 t/a of various NPK formulations)
- Kew Technology digestate and biochar plant (1,000 t/a of 6-5-5).

A company powered by innovation

Could you tell our readers how CCm first came about – and how it's able to transform low-value and variable waste streams into valuable crop nutrient products of consistent quality?

"The origins of CCm were at the school gate because Peter Hammond, our chief technology officer who's also a visiting professor at Sheffield University, and I had children at the same school. Peter, who's

been working with CO_2 for the best part of 30 years, had this eureka moment, turning a problem into the solution, realising that CO_2 and ammonia were being attracted onto the surface of fibre.

"So, our primary piece of technology is the natural chemical reaction between CO_2 and ammonia. Unlike many other technology solutions, you do not have to put it under pressure, heat to high temperature or add expensive enzymes or catalysts. It is just that ammonia and CO_2 will react with fibre as the third input.

"The fibre is purely there as a substrate in the first instance. So, we can use grass, wood chip, straw, compost, any waste fibre, or even biochar. But primarily it is digestate from an anaerobic digester because the fibre lengths are small, which means we've got a large surface area to load with ammonia molecules.

"It's a two-step process. So, in the first chemical reaction, you've got fibre with a large surface area, and you put a lot of ammonia molecules on it and then you pass through CO_2 to form ammonium bicarbonate. In a perfect world, those ammonia molecules are waste sourced from somewhere within the waste hierarchy.

"There's a plus and a minus to that. The plus is that it's an exothermic reaction, so you get some heat energy from that. The downside is under relatively high temperature conditions that chemical reaction will reverse. So, we need to do a second chemical reaction, which is to add a calcium salt, to stabilise those nutrients.

"What you end up with is ammonium nitrate, the building block of fertilizer, and calcium carbonate, chalk essentially, all embedded and bound up in the organic matter. So, you can then create a fertilizer, it's important to say a customised one, for the farmer.

"In our first year with PepsiCo, we did a 12-4-4 NPK, nitrogen, phosphorus, potassium formulation. The following year, the farmers in PepsiCo's supply chains said they wanted a bit more potassium, so we went to a 12-4-6. Then the following year, they wanted the potassium dialled back down. The message here is that it's customisable.

"This technology is a cool process that uses CO_2 as the binding agent for other waste streams and critically stabilises those nutrients. Because phosphates and nitrates in the wrong place – in a river in the West Country or Loch Neagh in Northern Ireland, or the Ganges or the Florida Keys – is not a good outcome. But, if you can stabilise using CO_2, then waste nitrates and phosphate become valuable inputs at the front end of fertiliser production.

"For our patent portfolio, the top line number is 44 individual patents, as you rightly say. The actual numbers granted in 64 jurisdictions is 101 now, although there are obviously some repeats in there. Then there are another 29 pending applications.

"So, it's a massive patent portfolio that costs us a huge amount. Not all of them relate to fertilizer, some of them are applications of the technology to power generation, heat storage and polymers."

Partnering on decarbonisation

Agricultural decarbonisation and reductions in Scope 3 emissions require collaboration across the whole food system. CCm has exemplified this approach through its projects with PepsiCo, Nestle, Cargill, Tesco and others. **How important are partnerships, in your view, for decarbonising agriculture and food products – and what can fertilizer input providers such as CCm offer the major supermarkets and fast-moving consumer goods companies?**

"When we first set up the business, bringing a new product to market, we didn't know who we needed to influence? Is it the consumer, as that's quite tricky for a small company, or is it the government – and trying to convince them to give you subsidies?

"[Actually,] I think it's a critical for low carbon fertilizer businesses not to seek government subsidies. It became clear [to us instead] that we were going to have to work [directly] with the regulators and the farmers. But the real drivers, the people leading this initiative, are the corporates.

"That's because, on average, for global food manufacturers like PepsiCo or Nestle, Scope 3 [supply chain emissions] are about 80% of total emissions. So, as they seek to decarbonise, then Scope 3 is both their biggest and most difficult challenge.

"Then two summers ago, Nestle came out with a statement saying that as a company they would no longer offset – they wouldn't, you know, be buying forests in the Amazon – and would only do insetting [in future].

"That's actually made their lives more difficult, which is symptomatic of the leadership companies are prepared to show. I think Ramon Laguarta, the chairman and CEO of PepsiCo, has been the absolute standout leader [on sustainability]. But other people are doing it as well.

"It makes a huge amount of difference when the person committed [to low-carbon fertilizers] is running the show. PepsiCo's chairman and CEO has absolutely been driving this, along with Jim Andrew, their chief sustainability officer. In the same way, Frontier's new managing director Diana Overton is totally directing this too.

"We had the same [positive] conversation with Mark Schneider when he was Nestle's CEO. If he says we're going to do this, then everybody within the organisation realises they don't have to use unnecessary political capital to try and force through new technology – because the person at the top has said 'we want to see this happen'.

"We're finding the same now at C-suite level with a European brewer. They bought in at the top table and that's made life a lot easier.

"How does that then filter through [to us as a company]? Data is critical. If PepsiCo or Tesco are going to make a claim [on Scope 3 emissions] we need to be sure that the data we're giving them is absolutely

PHOTO: CCM

CCm's pelletised 'climate positive' ammonium nitrate fertilizer incorporates recovered ammonia, plus calcium carbonate, within a fibrous organic structure and enriches soils with carbon.

100% bomb proof. That's why we work with the Carbon Trust specifically, because they're so reputable internationally."

What is a 'green' fertilizer?

Defining what is a sustainable and/or lower-carbon fertilizer is not straightforward, given there's no agreed standard definition of what a 'green' fertilizer actually is. **How has CCm approached verification and certification of its processes and products by working with the Carbon Trust and others?**

"You're right, the whole of the climate space, not just within ag, is reliant on robust data which have a high level of integrity. So, data become key, which is the reason why we're collaborating with Google Cloud who are helping us understand exactly how we can make data even more accessible to decision-makers.

"But if we go back to the fundamental challenge, fertilizer emissions divide between those that come from the manufacturing, the Haber Bosch process in the main, and those that happen in field. The Carbon Trust did an analysis in 2023 measuring the production emissions of our 12-4-4 NPK fertilizer. They said to us that a synthetic fertiliser with a comparable formulation had manufacturing emissions of about 1.2 tonnes of CO_2 equivalent per tonne of product.

"[For our product] we were hoping to be, I don't know, 70% better. The actual number they gave us for CCm fertilizer – which is verified and certified – is minus 0.9 tonnes of CO_2 equivalent per tonne, mainly driven by the use of renewable energy and other embedded factors in our process. Critically, the 'delta' [numerical difference] between that CCm fertilizer formulation and the equivalent synthetic product was over two tonnes.

"The delta does change slightly for different NPK formulations. We think the latest NPK formula that we'll be producing out of the two new [East Anglian] plants will have a delta closer to 1.5 tonnes.

"If you look at large food manufacturing companies, their supply chains are using well over half a million tonnes of fertilizer just in Europe [annually]. If you're then multiplying that by a delta of 1.5 the difference [with synthetic fertilizers] is huge – and that's just on the manufacturing emissions.

"The second piece of the equation is in-field emissions, which are pretty difficult to scope properly because there are two elements. One is the nutrients lost to leaching and runoff into rivers and groundwater and the other one is NOx gases emitted to air. A two-year study of in-field emissions paid for by Nestle and Cargill found, in simple terms, [that CCm's NPK fertilizer delivered] a reduction of about half in comparison with synthetic [fertilizers].

"Why is that the case? Well, first of all, you've got a lot more organic matter in a CCm pellet. That is organic matter being fed back into the soil and therefore reversing the decline in soil fertility from decades of industrial farming.

"What the CCm pellet also does, with calcium carbonate present, is act like a [fibrous] sponge that holds the nutrients. The lignin which is present in many of those fibrous materials, particularly straw-based materials, is really increasing nutrient [retention and] availability.

"One of the things that we're working on is the ability to apply less CCm fertilizer but get the same yield outcomes – that came from a study five years ago. We're in a position where not only are we starting to feed the soil and build up the soil organic matter but also finding – particularly around cereal crops – the ability for farmers to apply less nitrogen. Going forward, we want to apply less nitrogen to the ground if we possibly can, while maintaining yields.

"We also had a eureka moment talking to livestock producers who are huge buyers of animal feed. Now, if you use ultra low carbon fertilisers – it's actually a negative number but it's easier to say ultra low – to grow the corn, oats or barley to feed their animals, you're decarbonising the front end. Then, if you can take animal waste to make the fertilizer, you'll basically be decarbonising both the front end and the back end of livestock production."

Scaling-up to meet demand

While largely viewed as a demonstration market currently, agricultural demand for 'green' fertilizer is scaling up as food manufacturers and retailers roll out regenerative farming and strive to meet their decarbonisation targets. **How is CCm scaling up production and supply of fertilizers to meet current and future market demand?**

"We have a distributed 'hub and spoke' business model. In East Anglia, we'll have a couple of plants producing in the fourth quarter of 2025 within 30 miles of each other, drawing on waste resources that exist within the hub and spoke area. On their own, the [fertilizer production] capacity those two plants will provide will be about 53,000 tonnes by May 2027 – and upgrades mean that'll be up to about 77,500 tonnes the following year.

"Then, in addition, we've got a Northern Ireland licensee with another 30,000 tonnes for May 2028 and we've also got a contract manufacturer that is likely to produce another 30,000 tonnes. So [CCm's fertilizer production capacity] will be somewhere in the region of about 126,000-130,000 tonnes – through both our own facilities and from people who are licencing this technology.

"[Producing] about 126,000 tonnes [of fertilizer] by May 2028 is about five percent of UK current demand. That's appreciable from a standing start. Those amounts I'm giving you are for the spring application season when fertilizers are most needed.

"In the main, we will be licencing the technology internationally. Firstly, because that's the quickest way of doing it and, secondly, because customers like PepsiCo want us to do this to supply their overseas agricultural supply chain. We don't want to be building a huge operation that will need managing beyond our own capability. So, licencing through partnerships is crucial.

"On funding, we did the Series B raise [last year] successfully led by Frontier Agriculture. Frontier have been around for about two decades, half owned by Cargill and half owned by AB Foods, which is ultimately owned by the Weston family. They're basically the leading distributor of grain, seeds and fertilizers in the UK.

"That [Series B] round was really around the financing of the first production plant. Potentially, it's possible we'll do another equity round towards the end of this year, because the second plant emerged more quickly and is going to be bigger than we'd anticipated.

"But after that we then move into a position where we don't necessarily have to use equity because the off takers – not just from people like PepsiCo who've been incredibly generous and supportive – but other customers who are either food manufacturers or retailers.

"[They're] giving us long-term offtake over a 10-year time frame from which we can comfortably use debt funding. So, we're looking at one of our last equity runs at the end of this year – and that's probably us done!" ■

FertigHy – decarbonising fertilizer production at scale

FertigHy was founded in 2023 with the aim of developing, building and operating large-scale low-carbon fertilizer plants across Europe. Producing low-carbon fertilizers from renewable and clean electricity within the region, says the company, will promote re-industrialisation, supply security and stable long-term prices, while also contributing to the decarbonisation of the hard-to-abate fertilizer industry.

Introduction

Madrid-headquartered project developer FertigHy has plans to build a series of low-carbon fertilizer plants within the EU.

Each plant will produce half a million tonnes of low-carbon calcium ammonium nitrate (CAN-27) fertilizer per year and have an annual energy demand of around two terawatt hours (TWh). The carbon footprint of these production plants is expected to be 80-90% lower than their conventional natural gas-based equivalents – resulting in a CO_2 emissions reduction of up to one million tonnes every year.

Shifting from 'grey' to 'green'

Nitrogen fertilizers rely on ammonia (NH_3) as a key ingredient. This is traditionally synthesised from natural gas via the Haber-Bosch process. While Haber-Bosch will remain central to FertigHy's low-carbon fertilizer production process, the key difference lies in the way hydrogen is produced.

FertigHy will use electrolysers to generate hydrogen instead of the steam methane reforming (SMR) process traditionally used. SMR, being a conventional fossil fuel method, releases significant amounts of CO_2. FertigHy's plants, in contrast, by using low-carbon electricity instead of natural gas, can synthesise decarbonised ammonia and virtually eliminate CO_2 emissions.

Units downstream of the electrolysers – for ammonia synthesis, nitric acid, ammonium nitrate and CAN-27 production – utilise well-established and industry-proven technologies with a long history of reliable operation (Figure 1).

PHOTO: FLICKR/PIERRE ANDRÉ LECLERCQ

Windmill and farmland, Hauts-de-France. The Languevoisin-Quiquery area of this region in northern France will be the location of FertigHy's first large-scale low-carbon fertilizer plant.

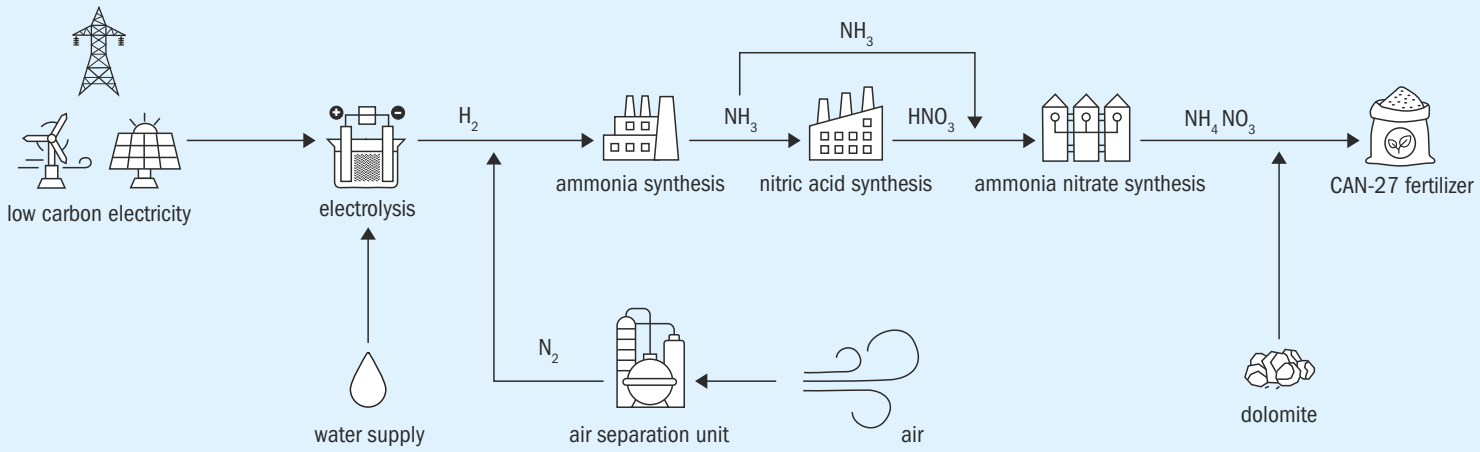
Northern France the launching pad

In May 2024, FertigHy selected Languevoisin in the Hauts-de-France region of northern France as the location of its first plant, with construction expected to begin in 2027. The new plant will produce 500,000 t/a of low-carbon fertilizers, a volume corresponding to around 10% of France's nitrogen fertilizer consumption, and is scheduled to become operational by 2030.

"This project requires an estimated investment of €1.3 billion and will create around 250 direct jobs in the region, demonstrating our commitment to local economic development and job creation," FertigHy said.

FertigHy's decision to establish its first low-carbon fertilizer plant in northern France was due to the following compelling reasons:

Fig. 1: **FertigHy's innovative production process for low-carbon CAN-27 production**



Source: FertigHy

- The region's long-standing agricultural base makes it a prime location for fertilizer production.
- France is Europe's biggest nitrogen fertilizer consumer, with demand of around five million tonnes annually underscoring its market potential.
- The country's attractiveness for clean hydrogen investment – a result of supportive government policies and subsidies.
- In particular, the development of a support mechanism for low-carbon and renewable hydrogen projects solidifies France's appeal as a place for FertigHy to invest in and do business.
- Additionally, the country's robust agricultural sector, coupled with a national roadmap on agricultural and food sovereignty, provides a conducive policy environment for the proposed fertilizer production plant.
- Finally, the chosen site, being strategically positioned in Northern France, offers proximity to key European markets and access to low-carbon baseload electricity.

The unveiling of Languevoisin as the location of FertigHy's first plant coincided with the announcement of two other major project milestones:

- The completion of a feasibility study and pre-FEED (front-end engineering design) by NEXTCHEM (MAIRE Group). This incorporated NX Stami Green Ammonia™ and NX Stami Nitric Acid™ technologies, while integrating NEXTCHEM's hydrogen and electrolyser know-how, to offer a consolidated technical solution.
- The selection of Egis for environmental permit assistance.

FertigHy has now completed these studies, and is preparing for the project's next phase, which will include the FEED and environmental authorisation.

Six founding shareholders with cross-sector expertise

FertigHy was formed as a consortium of six initial investors with expertise across the whole value chain:

- InnoEnergy, the company's originator, provides business acceleration services via its European Green Hydrogen Acceleration Centre (EGHAC).
- RIC Energy bring core knowledge in photovoltaic (PV) and electricity markets.
- MAIRE provides experience in the energy transition with competencies in project development, technology, and the engineering procurement and construction (EPC) of ammonia and fertilizer plants.
- Siemens Financial Services brings to the consortium experience in financing large-scale industrial projects.
- InVivo offers support as a purchaser and distributor of fertilizers to 300,000 farmers, representing more than 160 cooperatives.
- Finally, HEINEKEN is exploring ways it can decarbonise at scale, with FertigHy among the many sustainable agriculture initiatives being piloted.

In November last year, FertigHy successfully secured a fresh injection of capital when all its six shareholders unanimously agreed an equity raise.

"This new round of investment demonstrates the continued commitment of all shareholders to the strategic mission to decarbonize the fertilizer industry and the achievement of important milestones in FertigHy's first facility in Hauts-de-France after completing the feasibility studies," FertigHy said.

CAN confers benefits

FertigHy's decision to produce a low-carbon version of calcium ammonium nitrate (CAN-27) reflects the clear advantages offered by this fertilizer over other nitrogen products such as urea. The benefits of CAN-27 include lower volatilisation risk, its neutral impact on soil pH and rapid crop nutrient uptake. The agronomic advantages of CAN-27 and its better overall efficiency for crop cultivation – coupled with the potential for 100% decarbonisation – align perfectly with FertigHy's commitment to more sustainable agricultural practices.

Driving decarbonisation

Greenhouse gas emissions (GHGs) from Europe's agriculture sector are significant, accounting for some 10% of total EU emissions. European farmers apply over 11 million tonnes of nitrogen fertilizers annually, leading to substantial environmental impacts.

The production of nitrogen fertilizers is also a major source of industrial CO_2 emissions. Encouragingly, the shift to lower carbon hydrogen and ammonia, as part of efforts to decarbonise this sector, can drastically reduce the carbon footprint of fertilizer production.

Conventional fertilizers contribute significantly to Scope 3 emissions generated by the food value chain. The availability and supply of low carbon fertilizers are

therefore vital when it comes to food industry decarbonisation.

Scope 3 emissions typically represent 80-90% of the total emissions generated by food and drink companies. Consequently, many sector-leading companies have committed to ambitious decarbonisation goals, aiming to significantly reduce their GHG emissions in line with global climate targets. FertigHy, by producing and supplying low-carbon fertilizers, can support these emissions reduction efforts, thereby helping food and drink companies meet their sustainability goals, as well as mitigating climate change more broadly.

Europe's import dependency and competitiveness

Recent geopolitical events, such as the conflict in Ukraine, have amplified concerns around supply chain disruption. The reliance of European nitrogen fertilizer producers on externally sourced natural gas feedstock illustrates the region's supply vulnerability. The region's agriculture is also partly dependent on nitrogen fertilizers imported from North Africa and Russia.

FertigHy's ambition to establish new fertilizer production plants within the EU, by reducing these external dependencies, should enhance Europe's agricultural resilience and bolster food security. Fertilizer production via water electrolysis – generating low-carbon hydrogen using renewable and clean electricity – reduces dependency on fossil fuels as well as eliminating direct CO_2 emissions.

> **FertigHy, by producing and supplying low-carbon fertilizers, can help food and drink companies meet their sustainability goals, as well as mitigating climate change more broadly.**

Becoming more self-sufficient in fertilizer production also means less price volatility. Natural gas prices and the scarcity of fertilizer supplies have contributed to food price inflation in recent years by driving up costs. Ensuring a stable supply of fertilizers at predictable prices is therefore of strategic importance for Europe.

While low-carbon fertilizers might be more expensive initially, upcoming carbon taxes on traditional natural gas-based fertilizers, under the EU's Carbon Border Adjustment Mechanism (CBAM), will level the playing field. CBAM is being introduced from 2026 with full implementation by 2034.

CBAM will impose new taxes on fertilizer importers, while the reduction of free allowances under the EU Emissions Trading System (ETS) will increase costs for conventional fertilizer production within Europe. This dual pressure, both from CBAM and reduced ETS allowances, will make the availability to farmers of low-carbon fertilizers produced within Europe even more crucial. This shift to lower carbon production will also be important for the overall competitiveness of Europe's fertilizer industry.

Ammonia in the fertilizer value chain

Stamicarbon, the nitrogen technology licensor of NEXTCHEM, is pioneering future-proof solutions for low-carbon production with two ammonia designs, each tailored to specific project scales, feedstock types, and sustainability goals. **Deepak Shetty**, **Rolf Postma**, and **Nikolay Ketov** of Stamicarbon (NEXTCHEM) look at how the arrival of these technologies will shape the future of the low-carbon economy – across fertilizer, fuels, and the evolving clean energy market.

Growing demand, changing markets

Global ammonia production is forecast to rise in future, attended by further growth in both market value and production capacity. Currently, this expansion is occurring primarily in both the fertilizer sector and ammonia's traditional industrial applications, driven upwards by factors such as population growth and increasing food demand.

Beyond its conventional role as the key building block for nitrogen fertilizers, ammonia is also emerging as a clean energy carrier, particularly as a fuel and hydrogen vector for decarbonising hard-to-abate sectors.

Ammonia is relatively easy to store and transport in bulk, benefitting from a century-old global production and supply network. This extensive infrastructure is now being repurposed to support the energy transition, with existing ammonia storage, shipping, and port facilities offering a practical solution for moving renewable energy from centres of abundance to centres of demand.

Given that global ammonia production – driven by agriculture demand and its use as an energy vector – is set to increase significantly in coming years, the question is no longer whether demand will grow, but how fast: will ammonia demand simply track global population and economic growth, or accelerate faster as it becomes an essential component of the low-carbon economy?


IMAGE: STAMICARBON

Computer generated 3D model of a Stamicarbon Green Ammonia plant.

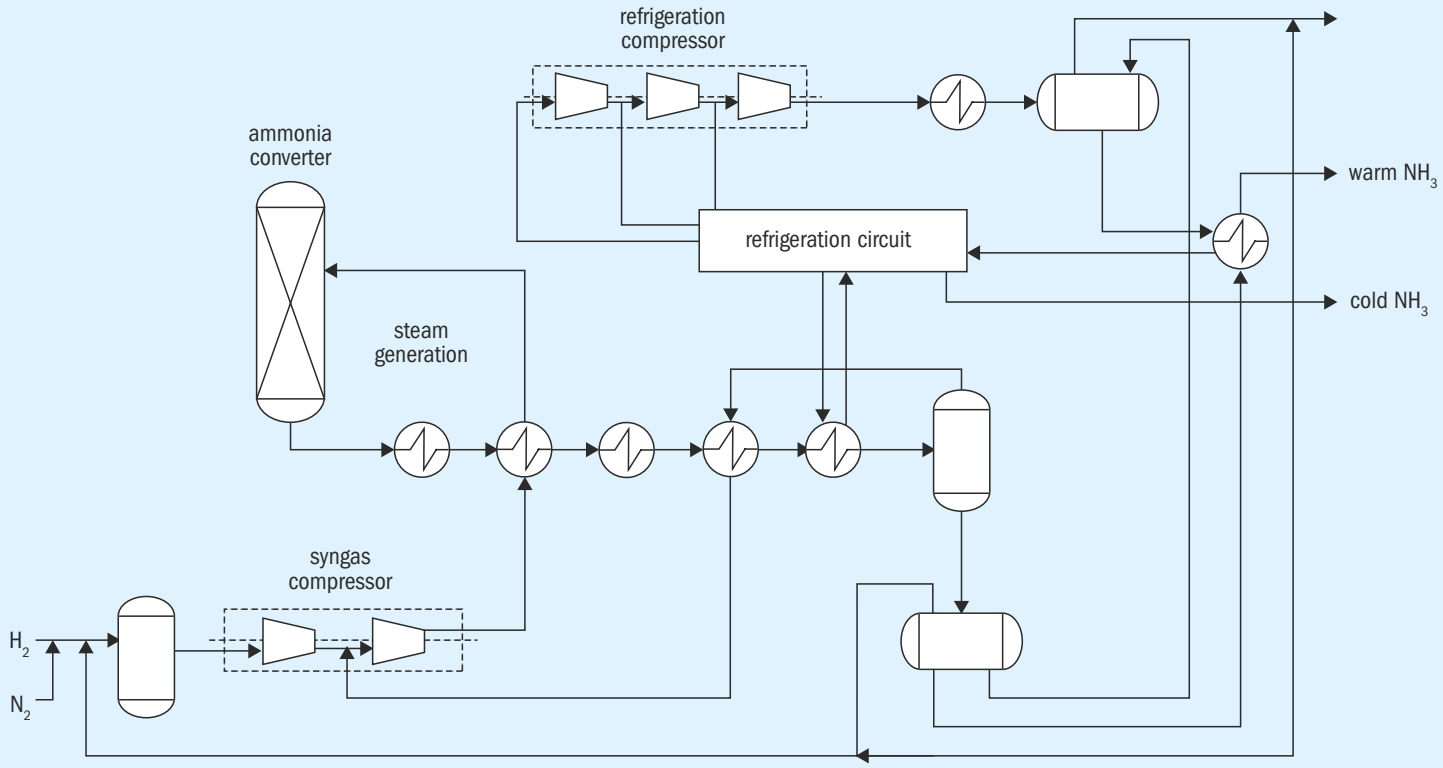
Reducing the industry's footprint

Ammonia synthesis, while playing a central role in global food production, is also a notable contributor to industrial CO_2 emissions. Reducing this footprint remains a key objective across the industry, with technology providers and producers exploring new pathways to cut fertilizer value chain emissions.

Each and every ammonia decarbonisation route has a role to play – regardless of whether they generate 'blue', 'green' or other colour coded products. Blue ammonia builds on established large-scale fossil-based processes, incorporating carbon capture to reduce emissions in the near term. Green ammonia, on the other hand, uses renewable electricity to produce hydrogen via electrolysis, offering a fully sustainable pathway with no direct carbon emissions. Both approaches will be critical as the ammonia industry adapts to meet higher demand and achieve sustainability objectives.

Stamicarbon, the nitrogen technology licensor of NEXTCHEM, is pioneering future-proof solutions for low-carbon production with two ammonia designs, each tailored to specific project scales, feedstock types, and sustainability goals. Whatever the priority, Stamicarbon offers a technology option to match – whether that's small- to medium-scale green ammonia production from renewable electricity, or large-scale blue ammonia production from fossil sources with integrated carbon capture, utilisation, and storage (CCUS). In all cases, the emphasis is on highly efficient processes, maximum energy integration, and minimised emissions.

Fig. 1: **NX STAMI™ Ammonia Medium-Pressure Design process diagram**



Source: Stamicarbon

Large scale, high efficiency

To meet the growing demand for cost-efficient, high-performance ammonia production at industrial scale, Stamicarbon offers the **NX STAMI™ Ammonia Medium-Pressure Design** (Figure 1). This solution builds on the proven Haber-Bosch process, optimised for capacities ranging from 50 to 3,500 metric tonnes per day (t/d). It is particularly well-suited for large-scale ammonia plants using natural gas or other feedstocks and can be effectively integrated with front-end technologies such as steam methane reforming (SMR), autothermal reforming (ATR), and CCUS systems.

With more than 45 industrial references, including large-scale installations, the NX STAMI™ design offers a reliable and economically viable option for producers seeking to balance scale, efficiency, and emissions performance.

In this design, ammonia synthesis takes place in a multi-bed radial-flow reactor improved to minimise pressure drop and maximise per-pass conversion efficiency. Essentially, the NX STAMI™ medium-pressure design can maximise the per-pass conversion of hydrogen and nitrogen with the smallest possible catalyst volume.

The converter's first catalyst bed has superior temperature control. This feature enables more efficient operation and extends catalyst life by avoiding hot spots. The result is a highly efficient synthesis loop that improves ammonia yield while consuming less energy. The design is also flexible and, by tailoring key operating parameters (pressure, flow rates, recycle ratios) to the client's individual needs, can be modified for optimal performance in different scenarios.

Conventional large-scale ammonia plants that use the NX STAMI™ design can be decarbonised by integrating carbon capture at the front-end. Stamicarbon offers advanced ATR technology, via its parent company NEXTCHEM, that is particularly advantageous for these types of 'blue' ammonia projects.

ATR, by yielding a high-pressure syngas stream with a high concentration of CO_2, makes downstream carbon capture far more efficient. In fact, carbon capture rates higher than 98% can be achieved by NEXTCHEM's ATR-based ammonia production – with 40% less solvent circulation compared to a conventional amine-based technology.

NEXTCHEM's ATR operates at a high pressure (60+ barg). This reduces the compression duty needed in the ammonia synthesis loop, compared to conventional lower pressure reforming, as well as reducing the reactor size versus a conventional ATR. This translates to a lower capital cost profile and lower operating costs.

Moreover, the ATR route uses well-proven and robust equipment and a simplified process scheme that improves overall energy efficiency rates. When coupled with CCUS, an ATR-based ammonia plant can achieve world-scale output with a significantly smaller carbon footprint.

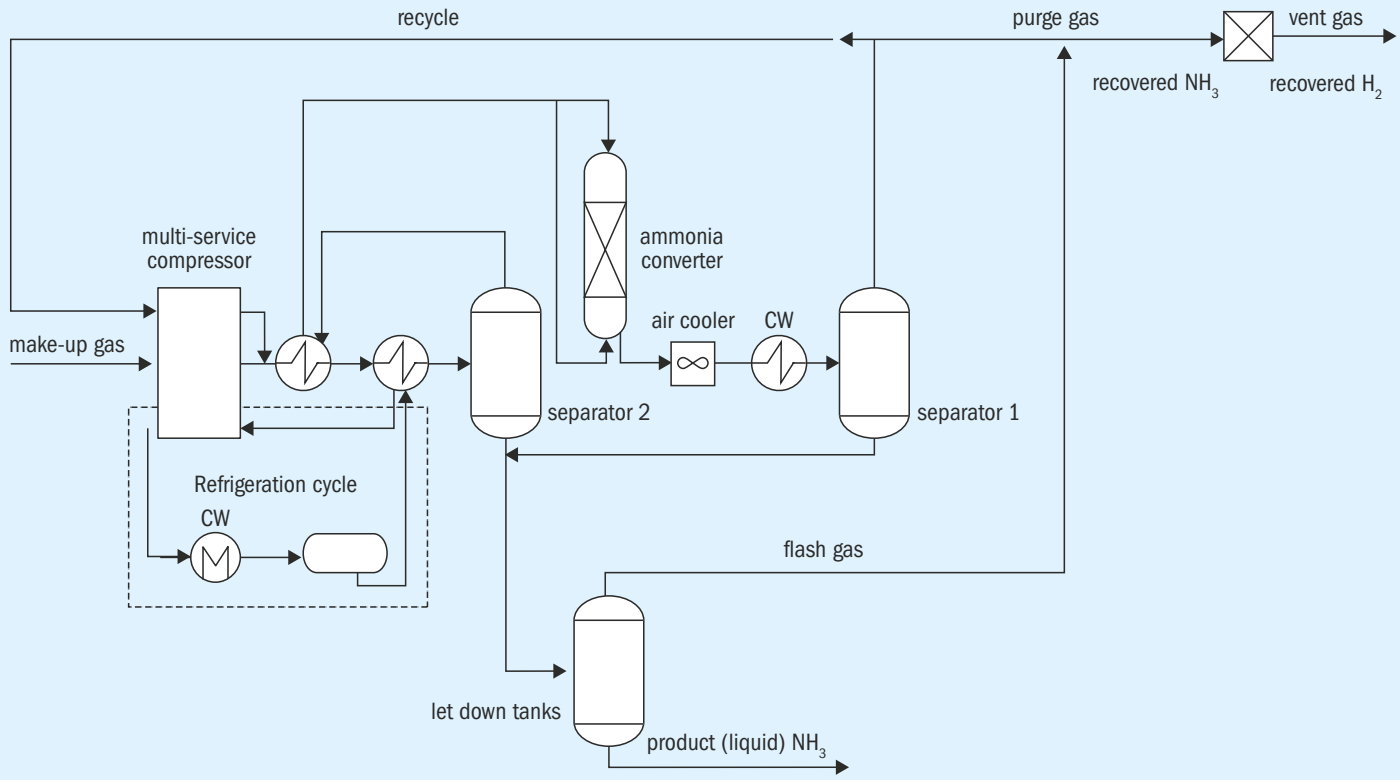
Powered by Renewables

Most 'green' ammonia projects today fall within the small to medium capacity range, being limited by the availability of renewable electricity and the scale of electrolysis equipment. Stamicarbon offers the **NX STAMI™ Ammonia High-Pressure Design** (Figure 2) – a proven solution for production capacities from 50 t/d up to 500 t/d – to meet growing demand for green ammonia plants.

Stamicarbon's process is specifically engineered for green ammonia production, where efficiency, small footprint and simplicity are key. It features a high-pressure synthesis loop operating at over 300 bar, with this enabling a high conversion rate per pass and reducing the need for recycle compression and refrigeration.

The elevated synthesis loop pressure allows the condensation of ammonia using cooling water in a single stage. This

Fig. 2: **NX STAMI™ Ammonia High-Pressure Design process diagram**



Source: Stamicarbon

significantly reduces the overall equipment count by eliminating the need for a refrigeration compressor. This operational simplification reduces capital expenditure for the synthesis section alone by an estimated 25-30%, making the NX STAMI™ high-pressure design a cost-effective and scalable choice for green ammonia production.

The single-bed axial-flow ammonia converter also features a compact tubular reactor design. Inside the converter, heat exchanger tubes are submerged within the catalyst bed to carefully control the temperature. This precise temperature control prolongs catalyst life and maintains performance by preventing hot-spot formation and catalyst sintering. The inclusion of an integrated start-up heater within the converter also ensures the reactor heats up smoothly during plant start-up.

A single, electrically driven reciprocating compressor is also used to handle both fresh make-up gas and recycle gas in the synthesis loop. This minimises the number of compressors required, improving reliability and cutting maintenance costs.

Overall, the converter and other equipment are more compact, thanks to the high operating pressure. This means the overall footprint of the plant remains very small – a key benefit for decentralised or modular green ammonia installations.

NX STAMI™ high-pressure technology has four operating green ammonia references, giving Stamicarbon the strongest reference list in the sub-500 t/d capacity range. Its efficient design with a simplified layout is ideal for distributed, smaller-scale projects that can be scaled up as renewable infrastructure grows. By adopting this proven technology, early movers in the green ammonia space are achieving their decarbonisation goals while positioning themselves for future expansion as electrolyser and renewable capacity grows.

Decarbonising the fertilizer value chain

Green ammonia can feed directly into a urea plant to produce low-carbon fertilizer, cutting the overall carbon footprint. Ammonia can also be converted to nitric acid and ammonium nitrate, these providing even greater potential for reducing greenhouse gas (GHG) emissions from fertilizer production.

Integrating green ammonia synthesis with downstream units can improve plant efficiency by sharing process outputs. An integrated low-carbon fertilizer complex can share the oxygen from water electrolysis, for example. These integrations save energy, lower emissions, and achieve savings in capital and operating costs through shared resources.

One example of an integrated low-carbon fertilizer plant currently under development is the FertigHy project in France (see page 49). Scheduled to begin construction in 2027, the plant will produce 500,000 tonnes of low-carbon nitrogen-based fertilizers annually, powered by hydrogen sourced from renewable and low-carbon electricity. Stamicarbon's NX STAMI™ Ammonia and NX STAMI™ Nitrates technologies will play a central role in the process, supporting low-emission ammonia synthesis and high-efficiency nitric acid production with minimal GHG emissions.

Conclusion

The development of advanced ammonia technologies – designed for a variety of feedstocks, scales, and applications – is opening the door to a new generation of low-carbon fertilizer production plants. By integrating blue and green ammonia technologies with downstream processes for urea and nitrates, it is possible to design fertilizer complexes that deliver on both economic performance and have positive climate impacts. The arrival of these technologies will shape the future of the low-carbon economy – across fertilizer, fuels, and the evolving clean energy market. ■

Redefining phosphorus efficiency with RhizoSorb

Phospholutions is meeting the phosphorus efficiency challenge head-on with its proprietary RhizoSorb® technology. Building on nearly a decade of research and commercialisation experience, the US-based company has developed a nutrient-efficient, next-generation fertilizer. This innovative crop nutrient product enhances phosphorus delivery, reduces environmental losses, supports sustainability goals, and extracts more value from phosphate reserves.

Introduction

Fertilizer demand has remained steady in 2025, despite rising prices, volatile global trade, and tightening profit margins. The rising cost of phosphate compared to grain prices has become a major concern for growers and the broader value chain. Stakeholders across the phosphorus value chain are now under pressure to find new strategies to remain profitable. With traditional cost-cutting measures offering diminishing returns, the industry is turning to innovation, particularly in nutrient use efficiency, to reduce costs and maintain competitiveness.

Practical, scalable, and cost-effective

RhizoSorb is the first dry granular fertilizer additive designed for full integration into phosphate production, offering manufacturers and farmers alike a practical and scalable option for improving phosphorus efficiency. The company currently partners with phosphate manufacturers to produce RhizoSorb 8-39-0 for distribution customers across the Americas.

Backed by five years of field trials across diverse soils and crop types, RhizoSorb enables growers to reduce phosphorus application rates by up to 50% without compromising yield. Field trial results show that farmers across the globe consistently achieve the same

PHOTO: PHOSPHOLUTIONS

Representatives from Phospholutions in Mato Grosso, Brazil, evaluating the field performance and yield results from RhizoSorb 8-39-0.

or higher yields using this more efficient and cost-effective alternative to products like monoammonium phosphate (MAP) and diammonium phosphate (DAP). In the United States, growers have seen returns on investment increase by up to $20 per acre when switching from MAP and/or DAP to RhizoSorb 8-39-0.

Delivering more value per tonne

RhizoSorb offers manufacturers a value-added technology that can be distributed uniformly throughout phosphate fertilizer granules during production. Unlike surface coatings and additives, which are applied post-production, RhizoSorb is incorporated directly into wet-process production as a dry powder during the granulation phase. The product generated by the in-process integration of this proprietary technology enhances phosphorus availability, reduces fixation losses, and increases agronomic efficiency per unit of P_2O_5.

The result is a high-quality, uniform granule with improved flowability and a more consistent bulk density. RhizoSorb 8-39-0, the company's current formulation, demonstrates physical properties comparable to those of standard MAP and DAP fertilizers. Its beneficial qualities extend into operations, minimising material hang-up, abrasion, and equipment wear during production. The net effect for manufacturers is greater handling efficiency, less unplanned downtime, and higher throughput per tonne. Consequently, manufacturers can maximise the efficiency of existing infrastructure, extracting greater value from this without significant capital investment – ultimately generating higher margins compared to conventional fertilizer production.

Strategic expansion through partnerships

Phospholutions is rolling out RhizoSorb globally and expanding its footprint through key partnerships in North and South America. In the US, **The Andersons**, one of North America's leading agricultural retailers and fertilizer distributors, serves as both a distributor and strategic investor, helping deliver RhizoSorb-enhanced fertilizers to growers across the Midwest and other major agricultural regions.

> **"We're building solutions that align profitability across the phosphorus value chain with sustainability," said Hunter Swisher, CEO of Phospholutions. "Very few solutions on the market today can offer more margin across a value chain while reducing environmental impact."**

Following registration approval in the second quarter of 2025, Phospholutions has partnered with **MustGrow** to support nationwide expansion in Canada (*Fertilizer International* 527, p8). The partnership with this Canadian ag-biotech firm, a recognised leader in specialty crop nutrition, was secured alongside a new strategic investment from Keytrade Ag, their parent company.

Keytrade Ag is supporting Phospholutions in its mission to deliver its patented phosphate technology, with all its attendant benefits, throughout the agricultural supply chain in Latin America. This partnership, by targeting specialty markets, aligns with the company's broader goal of accelerating the commercialisation and global adoption of RhizoSorb. In support of this, additional trials are currently underway in Brazil to address growing demand in the country – the world's leading agricultural powerhouse – for improved input efficiency.

To accelerate product development, Phospholutions has also developed a partnership with the **International Fertilizer Development Center (IFDC)**. This includes providing targeted financial support to maintain and upgrade IFDC's research infrastructure. In return, Phospholutions receives dedicated access to IFDC's facilities to conduct testing of new product formulations and materials.

> **"... the industry is turning to innovation to reduce costs and maintain competitiveness."**

As an investor in Phospholutions, Turkish fertilizer manufacturer **Toros** – the production affiliate of Tekfen Ventures – has also played a key role in advancing product development. This mutually productive relationship has enabled Phospholutions to refine product formulations and successfully execute its first large-scale production of RhizoSorb 8-39-0.

Affordable sustainability with proven impact

RhizoSorb enters the market at a time when agriculture globally is being asked to become resource efficient and do more with less.

Around the world, phosphorus-related water quality issues are also driving tighter nutrient management regulations. RhizoSorb helps meet these evolving standards by significantly improving phosphorus uptake while at the same time reducing environmental losses by, for example, cutting runoff by 78%.

As well as having economic, agronomic, and environmental advantages, with accrued benefits across the entire value chain, RhizoSorb also offer an affordable way of delivering on sustainability ambitions.

Life cycle analysis, for example, confirms that RhizoSorb reduces carbon emissions by up to 45% compared to conventional MAP. If adopted across all US corn acres, this would deliver a CO_2 reduction of 3.4 million tonnes, the equivalent of removing more than 730,000 cars from the road every year.

Conclusion

As the phosphorus industry faces mounting economic, political, and environmental challenges, RhizoSorb – the Next Generations of Phosphorus Fertilizer™ – is redefining what's possible for fertilizer engineering.

"We're building solutions that align profitability across the phosphorus value chain with sustainability," said Hunter Swisher, CEO of Phospholutions. "Very few solutions on the market today can offer more margin across a value chain while reducing environmental impact."

RhizoSorb delivers measurable agronomic performance, enhanced manufacturing value, and meaningful sustainability outcomes.

For manufacturers, distributors, and growers alike, RhizoSorb offers a pathway to stay competitive in an ever-evolving industry. Phospholutions is not just improving phosphorus use either, says the company, it's also redefining the way the world thinks about fertilizer efficiency. ■

Holland Novochem – sustainable, future-proof additives

Holland Novochem was founded in 1992 by a team of experienced engineers with expertise in fertilizer additives. The company has developed and commercialised a long-established range of high-quality, anti-caking, moisture repellents and de-dusting agents over the last three decades. It has also become the fertilizer industry's natural partner for sustainable fertilizer additives, says **Dr Erik Bijpost**, Holland Novochem's Procurement Manager.

A deep-end additive specialist

Holland Novochem has grown to become Europe's leading, deep-end specialist in fertilizer additives. The company's head office and laboratory are located close to Amsterdam in The Netherlands and its state-of-the-art fully automated production site is strategically situated on the Merwede river close to the port of Rotterdam.

Fertilizer additives are Holland Novochem's bread and butter. The company's philosophy is to focus on delivering the best service – together with the best products. We understand very well that each fertilizer plant and product is unique, requiring dedicated services and professional advice. Finding the best solution together with our customers is what drives us, with a focus on flawless production, security of supply, sustainability, safety and carbon footprint reduction.

As part of our commitment to help customers stay ahead in these challenging times, we aim to find solutions that serve their specific needs at present and also meet future environmental demands. We achieve this by working in close cooperation with our customers, sharing our extensive knowledge and R&D strengths to provide them with future-proof answers and innovative tailor-made solutions.

PHOTO: HOLLAND NOVOCHEM

Drum coating of fertilizer granules.

Holland Novochem serves the fertilizer industry in more than 90 countries through several branch offices located across the world. The company is well-known for its extensive range of **NovoFlow**- and **NovoDust**-branded fertilizer additives that protect against caking, moisture and dust. These high-performance products successfully address many of the problems associated with the production, storage and transportation of fertilizers, in either solid or liquid form.

The Holland Novochem Way

Over the years, Holland Novochem has built up a strong reference list that includes all the major global fertilizer-producing companies. The company attributes its success to the following factors:

1. **Dedicated staff:** building long term partnerships with our customers is the priority of our multi-disciplinary and highly experienced chemical, logistic and commercial team with more than 150 years of business experience in fertilizer solutions.
2. **Sustainable technology:** selected

and well-studied raw materials are used in all products, and the company ensures that all products have a minimal negative impact on nature. Holland Novochem was the first company worldwide to develop and supply bio-based and biodegradable coatings to the fertilizer industry.

3. **Independence of raw material selection:** the company is not restricted to using specific in-house raw materials, such as amines or paraffins.
4. **Cost awareness:** we focus on finding the optimal balance of price and performance in accordance with our customers' wishes.
5. **State-of-the-art fertilizer additives laboratory:** the company's modern laboratory has the necessary facilities to run all the specific tests needed to develop custom-made formulations and new applications.
6. **Consistency of quality and reliability:** the location of our production plant near the port of Rotterdam allows us to take full advantage of local automation and logistic services. In-time-delivery and security of supply are second nature for our team.

Sustainability and future-proof fertilizer additives

Traditionally, fertilizer additives – such as anti-caking agents and moisture repellents – are based on petrochemical compounds, especially paraffins and mineral oils. Historically, further performance improvements have also been achieved by the addition of active petroleum-derived ingredients, such as alkyl amines and fatty acids.

During the last few years, however, awareness that petrochemicals should be exchanged for more sustainable products has grown strongly. Sustainability has been prioritised internationally by the United Nations through its wide-ranging 2030 Sustainable Development Goals (SDGs). Similarly, the European Commission's flagship Green Deal policy has set a target for the EU to become climate neutral by 2050. As a consequence of this agenda, fertilizer anti-caking agents will need to undergo a transition in composition – moving away from petrochemicals – within a relative short time span.

Holland Novochem has been preparing for this transition for more than two decades. Since 2003, the company has been carrying out extensive research on bio-based fertilizer additives, with these studies resulting in dozens of filed and granted patents. More importantly, sustainable coatings have become increasingly popular with our customers worldwide over the last 20 years – with the number of companies adopting these continuing to rise annually.

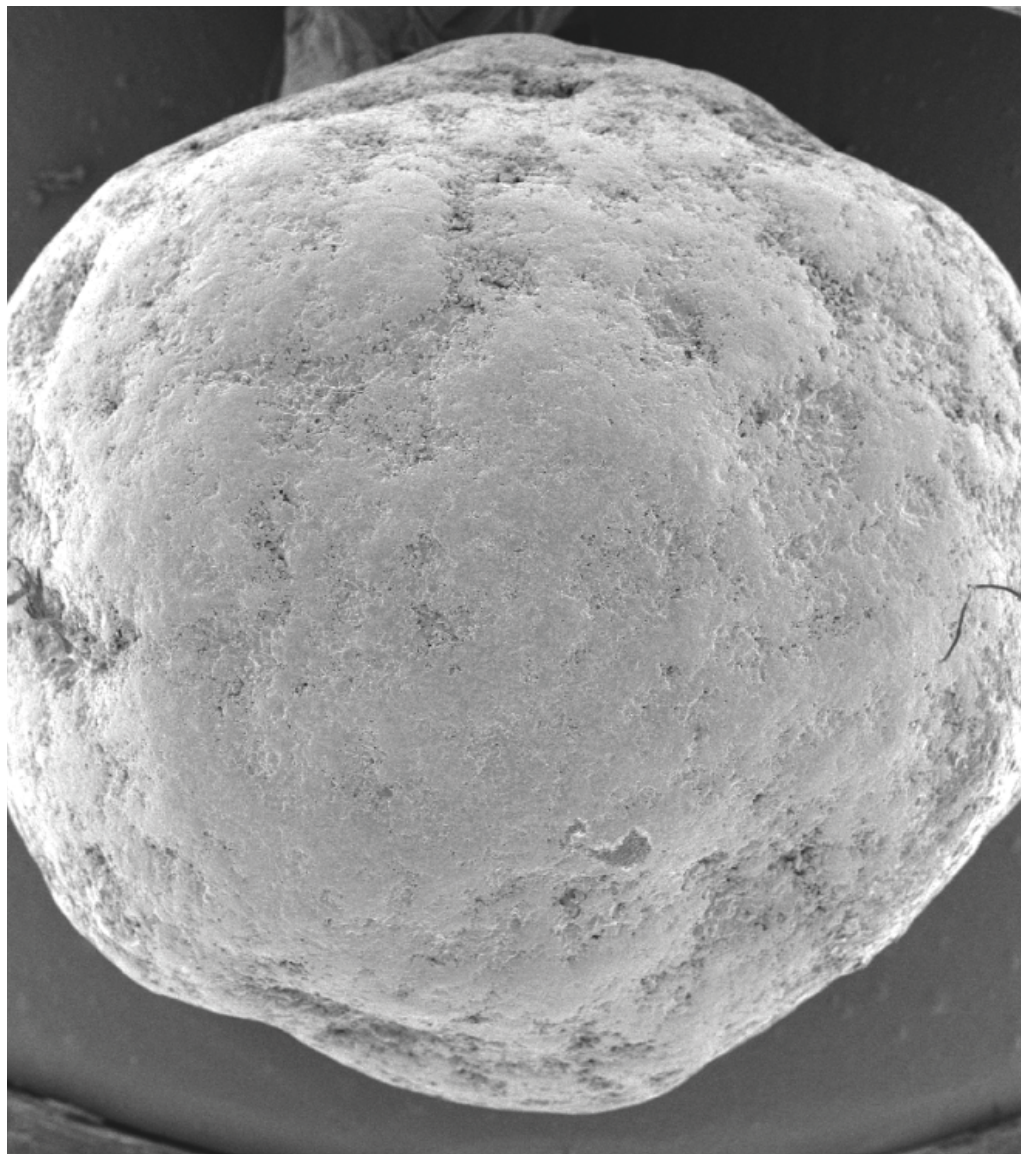


PHOTO: HOLLAND NOVOCHEM

A fertilizer granule protected by a Holland Novochem coating.

Continuous improvement

Holland Novochem's R&D team has also continued to optimise the company's bio-based product line. Recent breakthroughs have included the development of a more sustainable range of environmentally friendly anti-caking and moisture repellent agents.

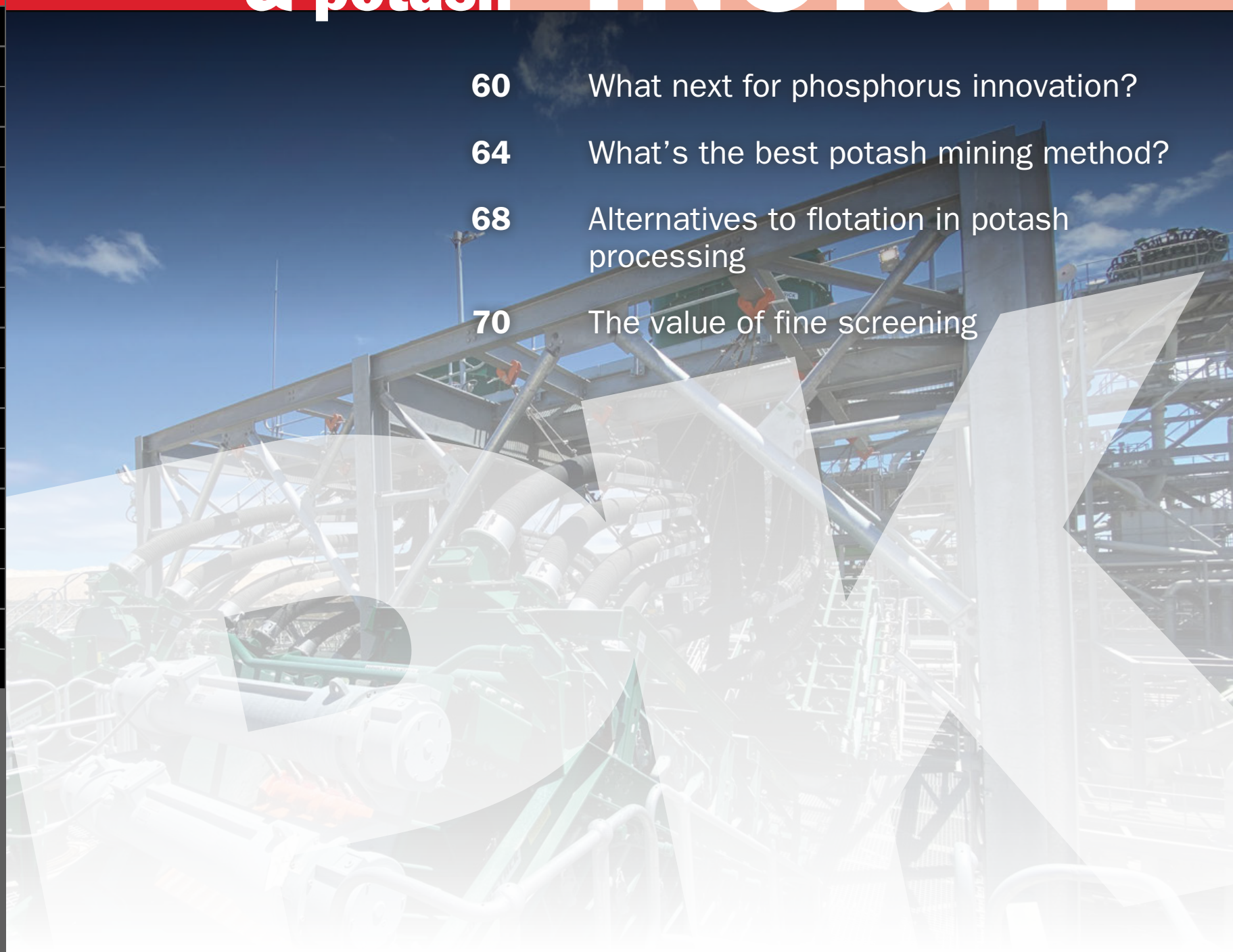
At first sight, replacing mineral oil and paraffins with their natural counter types – vegetable oils and derivatives – would seem to be the obvious option. However, the coating behaviour of vegetable oils, specifically their glycerol functionality, is affected by hydrolysis and other chemical reactions. These coatings therefore tend to become unstable and lose their performance very quickly over time. Holland Novochem has, however, successfully tackled these issues and advanced to a new product range that offers excellent performance on all well-known fertilizers.

> **"Sustainable coatings have become increasingly popular with our customers worldwide over the last 20 years – with the number of companies adopting these continuing to rise annually.**

It goes without saying that – to secure long-lasting fertilizer quality for all our customers – Holland Novochem will continue to develop sustainable, low carbon footprint products that are both affordable and readily-available. ■

September-October 2025

phosphates & potash INSIGHT



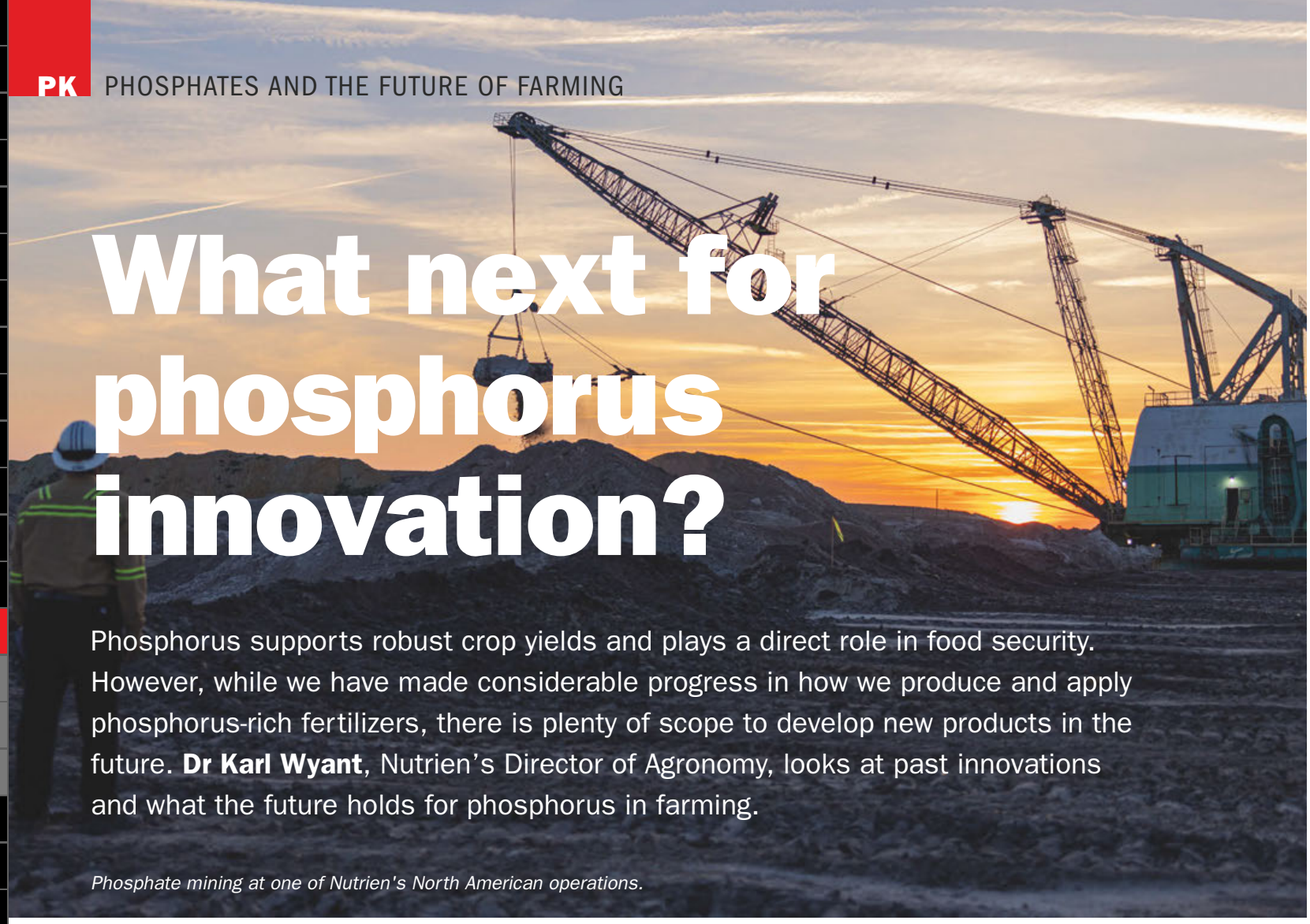


PHOTO: NUTRIEN

What next for phosphorus innovation?

Phosphorus supports robust crop yields and plays a direct role in food security. However, while we have made considerable progress in how we produce and apply phosphorus-rich fertilizers, there is plenty of scope to develop new products in the future. **Dr Karl Wyant**, Nutrien's Director of Agronomy, looks at past innovations and what the future holds for phosphorus in farming.

Phosphate mining at one of Nutrien's North American operations.

Introduction

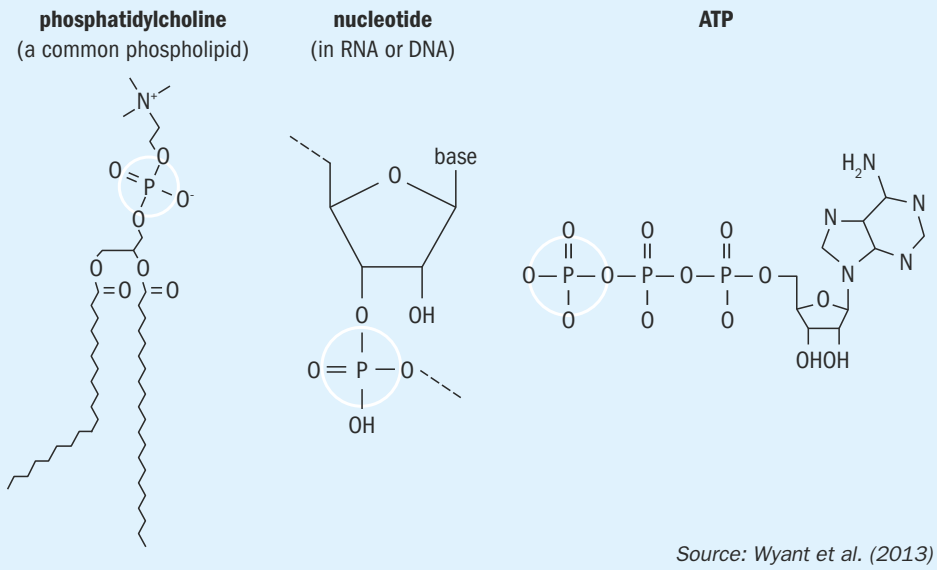
Phosphorus (P) is one of the three primary macronutrients, along with nitrogen (N) and potassium (K), that are essential for plant growth. Among its many roles, this vital element assists energy transfer within plant cells, being part of adenosine triphosphate (ATP). This can be thought of as the 'currency' that crops can 'spend' to perform biological work – such as allowing them to grow!

Phosphorus is also embedded within our genetic structure (DNA and RNA) and via membrane formation helps to enclose cellular machinery (Figure 1). At a more directly observable level, phosphorus contributes to root development and establishment, ensuring crops can access water and other nutrients efficiently. Adequate phosphorus also supports flowering and fruiting, thereby improving both the yield and quality of the crop.

We often see the impact of phosphorus scarcity when crops cannot get enough supply to meet their demands. When soils are deficient in phosphorus, plants exhibit stunted growth, delayed maturity, and poor seed or fruit production. This deficiency typically results in lower yield.

Farmers will apply phosphorus-rich fertilizers (usually in phosphate form) to meet demand from their current crop, and to replenish soil stocks when phosphorus is removed from the field in the harvested crop. Balancing phosphorus inputs with removal helps maintain soil health, optimise crop performance, and safeguards ecosystems by avoiding losses to the environment.

Fig 1: **Phosphorus is crucial for enclosing cellular machinery (phospholipid – left), for creating genetic material (nucleotide in DNA and RNA – centre), and as an energy 'currency' (ATP – right) that can be used by crops and animals alike to 'pay' for biological work (growing a corn cob, for example)**



Source: Wyant et al. (2013)

A global nutrient

Phosphorus – as a vital nutrient for plant growth – helps drive improved yield outcomes across global agricultural. As world food demand rises and diets change, so does the need for phosphorus-based fertilizers, particularly in regions with phosphorus-deficient soils. However, while phosphorus is a commonly applied nutrient on the farm, it can only be sourced profitably in its raw form

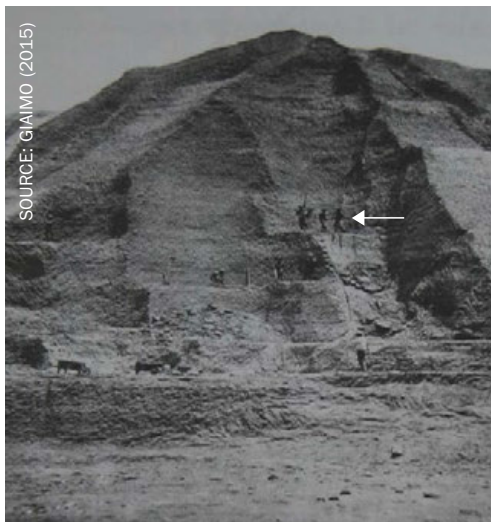


Fig. 2: Historically, large island deposits of guano were heavily mined for use as phosphorus fertilizer. Miners (arrow) picked out for scale.

Table 1: **Phosphate fertilizer use by region, including percent of total global share, for the 2023/2024 fertilizer year**

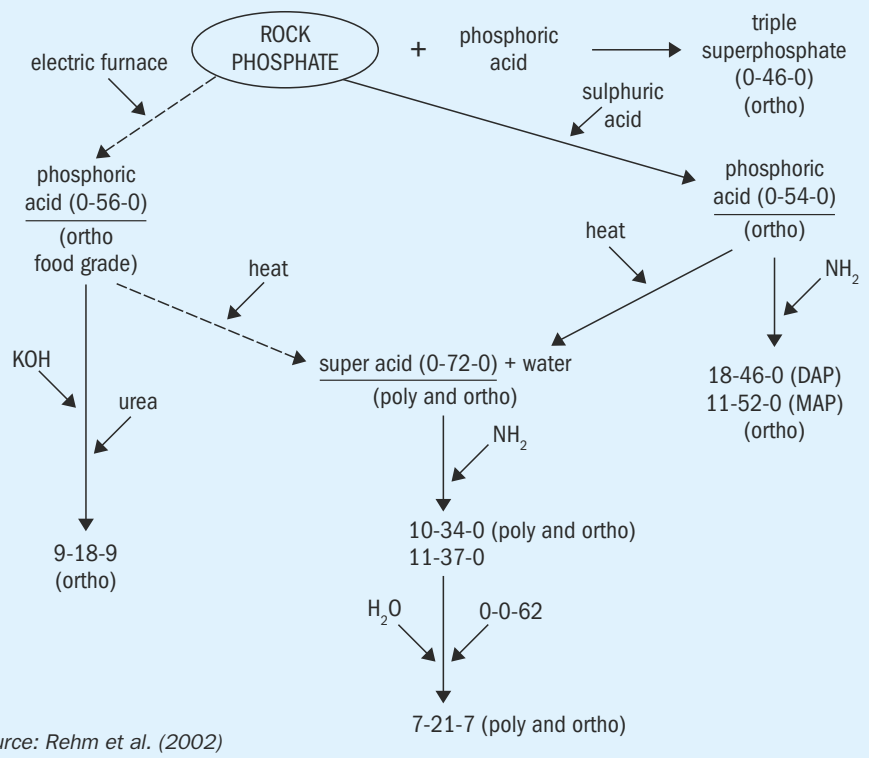
Region	P fertilizer use, '000 t	% Share of total P fertilizer use
North America	5,043	10.9%
Latin America & Caribbean	8,334	19.9%
Western & Central Europe	2,363	5.1%
Eastern Europe & Central Asia	1,766	3.8%
Africa	1,940	4.2%
West Asia	1,142	2.5%
South Asia	10,514	22.6%
East Asia	14,284	30.7%
Oceania	1,071	2.3%
World	**46,456**	

Source: Nutrien 2024 Fact Book

in just a few places worldwide. Phosphorus is mined from phosphorus-rich rock, with major reserves concentrated in countries such as Morocco, China, and the US. This uneven distribution raises concerns about long-term availability, the resilience of supply chains, and exposure to geopolitical risks.

To meet future agricultural needs for phosphorus, and do so sustainably, vital innovations are needed for improving the use efficiency of P by crops – with more phosphorus being used by the crop to generate yield relative to the amount of phosphate fertilizer applied. A step change in use efficiency is a critical necessity for numerous reasons. These include better resource stewardship, greater environmental protection and last – but definitely not least! – more profitable farm economics. Sustainable intensification (getting more crops using fewer inputs from the same land area) will also be key. In that context, this article sets out the history of phosphorus fertilizers, using this as a springboard to explore avenues for future innovation.

Fig. 3: **Schematic of modern phosphate fertilizer production. Rock phosphate (circled) is commonly processed and digested with acid to make the fertilizer products familiar today. Growers can match the phosphate chemistry (ortho or poly) of the fertilizer to their unique crop and soil needs**



Source: Rehm et al. (2002)

History of phosphorus fertilizers

The emergence and development of phosphorus fertilizers is full of stories of innovation. Farmers down the ages have applied manures and composts to fields to support higher crop yields and long-term soil fertility. Throughout history, fields that were not receiving these inputs often showed yield declines and sometimes were abandoned just a few years after first planting due to poor productivity. While farmers were not exactly sure what was in the manure, in terms of understanding its chemistry, the notable phosphorus concentration in the materials they were applying was playing a vital role in keeping their fields productive.

The next major innovation came with understanding how to concentrate sources of phosphorus into a form that could apply more nutrients per tonne of applied product. In the late 18th and early 19th centuries, this led farmers to use finely crushed animal bones – rich in calcium phosphate – as a soil amendment. It was thought that the phosphorus-rich bones and teeth of animals could be ground up and used as a concentrated fertilizer input – bone meal. Consequently, by the 1840s, bone meal was commercially sold across Europe and North America. However, as one might imagine, its availability as a source was not sustainable relative to the demand from farmers. After all, there are only so many bones to go around! In fact, so strong was the demand for bone meal that graveyards and catacombs ended up being pillaged to meet the demand for phosphorus.

Another innovation in phosphorus fertilizer came when suppliers globally began mining and exporting guano (seabird manure deposits) from islands in warm, dry parts of the world. Such islands, over time, had accumulated many metres

worth of dried, phosphorus-rich guano. These deposits were extracted, packed on ships, and sent to farmers around the world as a miracle plant food (Figure 2).

Again, the ample phosphorus concentrations in these materials played a vital role in the crop response seen in far away markets. And similarly to bone meal, finite reserves of bird guano were quickly exhausted, so we were again faced by another opportunity for innovation in the phosphorus fertilizer space. (For more information, there's an excellent story on this subject by Cara Giaimo in the references.)

Modern phosphorus fertilizers

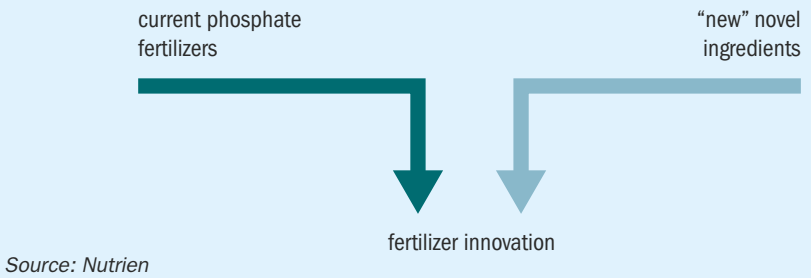
Modern phosphorus fertilizers eventually arrived in the 20th century with the mining and processing of highly concentrated phosphate rock.

The big breakthrough that enabled this came much earlier, when it was discovered that reacting bones and fossils (coprolites) with sulphuric acid concentrated the phosphorus present into a much more soluble and plant available form. This made phosphorus fertilizer applications more efficient in terms of crop uptake. Shortly afterwards, in 1849, John Bennet Lawes and Joseph Henry Gilbert in England patented a process for producing 'superphosphate' on an industrial scale. This innovation dramatically boosted phosphorus availability to plants and helped launch the modern fertilizer industry.

Fast forward into the 1940s, and the modern phosphate industry, as we know it today, begins with the introduction of granular monoammonium and diammonium phosphate (MAP and DAP) along with liquid fertilizers (phosphoric acid and ammonium polyphosphate), among others. Today, phosphate fertilizers are produced at large scale as widely traded commodities used by growers around the world (Table 1). We have come a long way from the old days of robbed bones and guano islands in just a short amount of time.

Innovative products such as DAP and MAP solved several problems in one swoop: the ore could be sourced from large phosphate rock reserves, physical beneficiation could highly concentrate the phosphorus, chemical processing could make it more plant available, and industrial-scale production could supply the finished phosphates in massive volumes (Figure 3). Most importantly, due to its high nutrient density (kilos of phosphorus contained in a tonne of fertilizer), these 'high analysis' concentrated products could be shipped around the world to reach distant markets profitably at a much lower cost than previous animal-based phosphorus sources.

Fig. 4: **Future innovations in phosphate fertilizer formulations largely centre on combining/modifying existing products with novel ingredients. While clear conceptually, this can be difficult in reality, due to the wide range of potential ingredient partners, the time necessary for product development, as well as market barriers to the acceptance of innovative products**



Source: Nutrien

Why phosphorus fertilizer innovation matters

As already stated, phosphorus ranks among the essential macronutrients driving plant development, underpinning critical processes like photosynthesis, energy transfer, and root formation. Phosphorus fertilizers support robust crop yields and play a direct role in food security. However, while we have made considerable progress in how we produce and apply phosphorus-rich fertilizers, we also have the runway to develop new innovations in the future.

The fertilizer industry, by developing alternative phosphorus sources and new formulations, can reduce its exposure to supply chain shocks and safeguard agricultural resilience worldwide (Figure 4). Moreover, advances in fertilizer formulations and technology can also boost phosphorus use efficiency on farms, helping farmers grow more with fewer inputs, as was seen with previous phosphorus fertilizer innovations.

Below is a list of some opportunities across the supply chain that are likely to push innovation in the phosphorus fertilizer industry (Figure 5).

Opportunities for phosphate fertilizer suppliers

Modern phosphate mining and production technologies now enable the production of the same high quality finished products from lower quality phosphate rock (e.g., using mined ore containing less phosphorus content per mined tonne). Such innovations can reduce the need for mine expansion by extending the mine life of existing properties. The option to turn phosphogypsum (PG) waste into a calcium-rich soil amendment is another opportunity for phosphate producers. While this would avoid the costly storage of PG in managed stacks, in the near term, such a shift would depend on regulatory review and approval in jurisdictions such as the US. Finally, some new market entrants and incumbents are starting to produce fertilizers by recycling secondary nutrient sources, including concentrated food industry waste and liquids and solids from wastewater treatment plants.

Opportunities for agricultural input retailers

One promising retail-level innovation is the custom blending of fertilizer components to address the unique nutrient management challenges of both soils and crops. Common components can now be blended at scale – including phosphorus-rich fertilizers – to best match the soil deficiencies of a particular field and address the nutrient uptake patterns of individual crops. Additionally, agricultural input retailers are in a unique position to add new functional components to blends. This involves adding novel compounds (humic acids, micronutrient coatings, etc.) that bring with them extra properties that differ from the foundational nutrient properties of fertilizers. Overall, this is an area of innovation that is teeming with activity at global scale, as retailers work to match soil and crop data to traditional fertilizers modified with help from the 'new ingredient' partners that have emerged in recent decades.

Fig. 5: **Innovation opportunities exist at several stops (stars) along the phosphate fertilizer supply chain, including at the mining, fertilizer supplier, agricultural retail, and grower stages**

Source: Nutrien

Opportunities for growers

Growers as the end buyer have a key role to play in the innovation pipeline. After all, they are ultimately the people who recognise and create the demand for inventions, based on their individual field needs, market conditions, or regulatory pressures. Growers, for example, have an opportunity to use soil and satellite data on farms to create prescription fertilizer application maps (e.g., variable rate) and generate custom blends for each field (mixes of urea, monoammonium phosphate, and muriate of potash, for example) as dictated by the unique characteristics of the field. Capturing innovative technologies and datasets allows growers to spend more judiciously on fertilizer inputs while optimising yield outcomes. Additionally, growers should benefit in future from an increasing ability to directly manage their fertilizer rates, the timing of the application, blend composition, and fertilizer placement (4Rs nutrient management) – changes which will also benefit phosphorus use efficiency and reduce off-farm nutrient losses.

Shaping tomorrow's supply chains

Humanity has long used phosphorus-rich materials to bolster crop yields and soil fertility. Yet modern phosphate fertilizer technology has undergone an exciting journey of rapid transformation in a relatively short period of time. It was not that long ago that we were mining guano islands as an agricultural source of phosphorus, and here we are now taking phosphate rock ore and turning it into high analysis finished phosphate fertilizers traded and used across the globe as valued commodities. One thing is certain, there will be many innovation story lines emerging in the phosphorus supply chain over the next few years that will be exciting to watch. Because of that, the industry should expect that a new frontier for this nutrient is just around the corner. ■

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What's the best potash mining method?

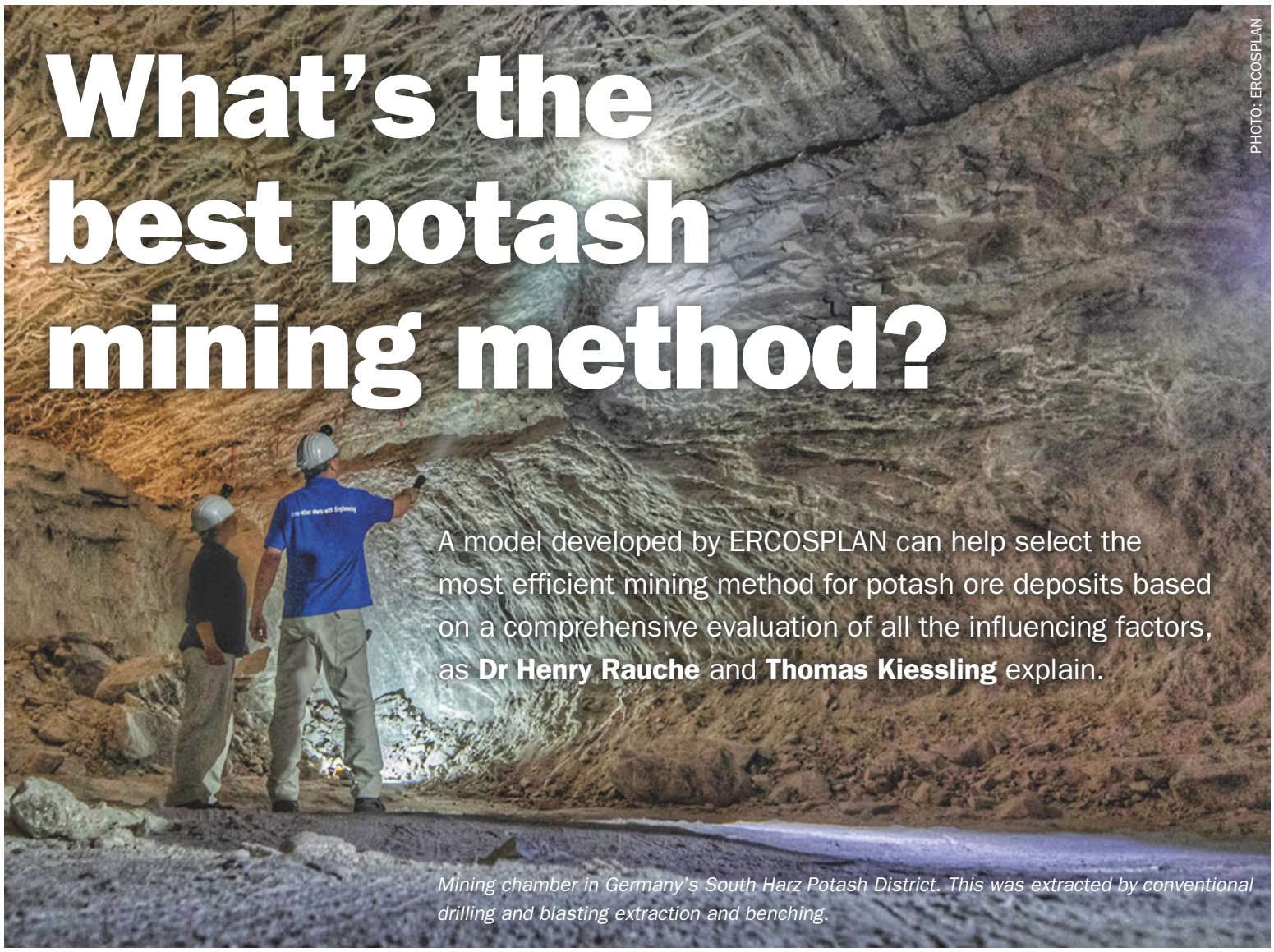


PHOTO: ERCOSPLAN

A model developed by ERCOSPLAN can help select the most efficient mining method for potash ore deposits based on a comprehensive evaluation of all the influencing factors, as **Dr Henry Rauche** and **Thomas Kiessling** explain.

Mining chamber in Germany's South Harz Potash District. This was extracted by conventional drilling and blasting extraction and benching.

Several types of natural resource form the basis for the production of potash fertilizers and other commercial potassium products including (Figure 1):

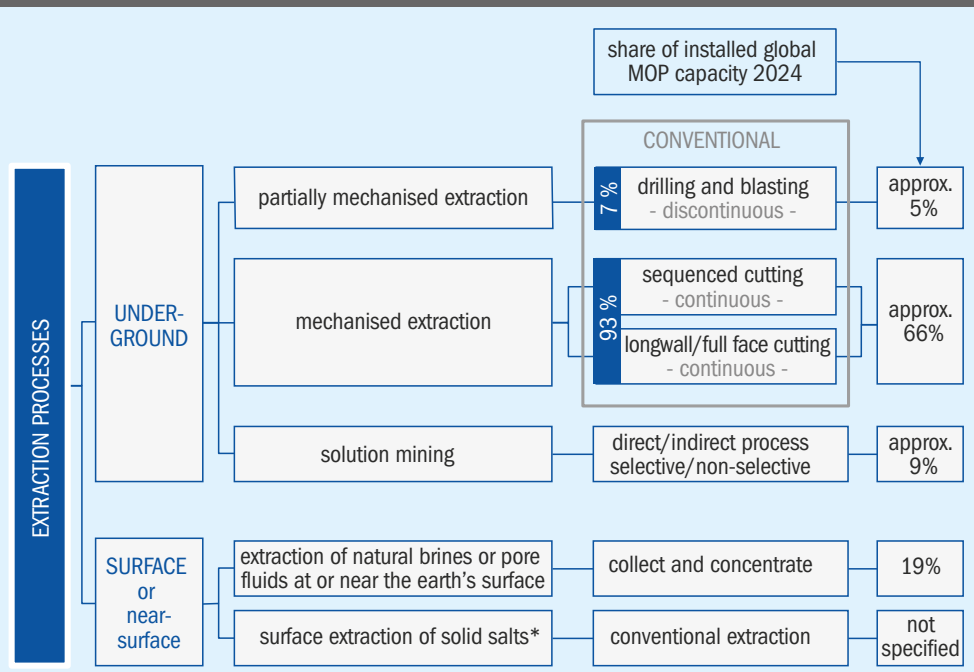
- Solid deposits of mineral salts in the geological subsurface
- Natural brines in natural salt lakes on the earth's surface
- Pore waters in near-surface sediments.

While solid mineral salts can be highly concentrated – with potassium chloride (KCl) grades of 40% or more – natural brines have far lower grades of between 1-7 grams of potassium (K) per litre. The commercial use of such low-grade brines, therefore, is only economically viable where pre-concentration via solar evaporation is cost-effective.

Mining costs and economics

For all of these natural resources, potassium must first be extracted from the respective deposit, transported to the processing plant, upgraded/enriched by

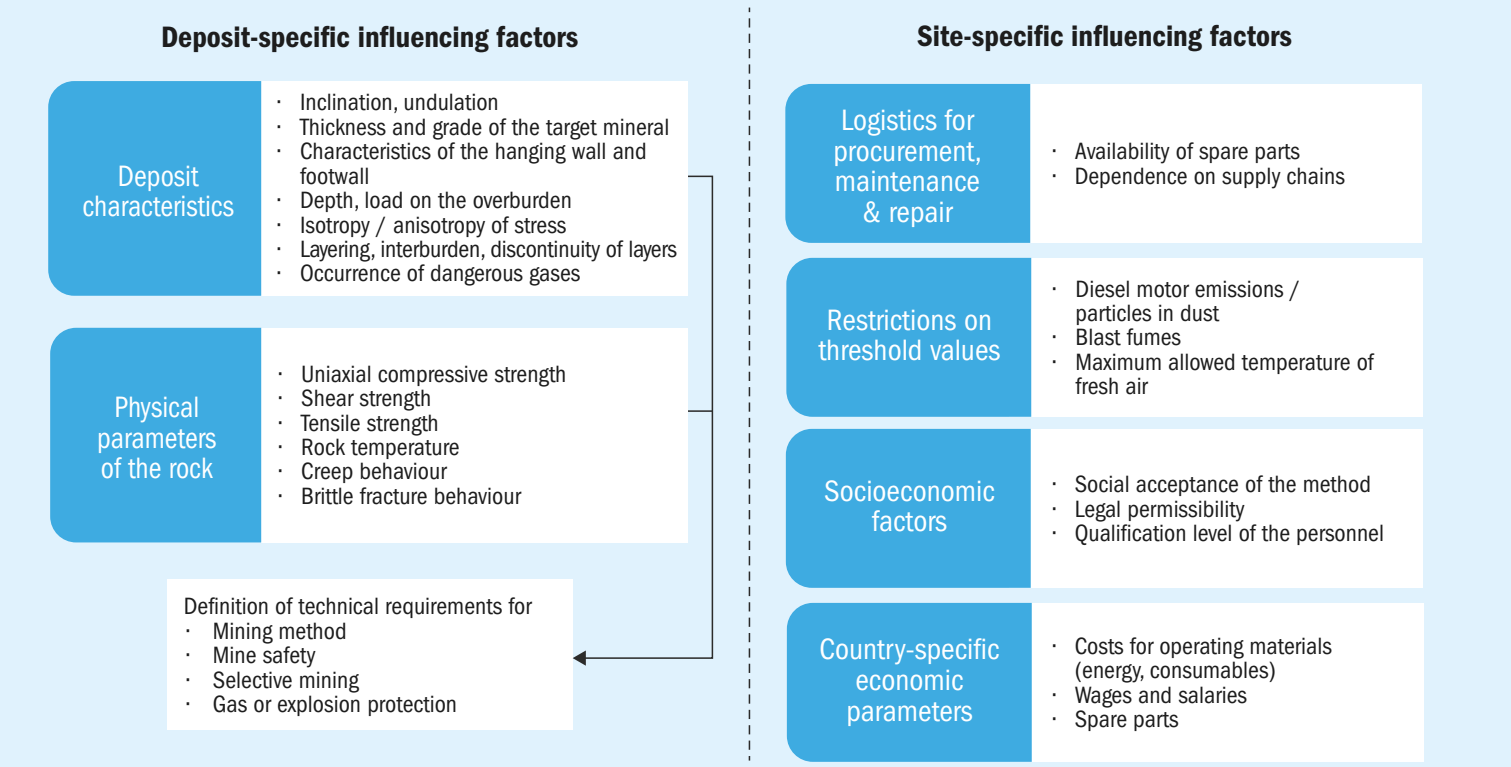
Fig. 1: **Overview of the main extraction processes used in muriate of potash (MOP) production, with relative share of 2024 global installed capacities shown**



* Conventional open-pit extraction of solid salts (Kalush, Ukraine)

Source: ERCOSPLAN

Fig. 2: **Overview of the main factors influencing the choice of potash extraction method**



Source: ERCOSPLAN

beneficiation with the harmful components removed, and finally refined into a saleable product.

Extraction costs usually account for between 5-25% of the total operating costs of potash fertilizer production. As might be expected, these costs are lowest when brines in natural salt lakes on the earth's surface are the starting raw material. The same applies to capital costs. Ultimately, for both capital and operating costs, the comparative mining costs between different potash resources reflect the degree of technical effort required for raw material extraction and transport to the processing plant.

Key site- and deposit-specific variables

Depth underground is a cost factor of particular importance, especially for the extraction of solid mineral salts located underground, regardless of whether these are mined using conventional mechanical methods or by solution mining. In both instances, capital and operating costs are directly dependent on depth. That applies whether accessing the deposit via shafts to extract solid potash, or by the initial drilling of a brine field and then removing the dissolved potash ore via solution mining wells.

In addition, depth also determines the preparatory lead-in times necessary for greenfield potash projects – initial shaft sinking being a particularly lengthy process, for example – another important factor affecting economic viability. Underground temperature also increases with depth. This is an advantage for solution mining as higher temperatures increase potassium chloride solubility and, consequently, extracted brines will enter the beneficiation process with higher amounts of the valuable KCl target.

In contrast, for conventional underground mining the opposite is true. Higher temperatures require considerable additional expenditure on ventilation technology. This is necessary to ensure compliance with health and safety requirements for the underground workforce, and for adequate cooling of the equipment used. Additionally, as the load from overburden increases with depth, the dimensions of the supporting pillars left along the mining horizon also need to be larger. This increases mining losses unless the mine cavern is backfilled.

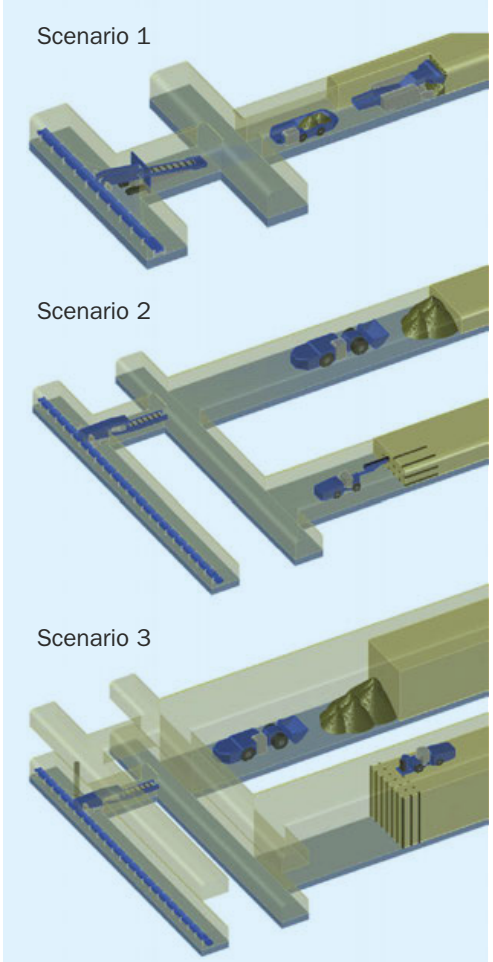
The upshot is that, beyond a certain depth, solution mining becomes both the technically and economically preferable option over conventional underground mining. There is no universal depth at which this applies. Instead, the exact deciding depth depends on a whole series of deposit- and site-specific conditions. These include geological factors, such as the thickness and shape of the mineralisation within rock formations and the grade of these deposits, as well as various socioeconomic and country-specific influences. An overview of the most influential deposit- and site-specific factors are shown in Figure 2.

Mining methods – what works best?

To an even greater extent, the geology of potash deposits determines extraction efficiency – i.e., the effectiveness of the mining methods and technical processes used to extract the natural solid ore from their rock formations underground. The ability to use either discontinuous drilling and blasting methods versus continuous partial-face or full-face cutting methods is particularly important here.

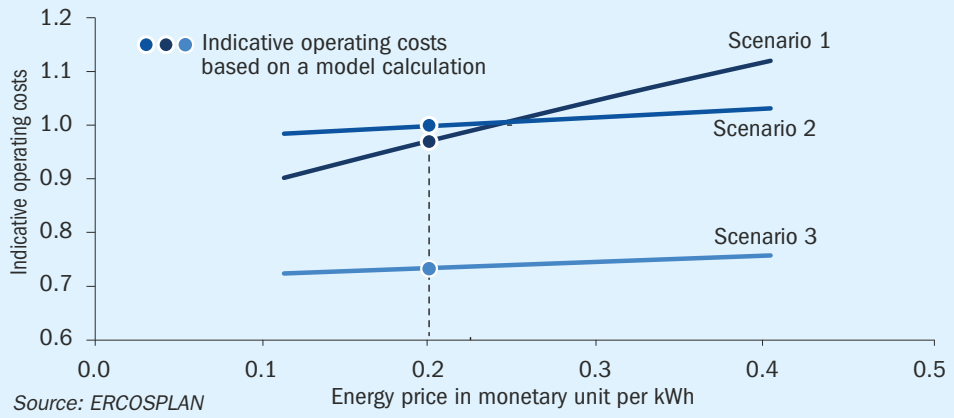
Continuous cutting extraction, especially full-face cutting, is an extremely effective extraction method – but is not always technical feasible. That's because the dimensions of the continuous miner place strict limits on its flexibility and ability to cope with changes in the dip (angle) of the deposit and/or variations in thickness. Consequently, this method is only truly efficient where – like in

Fig. 3: **Three potash mining scenarios: cutting extraction on one mining level (Scenario 1); drilling and blasting on one mining level (Scenario 2); drilling and blasting on two mining levels (Scenario 3).**



Source: ERCOSPLAN

Fig. 4: **How operating costs of the three potash mining scenarios (as shown in Figure 3) vary with energy prices.**



Source: ERCOSPLAN

midwestern Canada – homogeneous and largely horizontal potash deposits of consistent thickness are mined.

These same limitations apply to longwall mining. In general, varying dips, increases and decreases in the thickness of the deposit are completely unmanageable with both these mining methods, or lead to additional mining losses and/or a high degree of dilution in the mined ore. Likewise, solution mining does not function efficiently under such deposit conditions.

Potash mining by drilling and blasting, in contrast, can manage significant changes in bed dip and thickness, while also ensuring that the mining of waste rock from barren areas is avoided. This is a decisive factor, among others, explaining why this mining method continues to be used in Germany's generally more geologically challenging potash deposits.

A new approach

For the conventional underground mining of potash, drilling and blasting can be economically superior to cutting extraction under certain conditions. A recent study by ERCOSPLAN evaluated the various influencing factors that are faced in practice by potash projects when selecting the mining method. This involved developing a model based on equipment manufacturers' data and ERCOSPLAN's extensive performance database.

The model compared the operating costs of three potash mining scenarios (Figure 3):

- Cutting extraction on one mining level (Scenario 1)
- Drilling and blasting on one mining level (Scenario 2)
- Drilling and blasting on two mining levels (Scenario 3).

For potash mining on one level (Scenario 1 vs Scenario 2), it was found that the seemingly unequivocal economic advantage of cutting extraction, which is evident at low energy prices, is no longer valid once a certain energy price threshold is exceeded (Figure 4).

Additionally, it becomes clear that if extraction by drilling and blasting on more than one mining level is possible (Scenario 3) – due to the deposit's favourable thickness – extraction by benching from the upper mining level always delivers significant cost advantages (Figure 4). This is mainly because mined rock can be loosened much more effectively using explosives (Scenarios 2 and 3) than with electrical energy (Scenario 1).

It should also be mentioned that, as part of a comprehensive comparison of the economic efficiency of mining by cutting versus drilling and blasting, numerous other determining factors need to be evaluated. These include initial capex, the price volatility of explosives, and 'soft' factors, such as the skills requirements of employees and the corresponding costs associated with training and quality management.

Conclusions

The calculations made by ERCOSPLAN's potash mining model clearly demonstrate that examination of all the influencing factors is worthwhile – and that deposit- and site-specific characteristics, as well as empirical data, must be taken into account when selecting the extraction method.

For a given potash project, preliminary selection of the mining method is not generally possible, in our view, without an engineering assessment on a case-by-case basis. Indeed, an engineering-based approach is arguably mandatory, as the most suitable extraction method is dictated by the diverse natural boundary conditions of individual potash deposits and/or those already created by humans at specific mining locations.

With more than 70 years of experience in potash extraction and processing, ERCOSPLAN is well-equipped to assist with the individual determination and evaluation of key influencing factors, from initial exploration to the final production of potash fertilizers. ■

Acknowledgment

Dr Henry Rauche is the CEO and Thomas Kiessling is the Managing Director of ERCOSPLAN. This article is based on a presentation given by Thomas Kiessling at this year's *CRU Phosphates+Potash Expoconference*, Orlando, Florida, in April.

The call for papers for the next year's event in Paris, 13-15 April 2026, is now open: events.crugroup.com/phosphates/call-for-papers

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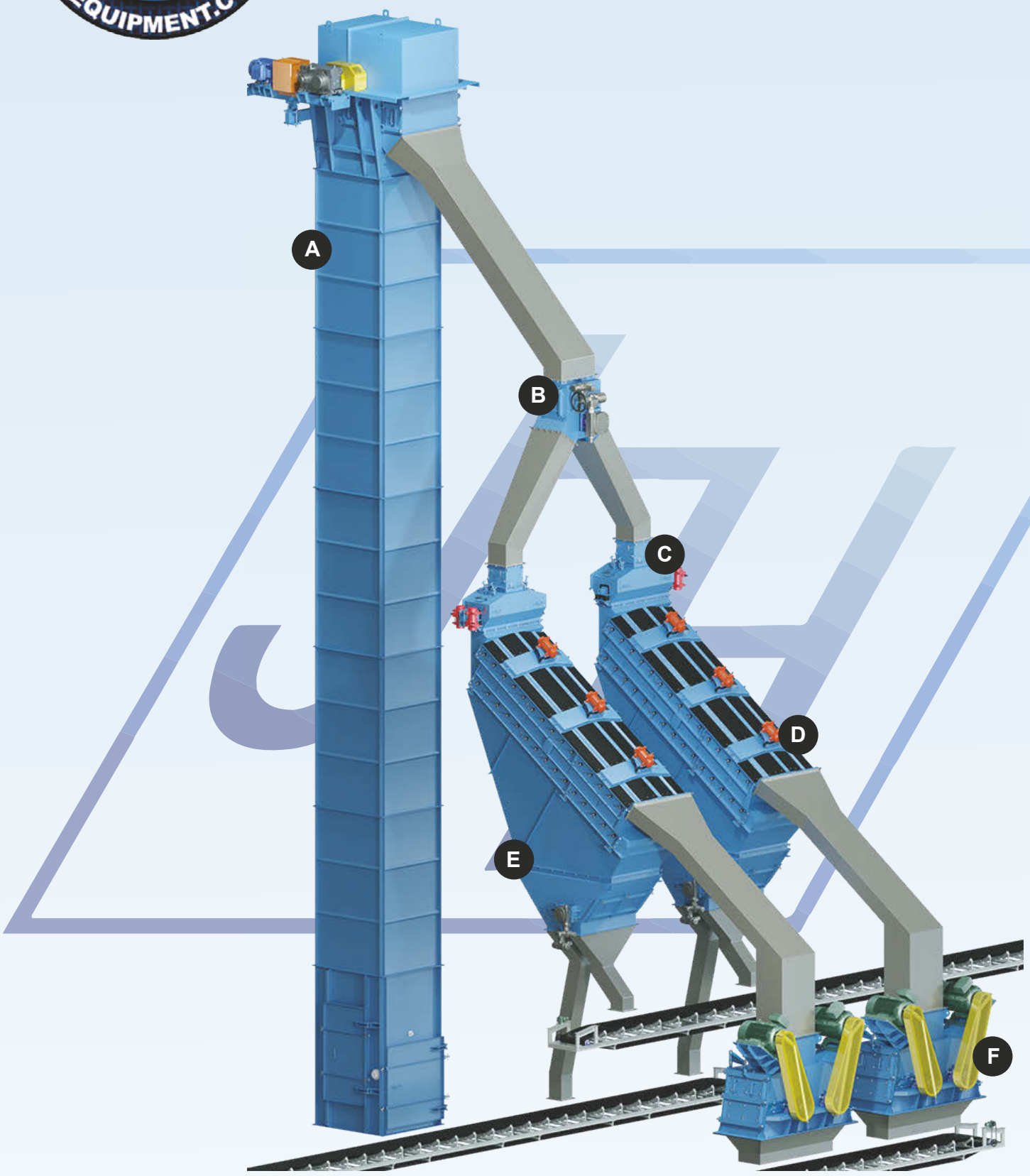


Fertilizer Process & Recycle System

- **A** Severe Duty, Continuous Discharge Bucket Elevator
- **B** Modulating Material Stream Splitter
- **C** Static Body, Vibrating Pan Screen Feeder
- **D** Static Body, Vibrating Wire Screen Machine
- **E** Recycle Control Splitter
- **F** Oversize Crusher

Alternatives to flotation in potash processing

Globally, froth flotation is the most popular potash beneficiation process used in the production of saleable potassium chloride. Leaching /crystallisation is, however, better suited to complex and hard-to-liberate potash ores, according to ERCOSPLAN's **Dr Eike Kaps**. Flotation can also be combined with leaching/crystallisation to optimise potash resource use and manufacture commercial potassium chloride and sodium chloride products.

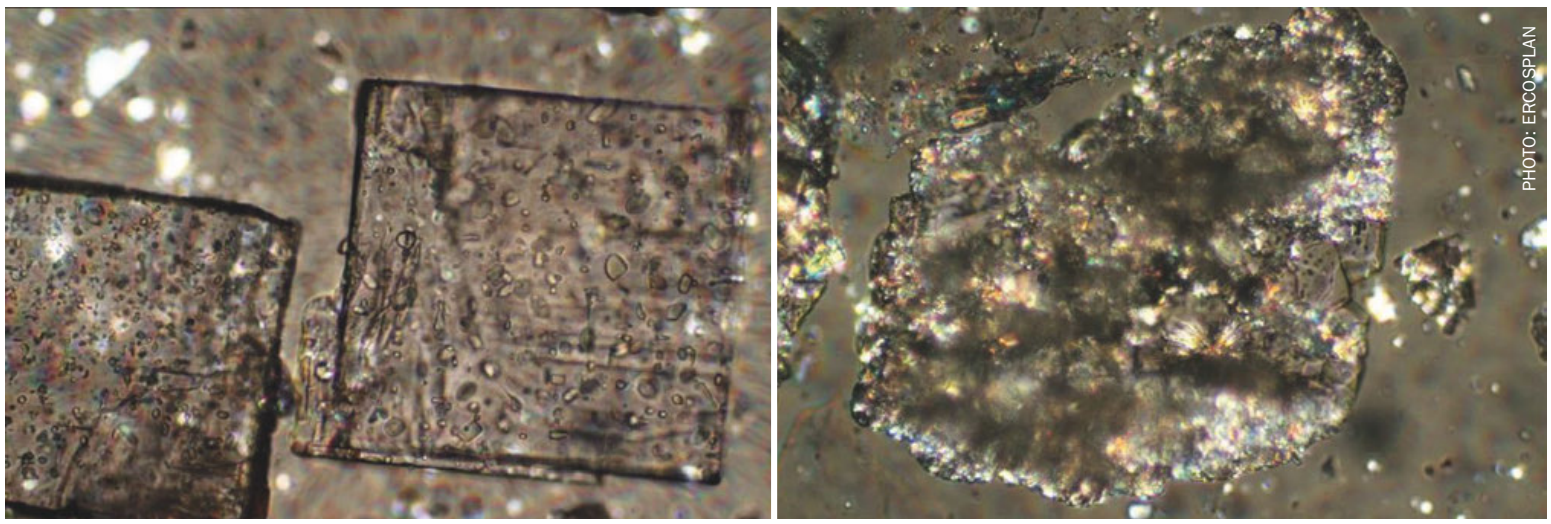


PHOTO: ERCOSPLAN

A completely liberated sylvite crystal (left) versus a sylvite crystal intergrown with anhydrite (right).

Potash, as one of the main components of multi-nutrient fertilizers, is essential for plant growth. With an annual production capacity of 80 million tonnes, it is one of three major crop nutrients – alongside phosphorus and nitrogen – that help secure the food supply of billions of people.

Muriate of potash (MOP) occurs naturally as the mineral sylvite (potassium chloride, KCl) in mineral salt deposits in combination with other minerals such as:

- Halite (NaCl)
- Anhydrite ($CaSO_4$)
- Kieserite ($MgSO_4 \times H_2O$)
- Polyhalite ($K_2SO_4 \times MgSO_4 \times 2\ CaSO_4 \times 2\ H_2O$).

Potash therefore needs to be separated out from these mineral mixtures before it can be turned into a primary product for fertilizer production.

Globally, froth flotation is the most widely used beneficiation process for separating sylvite from accessory minerals to generate a useable and saleable potassium chloride product (Figure 1). It is commonly practiced in several major potash production centres worldwide.

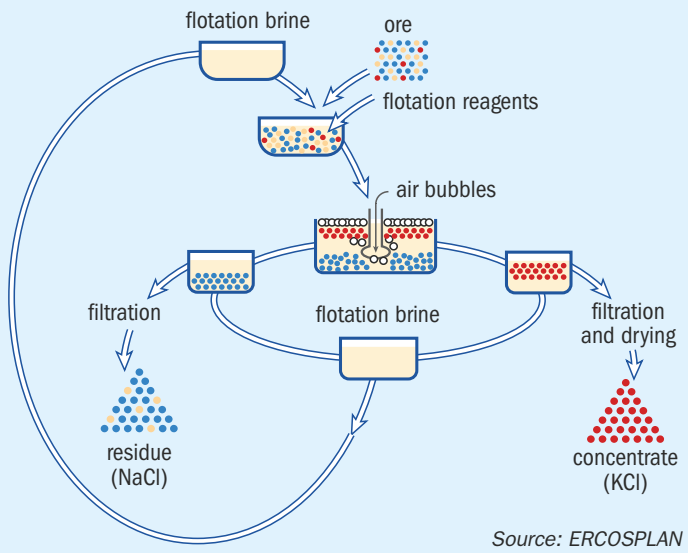
Flotation is generally suitable for potash beneficiation when the KCl occurs in a relatively simple mineral mixtures and is also liberated from the secondary components present – i.e., the crystals of the individual minerals are not intergrown.

However, flotation is not suitable for ore types where the sylvite crystals are not liberated from gangue minerals. If the Sylvite is intergrown with anhydrite (main photo, right) and halite crystals, for example, it is generally not possible to separate the sylvite from these via a mechanical separation method – such as flotation – and obtain a potassium chloride product.

In such cases, more complex chemical separation methods, like leaching and crystallisation, are necessary to separate the sylvite from the secondary components. Leaching and crystallisation work by exploiting the different solubility behaviour of individual minerals.

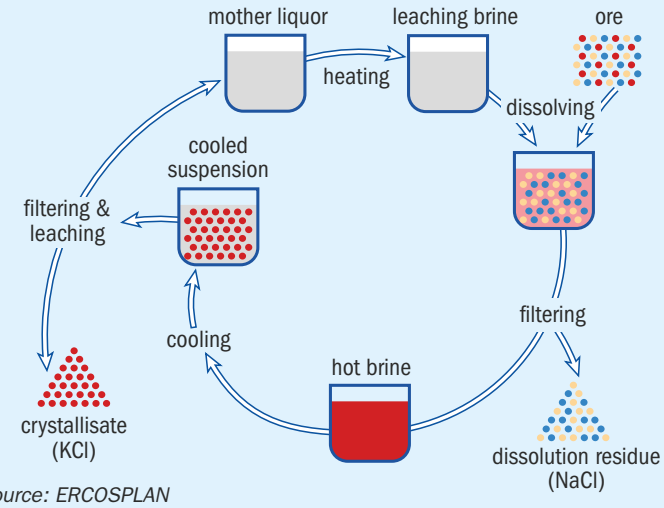
In potash processing, the ore is typically leached with a hot brine saturated with NaCl (sodium chloride) but undersaturated with KCl. While the KCl in the ore dissolves in the hot brine, both NaCl and the $CaSO_4$ remain undissolved as solids. After leaching, hot brine saturated with

Fig. 1: **Typical potash flotation process**



Source: ERCOSPLAN

Fig. 2: **General process scheme for potash leaching and crystallisation**



Source: ERCOSPLAN

KCl and NaCl is firstly separated from the coarse solids and then clarified to remove the fine solids.

Pure KCl is then crystallised out in a subsequent vacuum cooling crystallisation stage. This selective crystallisation occurs because the solubility of KCl declines with decreasing temperature, whereas the solubility of NaCl changes little during cooling and therefore remains in solution. A typical potash leaching/crystallisation process is shown in Figure 2.

As well as intergrowth of different minerals, the complexity of the mineral salt mixtures can also pose challenges for flotation-based potash beneficiation. The 'floatability' of the potash ore is generally limited if many different minerals are present – for example, when sylvite, halite, kieserite and polyhalite are all intermixed together. For such ore types, there is no flotation flowsheet available that can separate out all these minerals. Instead, pure and saleable KCl products can only be obtained by using a leaching and crystallisation process.

Improving sustainability and resource use

It is not just the ease of beneficiation that is important. Sustainability should also always be kept in mind during process selection and design.

Sustainability can generally be improved by increasing the overall yield of the process – as this reduces environmental impacts by lowering the requirement for utilities (water, gas, steam, chemicals etc) and even the physical footprint of the plant itself. Many successful sustainability improvements have been made through process adaptions in recent decades.

The recovery of by-products such as sodium chloride, to reduce waste and increase utilisation of the whole ore, is another approach that improves resource use and sustainability. It is conceivable that the demand for NaCl will increase rapidly in the years ahead – due to the development of new types of rechargeable batteries based on sodium ions and not on lithium.

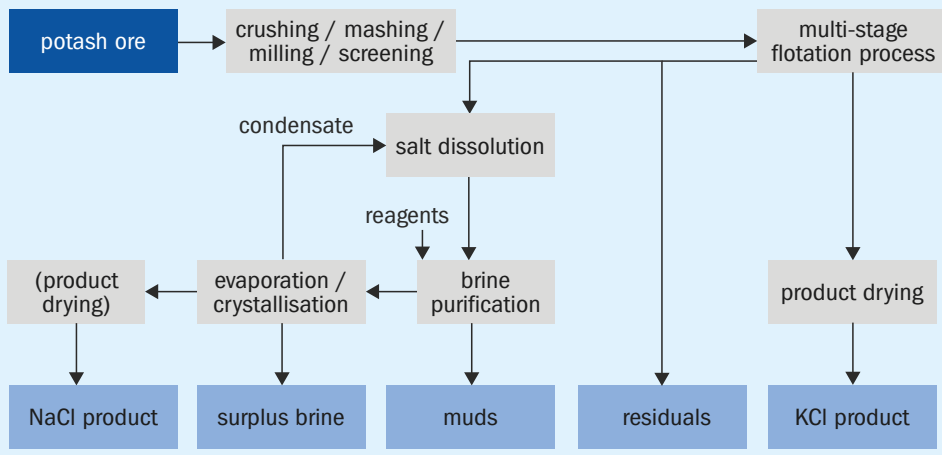
To meet the expected rise in demand, new beneficiation schemes will need to be designed that enable existing potash plants to be adapted to recover NaCl as a saleable product as well as KCl. This could be achieved via a leaching/crystallisation process only, for example, or by combining flotation with leaching/crystallisation, as shown in Figure 3.

In conclusion, the combination of mechanical separation processes, such as froth flotation, with chemical separation processes, like leaching/crystallisation, can optimise the utilisation of potash deposits and improve margins by manufacturing different salt products such as potassium chloride and sodium chloride. ■

Acknowledgement

This article is based on a presentation given by Dr Eike Kaps at this year's CRU Phosphates+Potash Expoconference, Orlando, Florida, in April. The call for papers for the next year's event in Paris, 13-15 April 2026, is now open: events.crugroup.com/phosphates/call-for-papers

Fig. 3: **General flowsheet of a combined flotation and leaching/crystallisation process for potash beneficiation – designed for both KCl and NaCl product recovery**



Source: ERCOSPLAN

The value of fine screening

In this article, **Danny Luu**, Processing Engineer, Derrick Corporation, outlines the transformative role of fine screening in potash and phosphate processing. Drawing from real-world case studies and technical insights, he highlights how fine screening has become a core component of modern mineral processing flowsheets.

Phosphate and potash ore are essential building blocks of the modern world, particularly in agriculture, where they form the basis of fertilizers critical for global food production.

As the demand for high-purity products grows and environmental regulations become more stringent, producers in the potash and phosphate industries face mounting pressure to improve efficiency, reduce costs, and minimise environmental impacts. Helping to meet these challenges is fine screening technology – a significant technological advance that, by providing a modern approach to particle classification and separation, offers compelling economic and operational benefits.

The need for mineral processing innovation

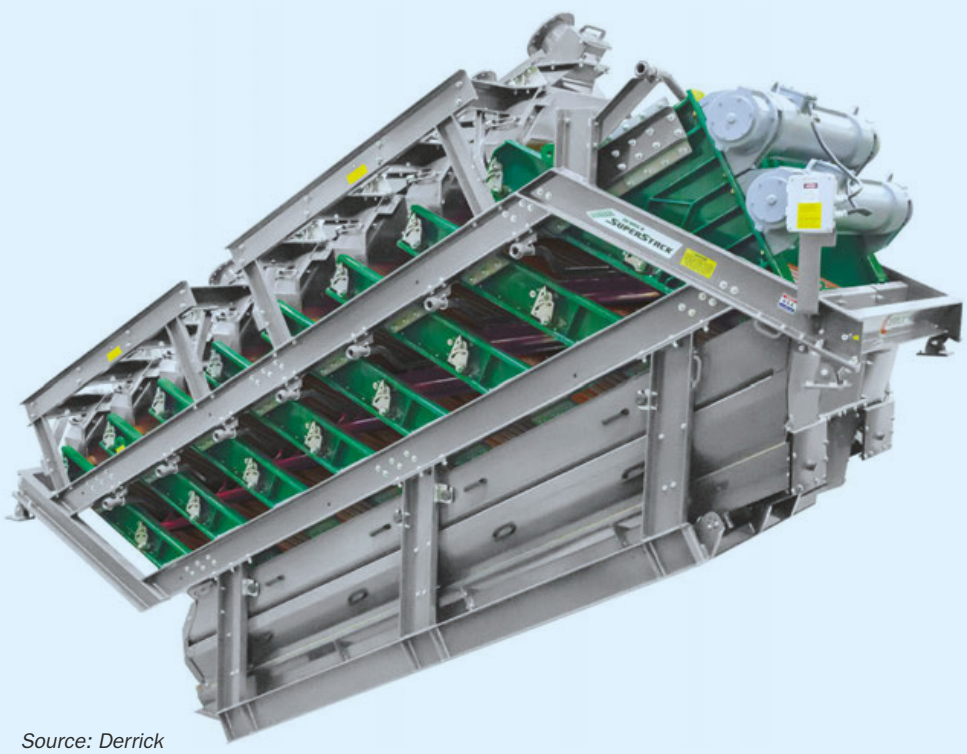
Traditional mineral processing methods, while effective in their time, often struggle to keep pace with the demands of today's industry. Conventional equipment, such as Huck bolted screens and hydrocyclones, have long been used for particle size classification in both phosphate and potash plants. Yet, these technologies carry limitations, as discussed below.

In the context of rising energy prices, stricter environmental regulations, and the need for sustainable mining practices, these drawbacks are becoming increasingly unsustainable. Producers are therefore seeking new technologies that can deliver higher performance while reducing costs and environmental footprints.

Enter fine screening – a precise and innovative solution offering high classification efficiency, and therefore less physical misplacement of materials, compared to other classifiers. Greater efficiency, by reducing circulating loads, translates into less wear and lower energy costs. It also minimises overgrinding by precisely separating particles by size. This reduces the unnecessary grinding of already fine particles, preserving valuable minerals and improving recovery. Fine screening also consumes less energy overall, contributing to lower operational expenses. Lastly, it has a smaller footprint, as multi-deck configurations save valuable plant floor space.

In summary, these attributes make fine screening an attractive upgrade in modern mineral processing operations. This is illustrated by the eight-deck SuperStack® machine offered by Derrick® Corporation shown in Figure 1.

Fig. 1: **Derrick® eight-deck SuperStack® fine screening machine for potash**



Source: Derrick

Improving potash operations

Potash production faces challenges from past screening systems. Huck bolted screens, for example, often limit capacity due to their low open surface area, causing bottlenecks, and require significant space and structural support for their high dynamic loading. Problems such as blinding, high maintenance downtime, shorter machine lifespans, and – most importantly – lower efficiency ultimately leads to both lower revenue generation and increased costs.

Modern fine screens from Derrick, such as the SuperStack replace the huck bolted screen to deliver the following benefits:

Table 1: **Summary of fine screening improvements achieved at potash plants with Derrick Stack Sizers versus traditional screening systems**

Ore Sizing Metrics	Before	After	% Change
Screen Efficiency	75%	92%	+23%
Oversize moisture content	15%	8%	-47%
Motor nameplate HP	15hp	5hp	-67%

Source: Derrick

- >95% size separation efficiency
- Higher open areas, leading to greater capacity and reduced fines generation
- Smaller footprint – often less than half that of huck bolted screens
- Lower dynamic loading, reducing structural steel requirements
- Quick panel changes – approximately 2-3 minutes per deck
- Longer machine lifespan – 8 to 10 years or more
- Long panel life of 2 to 4 years.

Potash applications

Primary sizing screens: usually positioned after the crushing and scrubbing stage, these screens cut at a 4.5 or 32 mm size range to send the coarse (de-brine) back to the crusher. Having a classifier that's cutting efficiently is critical for avoiding sending fines back to the crusher, as this leads to overgrinding and recovery loss. Lower efficiency also reduces the overall tonnage capability of the circuit.

Deslime screens: remove slimes that hinder effective flotation separation of potash. This step comes after the grinding circuit and before flotation, with a hydrocyclone as the traditional classifier of choice in this application. Derrick screens can, however, classify more efficiently with this improving flotation recovery, as there is less misplacement of particles.

Regrind screens: these go into the process after the flotation stage to improve recovery by recapturing the coarse unliberated particles (usually plus 1mm) and sending these back to the crusher.

Case study: success in Saskatchewan

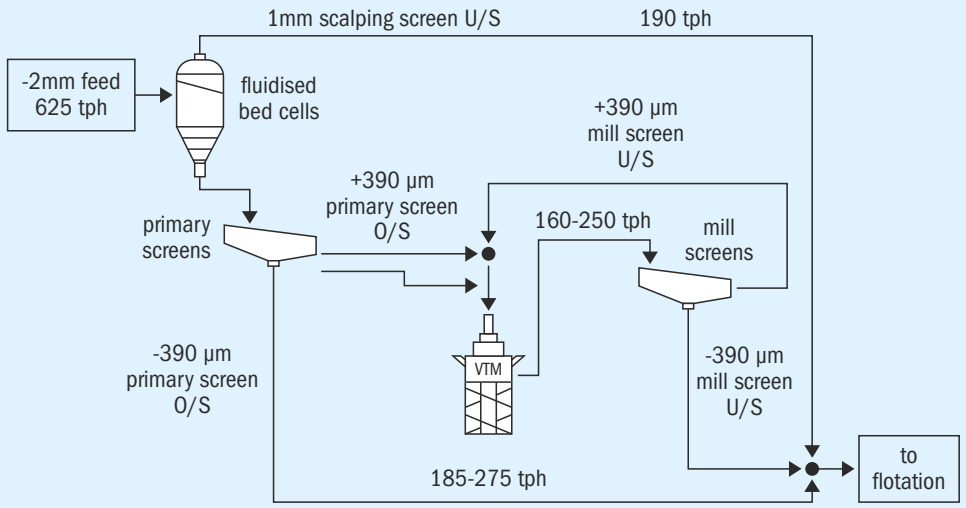
A compelling example comes from Saskatchewan, Canada, where more than 60 Derrick Stack Sizers operate across six potash plants. These installations handle screening at sizes such as 4.5 mm, 3.2 mm, and 1.4 mm.

The following benefits are reported by one of the world's largest potash producers:

- Over 25% more open screen area compared to huck bolted screens
- Approximately 20% higher separation efficiency
- A 50% reduction in the amount of -70 micron particles, minimising fines
- An increase of around 2% in potash recovery – a substantial gain given the high value of the product
- Recirculating load reduced by 35%.

Additional benefits, as reported by Derrick's customer, are summarised in Table 1.

Fig. 2: **Customer's existing phosphate processing flowsheet**



Source: Derrick

Transforming phosphate processing

Traditionally, phosphate plants have relied on hydrocyclones, hydrosizers, and fluidised bed separators (FBS) for particle classification. However, these systems often suffer from significant drawbacks, including:

- Lower efficiency
- High circulating loads
- Excessive overgrinding, leading to lower recovery rates
- Increased power consumption and operating costs.

Fine screening, particularly using high-frequency vibrating screens, has the following benefits:

- Higher classification efficiency (85-95%)
- Significantly reduced circulating loads (100-150%)
- Less overgrinding improves overall recovery, preserving valuable phosphate particles for flotation
- Lower power and maintenance requirements.

Overall, these advantages translate into increased throughput, reduced costs, and improved sustainability.

Case study: a South African phosphate mine

A phosphate mine on South Africa's west coast illustrates the advantages of fine screening. Initially, the flowsheet consisted of a fluidised bed separator followed by a closed grinding circuit with two-stage screening before flotation (Figure 2).

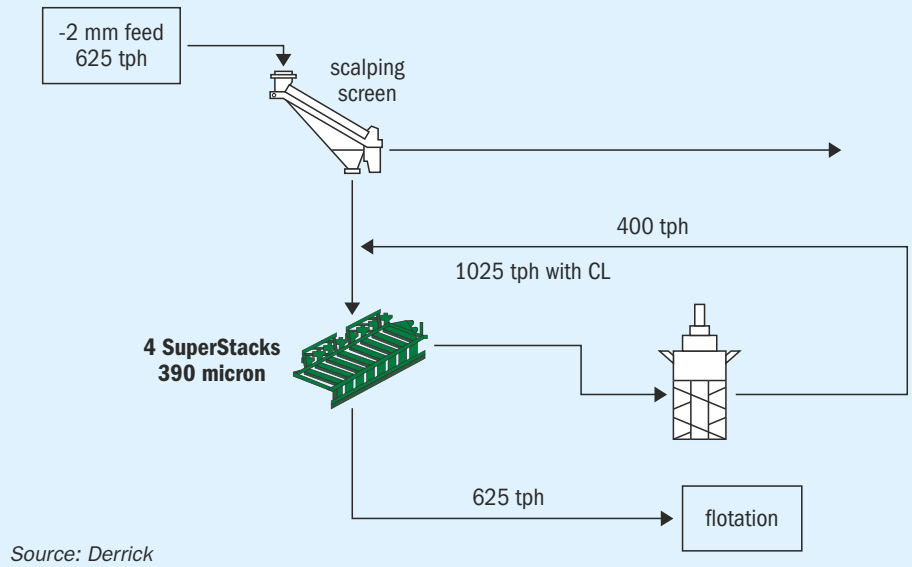
Working with Derrick Corporation, the mine tested an alternative solution. Full-scale laboratory trials demonstrated ~90% classification efficiency using 350/390-micron screens with spray water. Ultimately, the recommended flowsheet was simplified to screening with four SuperStack screens in a closed mill circuit, replacing ten competitor screens, and the fluidised bed separator was replaced with a scalping screen, as shown in Figure 3.

This successful South African case study highlights how fine screening can modernise phosphate processing, delivering substantial economic and operational benefits.

From other installations, phosphate industry clients have reported the following benefits:

- Production rate increased by 30%
- Flotation reagent consumption decreased
- Power usage dropped by 20-25%
- Circulating load reduced from over 400% to 135%
- Panel life exceeded 7,000 hours
- Lower capital and operational expenditure due to fewer screens, a smaller footprint, and reduced maintenance needs.

Fig. 3: **Customer's revised phosphate processing flowsheet**



Source: Derrick

Conclusion

Fine screening technologies such as Derrick's SuperStack® have proven to be game changers in phosphate and potash processing. They deliver superior efficiency, lower operational costs, and significant sustainability advantages. As global demand for fertilizers grows and the industry faces stricter environmental standards, fine screening stands out as a key solution for mining operations looking to secure a profitable and sustainable future.

From Derrick's perspective, the path forward for the mining industry is clear: to thrive in a changing world, embracing innovative solutions like fine screening is not just wise – it's essential.

Acknowledgement

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Fertilizer industry installation of a Derrick® SuperStack® fine screening machine.

PHOTO: DERRICK

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