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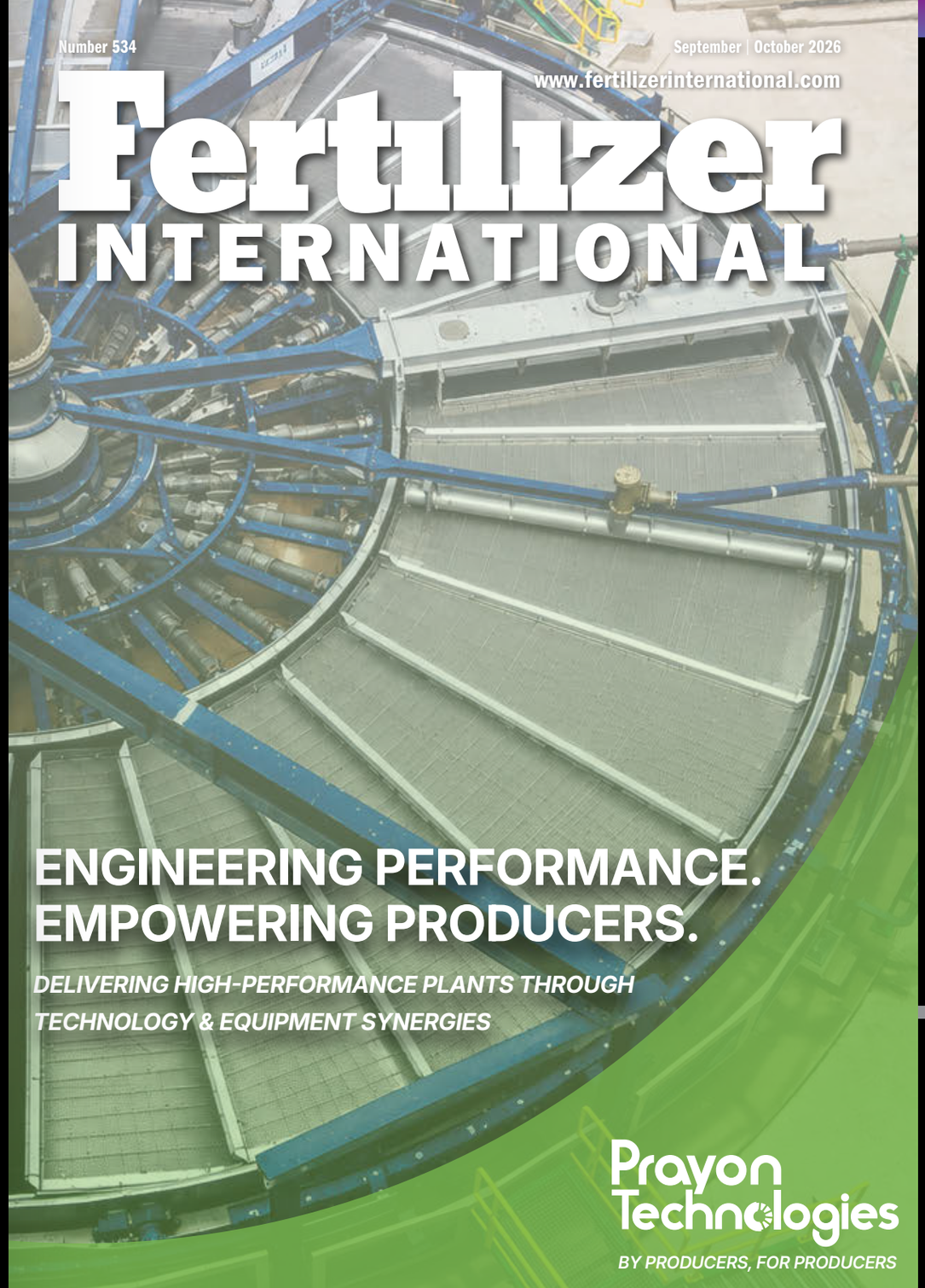

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ISSUE 534
SEPTEMBER-OCTOBER 2026

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Grade deflation

PHOTO: CRU

Maria Gamboa, Analyst, Phosphate Raw Materials Services

Average phosphate rock grades globally have been on the slide since the 1970s. CRU's **Maria Gamboa**, Analyst, Phosphate Raw Materials Services, looks at the most recent trends in rock grade and the cost implications for phosphate fertilizer production.

In the late 1970s, the average phosphate rock grade was 33% P_2O_5. By 2024, the largest share of rock production fell under 29.5% P_2O_5.

Phosphate rock grades have therefore been decreasing over time, an issue exacerbated by the recent fall in P_2O_5 levels in rock concentrate from China, the world's largest phosphate rock producer.

Underlying the long-term grade decline has been a fall in the production of medium-grade rock globally. At the same time, high-grade rock production – which has fluctuated over time – remains limited.

More trade in lower-grade

The traded rock market tells a similar story. Lower-grade rock is far more available than it was 30 years ago, while the diminishing availability of higher-grade rock has been exacerbated by the withdrawal of Russian tonnes since 2022.

Medium-grade rock has seen the largest decline, with rock grading 31.4–33.4% P_2O_5 falling in availability by almost 80% compared to 2004 levels. At the same time, exports of rock with a P_2O_5 lower than 29.8% have undergone an almost threefold increase.

These changes in the grade mix have been a key driver of phosphate rock prices over the past four years.

Before 2022, price differentials between rock grades were largely stable over time. Since the price peaks of 2022-23, however, the premium attached to medium- and high-grade rock has remained elevated, despite falls in absolute prices. This is directly linked to changing availability.

Moroccan rock has retained the largest relative premium among all benchmarks, while lower-grade benchmarks like Egypt and Algeria have returned closer to historical trends. This also relates to OCP's change in strategy: the Moroccan producer is capturing more of the inherent P_2O_5 value in its rock by prioritising downstream production over phosphate rock exports.

Sulphur and phosphate rock cost parity

In countries such as India, phosphate rock has historically accounted for the largest share of the cost of producing phosphate fertilizers. The recent rally in sulphur prices has brought the cost of both raw materials – sulphur and phosphate rock – close to parity, resulting in significantly higher phosphate production costs and decreasing margins.

The combination of higher sulphur prices and higher rock consumption, to account for decreasing P_2O_5 content, is proving extremely damaging for phosphate producers, especially in countries that purchase rock such as India. As a result, margins have been largely negative over the past five months.

Importantly, the decreasing P_2O_5 content of phosphate rock not only increases the amount of rock necessary to produce downstream fertilizers – it also increases the sulphur requirement. That is because the calcium content of rock tends to increase as P_2O_5 content drops, requiring higher sulphuric acid consumption.

Acid intensity – defined as the tonnes of sulphuric acid required to produce one tonne of diammonium phosphate (DAP), monoammonium phosphate (MAP) or triple superphosphate (TSP) – has trended upwards in recent years, rising from an estimated 3.7 tonnes in 2010 to 4.3 tonnes in 2025.

This increase has been driven largely by the acid consumption of China's phosphate industry, which accounts for 38% of global demand, with the country's acid intensity rising from 2.9 tonnes to 4.0 tonnes over the period 2010-2025.

Exports of lower-grade ore to rise

Should current trends persist, CRU estimates that sub-31.5% P_2O_5 rock will account for more than 80% of global export supply by 2040, with rock grading below 29% P_2O_5 accounting for approximately half of this.

Over the coming decades, CRU expects this trend to drive greater sulphuric acid consumption and increase demand for phosphate rock in downstream fertilizer production. Acid intensity is also expected to continue its upwards trend, with the global average forecast to reach 4.7 tonnes by 2030.

These market trends look set to place significant upwards pressure on acid intensity and input costs for non-integrated phosphate fertilizer producers in particular. Phosphate rock producers, meanwhile, are expected to retain higher-grade rock domestically as a hedge against future sulphur price volatility. ■

> **"Medium-grade phosphate rock has seen the largest decline, with rock grading 31.4–33.4% P_2O_5 falling in availability by almost 80% compared to 2004 levels. At the same time, exports of rock with a P_2O_5 lower than 29.8% have undergone an almost threefold increase."**

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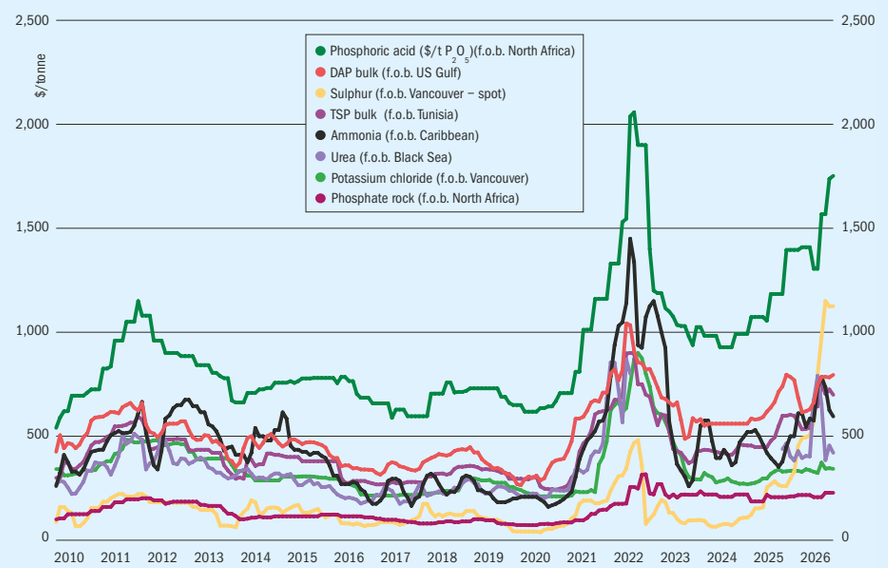
Historical price trends $/tonne



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PRICE TRENDS

Market snapshot, 20th August 2026

Urea price declines slow: While some granular urea prices appear to have turned a corner, it remains to be seen whether this rally can be sustained. The prospect of significant Chinese supply, meanwhile, continues to weigh on prilled urea pricing.

Rashtriya Chemicals and Fertilizers (RCF) issued letters of intent for the purchase of 1,779,500 tonnes of urea following the conclusion of its 11th August tender. This saw lowest offers in the $390s/t cfr range and is expected to be largely supplied by China, with estimated participation ranging from 1.2-1.5 million tonnes.

In the Middle East, latest prices are in the $390-410/t f.o.b. range, with the shipping situation in the Strait of Hormuz still uncertain. In Iran, the official price was cut to $345/t f.o.b., although several tenders failed to attract buying interest.

The most significant price recovery has been in North Africa. In Egypt, sales were concluded at $450/t f.o.b. by Mopco and at $475/t f.o.b. by Abu Qir. Progressively higher deals were also reported in Algeria, eventually reaching $467/t f.o.b. following an AOA sale for September.

The Americas have also seen a shift in sentiment. In Brazil, offers are reported to have climbed as high as $470/t cfr, although liquidity at these levels is non-existent for now. The US NOLA market also firmed, with September barges trading up to $405/st f.o.b.

Ammonia's regional divide continues: In northwest Europe, prices are unchanged, holding at above the $700/t cfr mark. This stability is underpinned by high Dutch TTF gas prices, which stood at €63.93/MWh ($21.5/mmBtu) on 20th August, and steady urea values out of Algeria.

East of Suez, Chinese f.o.b. offers in the $430/t range continue to set the floor, putting pressure on other urea producers. This was reflected in Southeast Asia, where the assessed price range eased to $420-500/t f.o.b., including a reported sale to India at $450/t cfr for ammonia of Malaysian origin.

The US market was quiet with attention shifting to the upcoming September Tampa contract settlement between Yara and Mosaic. Expectations are for a moderate decline from the August price of $635/t cfr, with most anticipating a settlement closer to $600/t cfr.

Phosphates prices stable: Spot prices across DAP/MAP markets were broadly stable. Sellers shifted tonnes to a range of destinations in response to slow demand in key import markets.

Bangladesh's Ministry of Agriculture closed a purchase tender on 18th August for 500,000 tonnes of DAP, 200,000 tonnes of TSP and 250,000 tonnes of MOP, according to market sources, with offers totalling 670,000 tonnes of DAP, 270,000 tonnes of MAP and 420,000 tonnes of MOP. The lowest DAP offer was at $979/t cfr for 40,000 tonnes of DAP from Egypt, while the lowest TSP offer was at $767/t cfr for 30,000 tonnes from Egypt/Bulgaria.

Market price summary $/tonne – mid-August 2026

Nitrogen	Ammonia	Urea	Ammonium Sulphate	Phosphates	DAP	TSP	Phos Acid
f.o.b. Caribbean	595	-	f.o.b. E. Europe 321	f.o.b. US New Orleans*	795	-	-
f.o.b. New Orleans	-	390		f.o.b. N. Africa	913	699	1,752
f.o.b. Middle East	523	379		cfr India	933	-	1,700
f.o.b. Black Sea	-	410					
Potash	KCl Standard	K_2SO_4	**Sulphuric Acid**		**Sulphur**		
f.o.b. Vancouver	333	-	cfr US Gulf 370		f.o.b. Vancouver	1,125	
cfr India	383	-			f.o.b. Arab Gulf	883	
fca Western Europe**	-	625			cfr China	1,050	
f.o.b. Baltic	326	-			cfr India	1,050	

*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*

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Ma'aden reportedly sold one DAP cargo for the Bangladesh tender at around $920/t f.o.b. The Saudi producer also confirmed it would now be exporting from Duqm port in Oman due to continuing shipping restrictions through the Strait of Hormuz.

In India, DAP was steady at $930-935/t cfr, with price clarity awaited on FACT's latest import tender. Prices in the subcontinent have remained relatively stable since Indian Potash Limited (IPL) awarded 13 suppliers for 1.347 million tonnes of DAP on its 7th May tender.

Spot prices for MAP cargoes to Brazil were also stable at $850-860/t cfr following two weeks of declines, with sales still scarce despite the price falls.

Early signs of potash price weakening: European standard MOP prices remained stable at €345-360/t cif, while granular prices declined marginally to €350-370/t cif due to waning seasonal demand. Similarly, Southeast Asian standard MOP prices remained broadly stable at $380-423/t cfr, while granular MOP prices declined marginally to $410-420/t cfr due to seasonal factors. Bangladesh's Ministry of Agriculture, meanwhile, closed its 250,000 tonne MOP tender with the lowest bids at $399/t cfr and the highest at $431/t cfr.

In Brazil, prices held stable at $390-403/t cfr. Some market participants are expecting October deliveries to decline to $370-380/t cfr. The US market remained steady at $340/st f.o.b., with limited activity reported at ports.

Sulphur market flat with buyers on sidelines: Most key sulphur benchmarks remained stable due to a widespread lack of spot market activity. While confirmed price drops were seen in the Mediterranean and domestic China, the dominant theme across other major regions was one of inaction, as most buyers in India, Brazil and Indonesia remained on the sidelines.

In the Middle East, sulphur f.o.b. prices held at a three-month low. The sulphur market remains caught between weak global demand signals and worsening local supply risks. The sulphur shipping backlog in the Strait of Hormuz has increased to 450,000 tonnes, according to Kpler, with no meaningful progress on securing safe passage for vessels.

In China, domestic port prices declined as inventories rose to an 11- week high of 884,000 tonnes.

The Indian sulphur market was quiet, with prices holding stable at $1,050-1,100/t cfr. Participants are currently awaiting a final decision on a proposed government subsidy.

Indonesian sulphur prices were similarly unchanged and remain at a two-month low. The Brazilian market is also in a stalemate, with prices stable amid a near-total absence of buying interest.

OUTLOOK

Limited urea upside as Chinese supply emerges: Global urea prices are expected to find some support in August, driven by a new tender in India and renewed purchasing in Europe. On the supply side, market tightness is expected to ease. While around 442,000 tonnes of urea across 10 vessels is currently at anchor west of the Strait of Hormuz, shipments should resume gradually through August before increasing in September. This is coupled with newly commissioned urea capacity in Nigeria and Iran. China's continued presence in the urea export market is also set to weigh on prices.

Ammonia's east-west divergence widens: In the short term, prices should hold firm in Europe, although values elsewhere could well undergo further pressure. The September Tampa contract price is also expected to decline. Ammonia pricing is increasingly split east and west of Suez. Northwest Europe, for example, is the only benchmark forecast to move higher in August. East of Suez, meanwhile, ammonia prices continue to ease under pressure from abundant Chinese supply and weak regional demand.

Phosphates prices approach ceiling: Phosphate prices are set to remain well-supported in the short-term. While the exceptionally tight availability affecting both finished products and raw materials is likely to drive up some benchmarks further, a price ceiling is approaching with poor affordability limiting the price upside. Gradual phosphate price declines are expected from late in the third quarter or early in the fourth.

Potash to decline as demand weakens: Potash prices are expected to decline in the short-term. This is due to weakening demand in key consumption centres, such as Brazil and China, and ample supply availability. The continuing presence of surplus MOP on the international market could place downwards pressure on prices globally.

Sulphur price correction moderates: The market is expected to remain flat-to-soft in the short-term. While the supply risk in the Middle East provides a floor, the widespread lack of demand across key import markets is preventing prices from moving. Looking ahead, prices are still forecast to fall, although the market correction will be moderated by the ongoing conflict in the Middle East and limited vessel movements in the region. ■

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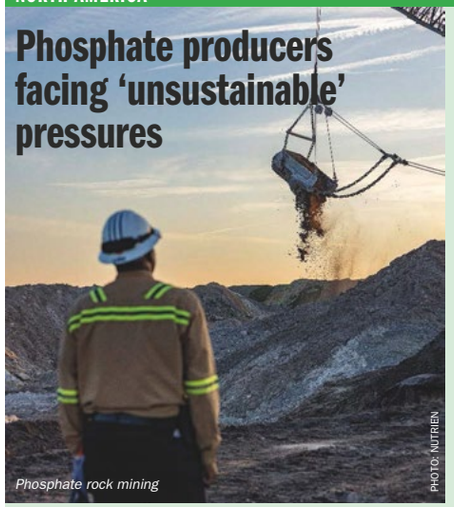
NORTH AMERICA

Phosphate producers facing 'unsustainable' pressures



Phosphate rock mining

PHOTO: NUTRIEN

Nutrien and Mosaic's second quarter 2026 results have laid bare the stark consequences of the global sulphur squeeze on North America's leading phosphate producers.

Both companies saw their average gross margins for phosphate production turn negative in April-June 2026. Phosphate segment earnings were also hit hard.

While Nutrien's phosphate net sales rose 18% year-on-year (y-o-y) to $468 million, earnings (adjusted EBITDA) collapsed to $23 million – 75 % down on April-June 2025. Similarly, Mosaic's phosphate business reported second quarter net sales of $1.25 billion, up by 7% on the same period in 2025, while quarterly earnings (adjusted EBITDA) fell by 41% y-o-y to $128 million.

These disappointing phosphate financials occurred in the context of better overall company results. Nutrien and Mosaic reported total second-quarter 2026 earnings (adjusted EBITDA) of $2.43 billion (down 2% y-o-y) and $407 million (down 27% y-o-y), respectively.

Commenting on the y-o-y phosphate earnings decline, Mosaic cited an increase in raw material cost with these being only "somewhat mitigated by higher prices and improved cost controls". Its second quarter raw material costs averaged $522/t for sulphur and $621/t for ammonia.

Nutrien, meanwhile, said its phosphate earnings decrease in the second quarter was "due to higher sulfur input costs, partially offset by higher global benchmarks and sales volumes".

Nutrien's average cost of goods sold (COGS) for its phosphate business segment was $812/t during April-June 2026 versus an average net selling price of $781/t. The resulting negative gross margin ($31/t) was due to an increase in production costs – primarily driven high sulphur input costs – outpacing higher phosphate market prices.

In comparison, Nutrien's net phosphate selling price of $714/t for the same quarter in 2025 was well above the average COGS of $646/t – generating a positive gross margin of $68/t.

Mosaic's second quarter 2026 phosphate production costs were similarly affected. Its average gross margin turned negative ($4/t) versus a positive margin of $67/t for April-June 2025. This was despite a 16% y-o-y rise in the average diammonium phosphate (DAP) selling price to $773/t f.o.b.

Mosaic announced phosphate production curtailments on 11th May and withdrew its 2026 phosphate guidance (*Fertilizer International* 533, p10). The company has now confirmed that these resulted in a y-o-y production decline for the quarter of around 100,000 tonnes to 1.4 million tonnes.

Mosaic's CEO, Bruce Bodine, provided an update on current curtailments during a 5th August analysts call. He confirmed that the company's Louisiana operations are offline, Bartow, Florida, is operating at 40% of capacity, while Mosaic's New Wales and Riverview production sites in Florida are operating at around 70-75% capacity.

"Our message for you today is simple. Mosaic is working through a difficult market by successfully managing what is under our control and positioning ourselves for an eventual recovery. Sulphur affordability and availability remain key drivers, but we know the situation will improve," Bodine said.

The sulphur supply and cost situation was more than just an inconvenience, he added.

"We believe global phosphate production will fall well short of last year by up to 30 million tonnes. With last year's low application rates, especially in the US, and limited fertilizer availability this year, crop yields will suffer, which could lead to food security challenges around the world in the near term. We are already seeing evidence of challenges in Brazil," Bodine said.

Asked about the prospects of improvements in phosphate affordability, Bodine thought this would be delivered by a combination of crop prices moving up and phosphate fertilizer prices moving down. A movement in the corn price above $5/bu could provide "a lot of tailwinds" for phosphate demand, in his view, with Brazil expected to be the first market to pick up due to the inability of its soils to bank nutrients.

Bodine said Mosaic was ready to ramp back up to full production "in weeks, not months", when market conditions improve.

Nutrien called the current operating environment for phosphate producers unsustainable.

"Global phosphate market fundamentals continue to be affected by trade flow disruptions, constrained sulphur feedstock availability and elevated costs, which have placed unsustainable pressure on phosphate producer margins and have resulted in reduced global operating rates," Nutrien said in its latest earnings release.

Nutrien announced a strategic review of its phosphate business unit – by far its smallest operational segment – in November last year. Future options include a reconfiguration of operations, bringing in external partners or divestment (*Fertilizer International*, 532 p40)

OCP is also understood to be moving more cargoes to the US, mostly focused on TSP, but also including some DAP/MAP. The follows news in late June that the US administration was authorising duty-free imports of Moroccan phosphate fertilizers by temporarily suspending countervailing duties (CVDs). ■

MEXICO

$1.7bn Fermachem fertilizer megaproject breaks ground

Fermachem officially began construction on its one million tonne per annum (t/a) capacity urea project in Durango, northern Mexico, in a groundbreaking ceremony on 8th June. The private developer is a subsidiary of Mexican conglomerate Fermaca Dreams.

Fermachem formalised the start of phase one construction at the ceremony by signing an engineering services agreement with Spain's Técnicas Reunidas. This makes the company responsible for both the design and engineering, procurement and construction (EPC) of the $1.6 billion state-of-the-art fertilizer project.

Fermachem's CEO, Ray Fletcher Celis, said the Durango fertilizer plant will be one of the most modern on the continent. It will incorporate KBR ammonia and Stamicarbon (Nextchem) urea process technologies.

The project has secured access to Texan-sourced natural gas through an agreement with supplier Essentia Energy – Fermachem being one of the company's shareholders. The project will also integrate sustainable practices such as carbon capture, on-site electricity generation and water reuse, according to media reports

The project is expected to create about 3,000 construction jobs and several hundred permanent posts. First production is currently scheduled for 2029.

Fermachem intends to supply domestic farmers and export the rest of its output to Latin America and the United States. Mexico currently imports more than 80% of its urea requirements. Supply from Fermachem could reduce the country's import demand by almost 60%, based on 2024 import levels of 1.7 million tonnes.

ARGENTINA

Latin America's largest urea plant gets the green light

Pampa Energía's Bahía Blanca urea plant is set to go ahead, after the company's board of directors approved the final investment decision (FID) on 17th July.

The 2.1 million tonnes per annum (t/a) capacity urea plant will be the largest in Latin America.

Wholly owned subsidiary Fértil Pampa can now proceed and construct the $2.7 billion plant at the Bahía Blanca Industrial Complex in southern Buenos Aires Province. The project is expected to create more than 3,500 constriction jobs and will employ approximately 300 people once it is operational.

One potential stumbling block remains, however. Financial support for the project is pending from two major national and provincial funding regimes – Argentina's 'Large Investment Incentive Regime' (RIGI) and Buenos Aires Province's 'Strategic Investment Regime' (REPIE).

Pampa Energía says approval under RIGI and REPIE are both "essential for the development of the project". It further advises that turnkey contracts with the project's construction and execution partners, SACDE and Tecnimont, could be affected if RIGI, in particular, is not approved.

The proposed Bahía Blanca plant will comprise of a large-scale ammonia unit alongside two granular urea production trains with a combined capacity of 6,000 tonnes per day (t/d). The project will also include a desalination plant, storage silos and new port facilities for truck and vessel loading.

Brazil, which imports 7-8 million tonnes of urea annually, is expected to be Fértil Pampa's primary market. The export-

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HOLLAND NOVOCHEM

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FERTILIZER INTERNATIONAL
ISSUE 534
SEPTEMBER-OCTOBER 2026

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oriented urea plant is expected to generate $1 billion in foreign currency earnings through import substitution and increased exports.

The plant's strategic location provides direct access to one of Argentina's main export ports, as well as the Vaca Muerta natural gas pipeline and Pampa's own thermal power plants and wind farms. The integrated supply of natural gas and electricity should ensure long-term profitability and provide Fértil Pampa with a competitive advantage, given that these two inputs account for around 70% of urea production costs.

"This represents the largest investment in Pampa's history and the most significant project we have undertaken in many years," said Marcelo Mindlin, Pampa Energía's chair. "This plant will provide Argentina with a reliable and competitive domestic supply of urea while creating new export opportunities across the region and international markets."

The FID was quickly followed by the award of major engineering and technology contracts for the plant.

Fértil Pampa awarded a €1.3 billion contract to Italy's MAIRE Group on 20th July. Its subsidiary Tecnimont will provide engineering, procurement, commissioning and start-up services to the project. Nextchem, meanwhile, another MAIRE subsidiary company, will supply Stamicarbon urea melt and granulation technologies under license and the plant's process design package (PDP). It will also provide associated proprietary equipment as well the plant's syngas primary reformer – which will be manufactured by KT Tech.

MAIRE's €1.3 billion contract is split between €1.16 billion for Tecnimont's scope of work and €140 million for Nextchem's technology package. Argentinian construction company SACDE will build the plant with completion expected in 41 months.

Alessandro Bernini, MAIRE's CEO, said: "This award marks our entry in Argentina and highlights our ability to integrate Tecnimont's recognized project execution capabilities alongside Nextchem's technology portfolio to deliver large-scale industrial projects worldwide. We are proud to contribute to the development of this strategic fertilizer complex in the region, which will support the monetization of natural gas reserves in the domestic downstream sector, and also strengthen the country's fertilizer production."

PHOTO: SAIPEM

Fertil Pampa's new urea plant will be bult within the existing Bahia Blanca Industrial Complex in Argentina's Buenos Aires Province.

KBR also announced on 20th July that its Purifier ammonia technology had been selected for the Fértil Pampa plant.

The Houston-headquartered company will provide technology licensing, the basic engineering design package and proprietary equipment for the 3,430 tonnes per day (t/d) ammonia plant at the Bahía Blanca complex. This will be the largest single-train ammonia plant in Latin America.

"We are excited to work with Pampa Energía, Argentina's leading energy company, SACDE and Tecnimont and support them in their quest for enhancing regional food security," said Jay Ibrahim, president, KBR Sustainable Technology Solutions. "KBR's proven and scalable ammonia process technologies are a preferred choice amongst customers worldwide. They enable plants to operate with optimum energy-efficiency while delivering maximum yield."

MOROCCO

Koch to acquire half share in JFC 1

Koch Ag & Energy Solutions (Koch) has signed an agreement with OCP Nutricrops (OCP) to acquire a 50% stake in Jorf Fertilizers Company I (JFC I).

JFC I owns a 1.2 million tonnes per annum (t/a) capacity phosphate fertilizer plant at Jorf Lasfar, Morocco, the world's largest phosphate fertilizer production complex. This plant will be operated as a 50:50 joint venture by Koch and OCP, on closure of the transaction, and serve customers around the globe, including those in North America.

The agreement, announced on 17th July, is the second joint venture between the Moroccan phosphate giant and the US nitrogen fertilizer producer. Koch previously acquired a 50% interest in Jorf Fertilizers Company III (JFC III) – renamed Kofert – from OCP in 2022 (*Fertilizer International* 507, p11). Combined, the two joint ventures will have a phosphate fertilizer production capacity of approximately 2.5 million t/a.

The new joint venture has been announced at an opportune moment, as it follows the US government's temporary suspension of countervailing duties (CVDs) on Moroccan phosphate fertilizer imports at the end of June. The lifting of CVDs will allow JFC 1 to supply US farmers with phosphate fertilizers, a move that should improve regional supply and diversify supply sources, according to Koch.

"This investment builds on the successful collaboration we have had through the Kofert venture," said Scott McGinn, President, Koch Fertilizer. "We are excited to expand Koch Fertilizer's phosphate offering for our customers and to continue to grow Koch's long-standing relationship with OCP."

"We welcome the signing of this agreement, which marks an important milestone in our long-standing partnership with Koch, a key North American player," said Faris Derrij, the chairman and CEO of OCP Nutricrops. "The joint venture strengthens our ability to deliver reliable, high-quality soil nutrition solutions to farmers and customers, including across North America, while contributing to more resilient agricultural value chains and long-term food security."

If approved, Koch's second joint venture with OCP – by strengthening its phosphate product offering and expanding its international production base – marks a further diversification away from being a predominately North American nitrogen fertilizer producer and distributor. OCP, meanwhile, will benefit from the cash proceeds of the part sale of JFC I and gain a better route to market in North America.

The transaction between the two companies requires regulatory approval and needs to satisfy customary closing conditions. Its value has not been disclosed.

CHINA

Envision supplies PepsiCo with low-carbon ammonia certificates

China's Envision Energy is to supply PepsiCo APAC with environmental attribute certificates (EACs) for green ammonia under a new four-year agreement.

In an announcement at the end of July, Envision revealed that PepsiCo had already received 1,000 tonnes worth of low-carbon ammonia EACs. These are being issued through an environmental attribute registry managed by S3 Markets. This first tranche of EACs should correspond to an emissions reduction of around 5,000 tonnes carbon dioxide equivalent (CO_2e).

EACs should help to decarbonise the fertilizer market by linking together emerging low-carbon production supply with downstream demand. Their purpose is to kickstart Scope 3 emissions reduction efforts – by multinational packaged goods companies (PGCs) such as PepsiCo, for example – at a time when low-carbon ammonia supply chains are not yet physically available at the required scale. The certificates are issued as a paper transaction with no physical exchange of commodities taking place.

Under the new agreement, which runs from 2026 to 2030, Envision will supply PepsiCo APAC with EACs associated with green ammonia produced at its Chifeng Net Zero Industrial Park, Inner Mongolia, China. The site is currently the home of the world's largest green hydrogen project.

The agreement is intended to help PepsiCo reduce its Scope 3 emissions in the APAC region by providing the company with an innovative pathway to decarbonise fertilizer use within its agricultural value chain, Envision said in a statement.

Ammonia is consumed in high volumes in fertilizer production as a feedstock for the manufacture of widely-traded nitrogen and ammonium phosphate products. These include urea, ammonium nitrate (AN), urea ammonium nitrate (UAN), monoammonium phosphate (MAP) and diammonium phosphate (DAP). It is also applied directly as a nitrogen source in agriculture in the form of anhydrous ammonia.

Currently, ammonia is mainly manufactured for fertilizer consumption via hard-to-abate energy- and carbon-intensive processes (e.g., steam methane reforming, SMR)) using fossil fuel sources such as natural gas or coal. As a consequence, ammonia is a significant source of agricultural supply chain and broader food system emissions.

The transition away from high-carbon 'grey' ammonia to low-carbon 'green' ammonia is therefore a critical decarbonisation lever for fertilizer producers, farmers and high profile crop buyers – such as leading global food brands.

Consistency is everything.

The need to take care of our planet for future generations is more important than ever. This is why we use pure and raw materials, while ensuring all our products to be free from contaminants. We were the first worldwide to develop and supply biodegradable and bio-based coatings to the industry.

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PHOTO: HURL

HURL's Gorakhpur urea plant in Uttar Pradesh was commissioned as part of the Indian government's National Investment Policy for urea.

PepsiCo's EAC agreement with Envision will use a 'Book & Claim' model. This allows the decoupling of physical products from their environmental attributes, an approach which is already used in sectors such as sustainable aviation fuel.

Under the Book & Claim system, Envision generates traceable EACs for the tonnages of low-carbon ammonia it produces in Chifeng and allocates these to PepsiCo APAC – without the need to physically transport green ammonia over long distances.

The environmental attribute registry managed by S3 Markets issues, allocates, tracks and ultimately retires EACs. The system is designed to create an audited chain of custody by linking each certificate to relevant production, emissions, sales and retirement documentation.

"Commodity-linked EAC markets will only scale if the infrastructure is as credible as the underlying low-carbon production," said Saman Baghestani, co-founder and CEO of S3 Markets. "This transaction is a leading example of that approach, combining verified production, clear attribute ownership, and auditable registry records to support credible downstream claims."

For PepsiCo, the EACs should provide an efficient option for Scope 3 emissions reduction within its agricultural supply chain – without having to solely rely on the physical transport of low-carbon ammonia over long distances and across borders.

"Emissions associated with fertilizer are often a significant component of Scope 3 emissions in the food and agriculture value chain, yet they are also among the most difficult and fragmented to address," said Fred Li, Supply Chain Senior Vice President, PepsiCo APAC & Greater China. "This agreement with Envision is intended to support our efforts to address emissions associated with upstream agricultural inputs more efficiently, without changing our existing procurement or production arrangements."

"This is another important example of PepsiCo Positive (pep+) in action. The agreement supports our ambition to achieve net-zero emissions by 2050 or sooner and provides an innovative way to support our efforts to address emissions associated with key agricultural supply chain hotspots," said Ashley Brown, Chief Sustainability Officer of PepsiCo APAC & India.

"Our collaboration with PepsiCo APAC marks a significant step forward in Envision's green hydrogen and ammonia business model innovation," said Frank Yu, Senior Vice President of Envision Energy. "The fertilizer industry consumes significant volumes of ammonia and represents substantial decarbonization potential. The value of the Book & Claim model for green ammonia EACs is that it allows environmental attributes to be matched with genuine decarbonization demand more efficiently and flexibly, without requiring the physical product to be transported over long distances."

CF Industries recently entered into an agreement to supply PepsiCo's US potato growers with certified low-carbon UAN solution (*Fertilizer International* 533, p9). PepsiCo is already trialling low-carbon fertilizers with its growers in Europe under supply agreements with Yara (*Fertilizer International* 522, p27) and Fertiberia (*Fertilizer International* 527, p18).

PepsiCo's use of low-carbon fertilizers is scaling up fast globally. Fertiberia recently agreed to supply the company's growers with up to 150,000 tonnes per annum of low-carbon fertilizers by 2030. PepsiCo expects low-carbon sources to account for about 50% of the fertilizer use in its European supply chain by the end of the decade.

INDIA

Government plans huge new wave of urea plants

The Indian government is aiming for urea self sufficiency by expanding the country's annual domestic production capacity by an extra 10 million tonnes. The massive expansion programme was unveiled in the National Investment Policy for Urea-2026 (NIPU-2026).

The new policy, which extends and revises the previous 2012 New Investment Policy (NIP), was approved by the government on 15th July. It supports the development of a new wave of around 8–9 domestic, natural gas-based urea plants.

According to the government, India's current annual urea production is around 30 million tonnes, versus a demand requirement of 40 million tonnes, leaving imports to make up the 10 million tonnes shortfall.

India has, nonetheless, made huge strides towards urea self sufficiency over the last decade.

Since 2012, the country has added 7.62 million tonnes per annum (t/a) of extra production capacity under NIP. Six new urea plants were commissioned to achieve this – each with a capacity of around 1.27 million t/a:

- **Ramagundam, Telangana**. Operated by RFCL and funded through so-called public sector undertaking (PSU) joint venture companies (JVCs).
- **Gorakhpur, Uttar Pradesh**. JVC plant operated by Hindustan Urvarak & Rasayan Limited (HURL).
- **Sindri, Jharkhand**. JVC plant operated by HURL.
- **Barauni, Bihar**. JVC plant operated by HURL.
- **Panagarh, West Bengal**. Privately funded and operated by Matix Fertilizers and Chemicals Ltd.
- **Gadepan-III, Rajasthan**. Privately funded and operated by Chambal Fertilizers and Chemicals Ltd.

The government's 2015 New Urea Policy (NUP) also set a target of delivering an extra 2.0–2.5 million t/a of domestic production by maximising output from existing capacity.

Thanks to these policy measures, India's urea production has increased from 22.5 million tonnes in 2014-15 to a record 31.41 million tonnes in 2023-24, with 29.33 million tonnes produced in 2025-26.

Currently, the Assam Valley Fertilizer and Chemical Company Limited (AVFCCL) is developing the Talcher fertilizer project, a 1.27 million t/a capacity brownfield urea project at Namrup, Assam, following government approval.

India's ability to source and produce urea has been affected by the closure of the Strait of Hormuz and the consequent loss of traded fertilizer and liquid natural gas (LNG) from Gulf producers.

The country's authorities have responded to the ongoing supply crisis since the end of February by broadening their sourcing. This has seen India successfully secure urea imports totalling 4.27 million tonnes, through global tenders of 2.5 million tonnes and 1.77 million tonnes in April and June 2026, respectively,

To keep fertilizers flowing to farmer, India's Department of Agriculture & Farmers Welfare is carefully monitoring seasonal demand requirements. The Department of Fertilizers, meanwhile, is allocating fertilizer supplies via monthly plans. The Department accurately tracks fertilizer movements through its Integrated Fertilizer Management System (iFMS). The government is also ensuring continuity of supply by holding weekly review meetings with state officials and by monitoring forward imports.

For supplies of phosphates and potash, India operates the Nutrient Based Subsidy (NBS) scheme.

The NBS, which has been place since 2010, regulates the import and manufacture of P&K fertilizers under license. Earlier this year, an NBS budget of INR 415.34 billion ($4.98 billion) was approved to secure P&K supplies for India's April–September 2026 Kharif season. ■

Acknowledgement

Additional reporting by Natalie Noor-Drugan, Senior Editor, CRU Communities.

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People

Anglo American and Teck Resources have announced the future executive leadership team (ELT) of Anglo Teck plc, the combined company that will be formed through their merger. These ELT roles will take effect immediately following completion of the merger. This is currently expected between September 2026 and March 2027, being conditional on final regulatory approval.

Both companies said: "The future ELT combines deep operational and financial expertise and global market insight with a strong track record of safety leadership, values-based decision-making and project delivery to create enduring shareholder and stakeholder value."

On completion of the merger, the ELT of Anglo Teck will comprise:

- **Duncan Wanblad** – chief executive officer (CEO)
- **Jonathan Price** – deputy CEO & chief strategy officer
- **John Heasley** – chief financial officer (CFO)
- **Ruben Fernandes** – chief operating officer (COO)
- **Ian Anderson** – chief people officer
- **Lyndon Arnall** – chief legal & sustainability officer
- **Alison Atkinson** – chief technical officer and CEO of Crop Nutrients
- **Karla Mills** – chief projects officer
- **Matt Walker** – CEO, marketing.

Nolitha Fakude will continue in her current role as the chair of Anglo Teck's management board in South Africa, reporting to Duncan Wanblad.

Duncan Wanblad, CEO of Anglo American and CEO designate of Anglo Teck, said: "Announcing Anglo Teck's future Executive Leadership Team marks another major milestone as we progress towards combining these two great companies. As the incoming CEO of Anglo Teck, I have utmost confidence in the highly capable executive and regional leadership teams that I have set out today, benefiting from their track records of delivery and their diversity of global experience."

PHOTO: ANGLO AMERICAN

Duncan Wanblad, CEO of Anglo American and CEO designate of Anglo Teck.

Jonathan Price, Teck's president and CEO and deputy CEO designate of Anglo Teck, said: "Today represents a significant next step in the creation of Anglo Teck, which we are setting up to be a top tier global copper producer with world-class operations and exceptional growth opportunities. This executive leadership team will provide strong continuity for the combined business and positions us to unlock the full potential of Anglo Teck."

As previously announced, **Sheila Murray**, currently chair of Teck, will chair the board of Anglo Teck, with Duncan Wanblad, Jonathan Price and John Heasley serving as executive directors. **Richard Price**, currently chief legal & corporate affairs officer of Anglo American, will also join the Board of Anglo Teck as a non-executive director.

ADM has appointed **Jeff Rowe** to the newly created role of executive vice president (EVP) and COO, with effect from the 17th August 2026. Rowe will oversee ADM's commercial businesses, global manufacturing and R&D efforts. He will report to Juan Luciano, chair of the board and ADM's CEO.

Rowe joins ADM from Syngenta Group, where he has held a series of senior leadership roles, after joining the company in September 2016, before being appointed CEO in January 2024. Prior to Syngenta Group, he spent more than 20 years at DuPont Pioneer in a variety of executive positions spanning strategy, international operations, biotech and regulatory affairs.

Juan Luciano said: "Jeff has an outstanding reputation in the industry as a proven leader with a strong track record of advancing innovation and operational excellence. I am confident that he will be a wonderful addition to ADM's global family of leaders. On behalf of all of us at ADM, I am delighted to welcome Jeff to the Company and look forward to working alongside him."

Jeff Rowe replied: "I am honored to join ADM and drive continued innovation at a global, agricultural leader. I have long admired ADM for its rich history and strong values. I look forward to partnering with the Company's talented team to build on that foundation, advancing ADM's growth strategy, supporting farmers and creating value for customers and shareholders."

Rowe is a fifth-generation farmer, helping to run his family's farm in Illinois. This employs regenerative agriculture practices to reduce environmental impact and improve sustainability, productivity and profitability. ■

Calendar 2026-27

SEPTEMBER

28-30

TFI World Conference, DALLAS, Texas, USA
Contact: Valerie Sutton, Director, Member Services and Conferences
Tel: +1 202-515-2709
Email: vsutton@tfi.org

NOVEMBER

3-5

CRU Sulphur & Sulphuric Acid Expoconference 2026, BERLIN, Germany
Contact: Event Client Services
Tel: +44 (0)20 7903 2444
Email: conferences@crugroup.com

3-5

38th AFA Technical Conference & Exhibition, AMMAN, Jordan
Contact: Arab Fertilizer Association
Tel: +202-23054464 / 67
Email: events@arabfertilizer.org

26-28

FAI Annual Seminar 2026, NEW DELHI, India
Contact: Secretary, The Fertiliser Association of India
Tel: +91-11- 46005204
Email: secy@faidelhi.org

JANUARY 2027

17-20

CRU/Argus Fertilizer Latino Americano 2027, RIO DE JANEIRO, Brazil
Contact: Event Client Services
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MARCH

16-18

CRU Phosphates+Potash Expoconference, ROME, Italy
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TECHNOPHOS is a technology and innovation center dedicated to developing and validating sustainable, solutions for the global phosphate industry.

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Backed by more than a decade of innovation, we bridge the gap between laboratory research and industrial-scale implementation, delivering practical technologies that improve efficiency, sustainability, and profitability.

BENEFITS of working with us:

- **Innovative phosphate technologies** that convert low-grade raw materials into valuable products.
- **Reduced waste, water, and energy consumption** through sustainable process design.
- **Pilot & Semi-industrial validation facilities** to prove performance before full-scale investment.
- **Expert R&D support** from a multidisciplinary team of engineers, scientists, and phosphate specialists.
- **End-to-end partnership** from technology development and raw material validation to client personnel training and start-up.

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PHOTO: HILTON

AFA's 38th International Technical Conference & Exhibition

The conference venue: Signia by Hilton, Amman, Jordan.

The Arab Fertilizer Association (AFA) will convene the 38th International Technical Conference & Exhibition, 3-5 November, at the Signia by Hilton, Amman, Jordan. Hosted by the Jordan Phosphate Mines Company (JPMC), the theme of this year's event is 'Beyond Production – The Fertilizer Industry Transformation Summit'.

Welcome to Jordan!

Now in its fourth decade, AFA's International Technical Conference & Exhibition has become the definitive gathering for the Arab fertilizer industry and its global partners. This year's event is being held in Amman with host sponsorship from the Jordan Phosphate Mines Company (JPMC).

Recognised as one of the fertilizer industry's most influential gatherings, more than 500 senior delegates are expected to attend. This will include **100+ chairs and CEOs** from leading Arab and international companies, accompanied by their technical and commercial teams.

The conference 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 nitrogen, phosphate and potash value chains.

Delegates typically include EPC contractors, technology providers, equipment manufacturers, catalyst and chemical suppliers, project management consultants and market analysts – making the event a highly valuable networking and knowledge-sharing opportunity. A specialised exhibition featuring 25-35 leading international suppliers will also run throughout the three-day event.

Beyond production

During the previous half a century, the Arab fertilizer industry has measured itself in tonnes: capacity built, cargoes shipped, output records broken. Midway through the 2020s, however, the present-day industry is starting to be measured very differently – by the value it creates beyond the factory gate, the carbon embedded in its products and the operational excellence of its plants.

It is this shift that gives the 38th AFA International Technical Conference & Exhibition its theme: **Beyond Production – The Fertilizer Industry Transformation Summit**.

Three days, eight technical sessions

- **Day one** of the three-day conference will cover **Strategy & Technology Direction**
- **Day two** turns to the installed production base with an exploration of **Operational Excellence & Asset Optimization**
- **Day three** concludes by looking squarely ahead with a focus on **Digitalization, Safety & Future Technologies**.

The conference opens on Tuesday 3rd November with an executive keynote panel discussion. This will bring together leaders from prestigious global technology licensors, engineering houses and conference host JPMC. The wide-ranging debate will cover: the fertilizer asset base of 2035, licensing and capital discipline in a decarbonising market, the growth in low-carbon ammonia technology, and the next MENA investment cycle.

A programme of more than twenty presentations across eight technical sessions over three days will highlight the following:

- **Ammonia and syngas technology** – with presentations covering large-scale ammonia synthesis, high-performance metallurgy in the revamping of steam methane reformers and next-generation nitric acid production using pure oxygen.
- **Industry engineers will find dedicated coverage** of critical urea equipment, the performance of digitally-enabled production plants and granulation screening.
- **The energy and low-carbon agenda** ranges from decarbonisation of the phosphate industry, to steam and power integration across JPMC's Aqaba complex, and the commercial implications of regulatory changes (CBAM, ETS and RFNBO) for regional fertilizer producers.
- There will be a spotlight on **artificial intelligence (AI)**, as it moves from promise to practice, with AI-based reformer optimisation, computational fluid dynamics in plant design, and real-time greenhouse gas (GHG) monitoring.

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AFA International Technical Conference & Exhibition

Beyond Production:
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November 3 to 5, 2026
Amman, Hashemite Kingdom of Jordan

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WELCOME MESSAGE

PHOTO: AFA

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

"The global fertilizer industry stands at a historic pivot point. We are no longer defined solely by tonnage and capacity. The new era is defined by intelligence, sustainability, and value creation across every nutrient that feeds the world.

"The Arab Fertilizer Association (AFA) is proud to present its 38th International Technical Conference & Exhibition, taking place in the dynamic capital of Amman. Hosted by global leader Jordan Phosphate Mines Company (JPMC) in a kingdom whose mineral wealth spans the phosphate of its mines and the potash of the Dead Sea, this year's summit moves 'Beyond Production'.

"We are gathering the industry's brightest minds across the full nutrient spectrum. From the decarbonization of ammonia and low-carbon nitrogen, through the smart mining and beneficiation of phosphate rock, to the recovery of potash from the mineral-rich brines of the Dead Sea and the precision delivery of balanced NPK in the field, we are rewriting the rulebook on efficiency and decarbonization.

"Here, smart mining, green manufacturing, and digital intelligence converge to redefine how the world is fed. Join over 500 industry leaders to shape the roadmap for a low-carbon, high-efficiency future for nitrogen, phosphate, and potash alike."

Saad Abou El-Maaty, Secretary General, Arab Fertilizer Association.

PHOTO: WILLIS THOMAS/CRU

CRU will attend, exhibit and present at the event under a media partnership with the AFA.

- A dedicated **process safety management session** will close the programme, alongside a global fertilizer market outlook from a leading market intelligence house.
- Fittingly for a conference held in Amman, the programme also **embraces both phosphate and potash production** – placing both pillars of Jordan's mining industry on the same stage.

The choice of host sponsor is also apt. Established in 1949, **Jordan Phosphate Mines Company (JPMC)** spans the entire phosphate value chain – from the Eshidiya, Al-Hassa and Al-Abiad mines to the integrated industrial complex at Aqaba, where Jordanian rock is transformed into phosphoric acid, diammonium phosphate (DAP) and a growing portfolio of value-added fertilizers.

Jordan's high-purity, low-cadmium phosphate rock reserves are a genuine competitive asset. This is more true than ever at a time when cadmium limits in phosphate import markets are tightening and carbon taxation, such as the EU's Carbon Border Adjustment Mechanism (CBAM), is redrawing trade flows.

These themes will be explored in the dedicated host session **From Rock to Product: The Phosphate Value Chain**. This will bring together international technology licensors, process specialists and the host sponsor JPMC. A deep dive into the performance of wet-process phosphoric acid production, merchant-grade acid (MGA) logistics and downstream product diversification is promised.

An industry celebration

The conference is equally a celebration of people in the industry:

- The AFA Awards will be presented during the opening ceremony.
- A gala dinner hosted by JPMC promises Jordanian hospitality at its finest.
- While the closing session will review AFA's year of technical activity – through its committees, working groups, workshops and webinars – and announce the host of the 39th edition.

Amman awaits you!

Amman is a capital city that combines millennia of continuous civilisation with one of the region's most forward-looking industrial sectors. It is also only an hour's drive from some of the world's most significant phosphate deposits.

For an industry wishing to look beyond production, AFA's message is straightforward: when its comes to the transformation of the fertilizer industry, attending the 38th International Technical Conference & Exhibition in Amman is an invitation to lead it from the front row. ■

For programme information and registration, sponsorship and exhibition enquiries contact events@arabfertilizer.org. See page 17 for further information, or visit the website: technical.arabfertilizer.org/

The rise of predictive maintenance

Brett Binnekade of Bagtech International highlights how the implementation of predictive maintenance with artificial intelligence (AI) is improving the efficiency and reliability of fertilizer blending and bagging plants.

Fertilizer blending plants typically involve multiple stages including raw material handling, blending, bagging and distribution. Motors, gearboxes, conveyors, weighing devices, mixers and packaging lines must all work together in perfect harmony – to meet precise nutrient formulations and packaging standards.

Even minor mechanical issues can stall the production of blends, disrupt the supply chain and jeopardise product uniformity. Many blending lines are also run in 'just-in-time' mode with zero stock holding, raising the stakes even higher.

PHOTO: BAGTECH

Bagtech International's customised blending, coating and bagging machines are equipped with 'Industry 4.0' online control systems that monitor the complete process in real time, allowing the user to change settings from anywhere in the world.

Why predictive maintenance?

Historically, two basic approaches to fertilizer plant maintenance have prevailed:

- Firstly, **reactive maintenance** where repairs occur after failure. This approach can lead to extended downtime and safety risks, especially when a single component's breakdown causes a production line stoppage.
- Secondly, **preventive maintenance** based on scheduled checks or fixed usage intervals. This pre-empts some failures but can cause unnecessary downtime and replacement of parts, if maintenance intervals are set too conservatively. Conversely, if intervals are too long, unexpected failures can then occur.

Overall, unplanned downtime or sub-optimal maintenance scheduling can be financially crippling for plant operators, given the tight operational window for fertilizer blending and bagging, particularly during peak agriculture seasons. This has led to rising interest in predictive maintenance.

Definition and core principles

Predictive maintenance uses real-time and historical data, alongside artificial intelligence (AI) and machine learning models, to predict potential equipment failures before they happen. Instead of relying on rigidly timed maintenance checks, it schedules maintenance using accurate condition-based insights. These are derived from:

- **Sensor data:** vibration, temperature, acoustics and other parameters continuously measure equipment health.
- **Operational data:** current and voltage signals from variable speed drives (VSDs), plus load and throughput information.
- **Predictive algorithms:** advanced analytics detect anomalies and forecast the remaining useful life of critical components.

By identifying subtle performance deviations, predictive maintenance empowers operators to service machinery at precisely the right time.

Benefits for fertilizer blending plants

Predictive maintenance can deliver a range of operational improvements at fertilizer plants, including:

- **Reduced downtime:** anticipating problems means scheduling repairs during planned outages, mitigating abrupt production stoppages.
- **Improved equipment utilisation:** components are replaced only when necessary, extending their operational life.
- **Consistent quality:** optimally functioning mixers, weighers and bagging lines maintain precise nutrient ratios and package weights.
- **Cost savings:** lower parts consumption, fewer emergency repairs and stable production schedules all drive down costs.
- **Enhanced safety:** early fault detection mitigates the risks associated with running failing machinery.

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Next-level condition monitoring with AI

AI and machine learning can also translate data into actionable insights. While condition monitoring has existed in some form for decades, AI-based predictive maintenance significantly elevates its capabilities. Large volumes of sensor and operational data, gathered from neural networks or support vector machines, can be continuously monitored and analysed to detect evolving failure patterns. In this way, AI can catch early warning signals that may be too subtle for standard threshold-based monitoring systems.

Data integration and processing

PHOTO: BAGTECH

Computerised monitoring at a fertilizer blending and bagging plant.

A successful predictive maintenance system relies on robust data. These need to be collected, transmitted, stored and modelled.

- **Sensor and drive data collection:** fertilizer plants can deploy sensors on motors, gearboxes, and conveyors to measure variables such as vibration, temperature and pressure. Additionally, Bagtech collects data directly from variable speed drives (VSDs). By monitoring real-time current and voltage trends, this provides important information about motor load, electrical spikes and inefficiencies.
- **Data transmission and storage:** modern plants often rely on programmable logic controllers (PLCs) and supervisory control and data acquisition (SCADA). These systems transmit sensor and drive data to databases or cloud platforms for processing.
- **Machine learning models:** in machine learning, historical data associated with past failures can be used to train the models, enabling them to recognise the symptoms of future failures. These models then generate alerts or recommendations based on trends that deviate from normal baselines.

Challenging blending plant conditions

Despite the promise of AI, operators must overcome a number of environmental hurdles at fertilizer blending plants.

- **Dust and corrosion:** fertilizers are often hygroscopic and corrosive. Sensors and equipment therefore need to be rugged. Frequent cleaning or calibration may also be necessary.
- **Variable operating conditions:** blending different fertilizer grades changes mechanical loads – requiring the AI model to adapt to different operating states accordingly.
- **Legacy equipment:** integrating new sensors and data-gathering technologies into older machinery can be complex. Wireless industrial internet of things (IIoT) solutions can ease this process, although consistent connectivity must be ensured.

Essentials for an AI-driven approach

Predictive maintenance strategies hinge on:

- **Modular sensor kits:** easily deployed vibration, temperature and other sensors on critical blending and bagging components.
- **Drive-based data:** capturing current, voltage, torque and speed signals from variable speed drives to identify anomalies without installing additional dedicated sensors in certain areas.
- **AI models tailored to fertilizer operations:** years of fertilizer process knowledge inform predictive algorithms, making them highly relevant to blending, bagging and material handling steps.
- **User-friendly dashboards:** real-time alerts, condition analytics and maintenance schedules are centrally displayed, providing straightforward insights for operators.

> **Predictive maintenance uses real-time and historical data, alongside AI and machine learning models, to predict potential equipment failures before they happen.**

Practical implementation

The implementation of predictive maintenance at a fertilizer blending and bagging plant requires the following steps:

- Sensor and data strategy
- Connectivity and processing
- Algorithm development
- Workforce training.

CASE STUDY: MOTOR MONITORING WITH VARIABLE SPEED DRIVE (VSD) DATA

In a pilot project targeting key blending motors, Bagtech utilised both vibration sensors and VSD data. By correlating current and voltage trends with vibration signatures, the system identified early-stage bearing wear and alignment issues.

When deviations appeared in motor current draw at certain load points, the AI module cross-referenced vibration data to confirm potential faults. Maintenance personnel received timely alerts, enabling them to replace bearings before a catastrophic breakdown.

This proactive intervention increased the blender's uptime, improved product consistency and reduced repair expenses. ■

Companies can adopt a dual approach for collecting sensor data. While dedicated sensors remain crucial for detailed vibration and temperature monitoring, the mining of VSD data can maximise information on existing plant systems. This strategy keeps hardware costs manageable and accelerates the introduction of predictive maintenance through:

- **The identification of critical assets:** motors driving conveyors, mixers, and bagging machines are prime targets, along with gearboxes and high-wear components.
- **Sensor deployment:** for components showing frequent failure or extreme operational conditions, direct vibration or temperature sensors provide detailed 'granular' data.
- **VSD integration:** by reading current, voltage and torque signals from drives, the system can detect changes that suggest mechanical or electrical stress.

For data connectivity and processing, operators can choose a cloud-based approach, ideal for large, geographically dispersed

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operations, or an edge-based approach for real-time results on-site. In either case, the data need to flow seamlessly into the analytics engine, where AI models detect anomalies. Key considerations include:

- **Network reliability:** fertilizer plants often operate in harsh or remote environments, making robust networking crucial.
- **Scalable architecture:** as more equipment is added or new data streams become available, the system needs to be scaled-up without performance issues.
- **Data security:** safely managing intellectual property, operational integrity and cybersecurity risks is paramount, especially when external networks or cloud solutions are involved.

For algorithm development, Bagtech starts with supervised learning, using historical records of failures to label data. Over time, semi-supervised or unsupervised methods can uncover subtle, previously unidentified fault indicators. Regular retraining ensures models remain current when operational conditions shift, new fertilizer grades are processed, or equipment undergoes modifications.

Workforce training is essential because predictive maintenance only succeeds if maintenance staff trust and understand the system's insights. Training can be provided to help operators:

- **Interpret alerts:** recognise the severity of an alert and understand recommended actions.
- **Perform proactive repairs:** conduct interventions ahead of failures, extending component lifecycles and preventing line stoppages.
- **Document outcomes:** input feedback into the system, refining machine learning models with each real-world event.

Predictive maintenance – benefits and returns

Predictive maintenance offers blending plant operators a plethora of production improvements, due to its ability to:

- Minimise downtime
- Optimise maintenance costs
- Maintain product quality and safety
- Strengthen competitive position.

Predictive maintenance allows operators to schedule interventions during planned breaks or off-peak production periods. This reduces unplanned outages by as much as 30%, enabling manufacturers to meet demanding production schedules more reliably.

Predictive maintenance achieves cost savings in several ways, including fewer emergency repairs, decreased spare-part inventory and improved labour allocation. Plant maintenance driven by real-time conditions has two key benefits. Firstly, it avoids replacing components prematurely and, secondly, it prevents the early signs of imminent failure being missed. Consequently, total maintenance expenses can drop by as much as 15-30%, depending on plant size and complexity.

Product quality is affected by inaccurate blending. This can occur when materials are fed at inconsistent rates – due to motor or gearbox stress, product build-up or blockages. Predictive maintenance, by detecting such irregularities early, stabilises production, preserving the precise nutrient formulations demanded by modern agriculture.

Additionally, preventing equipment failure helps maintain a safer working environment, aligning with strict safety and environmental regulations.

> **AI and machine learning can translate data into actionable insights. While condition monitoring has existed in some form for decades, AI-based predictive maintenance significantly elevates its capabilities.**

Finally, predictive maintenance translates into a more consistent, high-quality product output and fewer supply chain disruptions, both essential for customer satisfaction. In a market where fertilizer supply timing can affect crop yields, reliability offers blending plant operators a formidable competitive advantage.

The future of maintenance – going beyond prediction

Predictive maintenance itself is a stepping stone to more advanced approaches to maintenance involving:

- Digital twins and prescriptive maintenance
- Augmented reality (AR) and connected workers
- Integration of activities up and down the value chain.

In future, digital twins – virtual replicas of physical equipment – could be used to simulate machine behaviour by integrating sensor and VSD data with physics-based models. This would then enable advanced 'what-if' analysis. If a mixer motor shows impending wear, for example, operators could use a digital twin to model the impact of slowing production throughput and adjust blending sequences until repairs can be scheduled.

As AI techniques evolve, prescriptive maintenance will accurately pinpoint maintenance windows and provide details on the likely cost implications and/or production risks.

In future, AR headsets could allow maintenance personnel to receive real-time instructions, visualise hidden components, and share live equipment data with remote experts. This would help to reduce repair times and errors, particularly for intricate blending towers or large-scale bagging lines.

Predictive maintenance data from blending plants could also inform upstream and downstream activities in different parts of the value chain. This would allow fertilizer producers to coordinate shipments with distributors, based on predicted plant throughput, helping to optimise fertilizer supply chains by improving on-time delivery and reducing storage or handling costs.

Conclusions: the pathway to resilient fertilizer blending

As global demand for fertilizer grows, balancing efficiency, reliability and product quality has become ever more critical.

Predictive maintenance driven by AI, and powered by robust data from sensors and variable speed drives, offers a transformative approach. Fertilizer blending plants that implement these strategies can reduce their downtime, trim operational costs and consistently deliver products that meet stringent nutrient specifications.

Through real-time condition monitoring, actionable analytics and well-prepared maintenance teams, fertilizer manufacturers can seize new efficiencies and opportunities. In a climate where achieving maximum throughput and reliability is paramount, predictive maintenance stands out as both an operational advantage and a strategic imperative.

By embracing AI-powered solutions, fertilizer blending and bagging plants can secure their future in an increasingly demanding agricultural landscape, one where data and technology converge to optimise productivity and drive sustainable growth. ■

INDUSTRY 5.0 – A PERSONAL VIEW FROM FRED COELHO, CEO, BAGTECH INTERNATIONAL

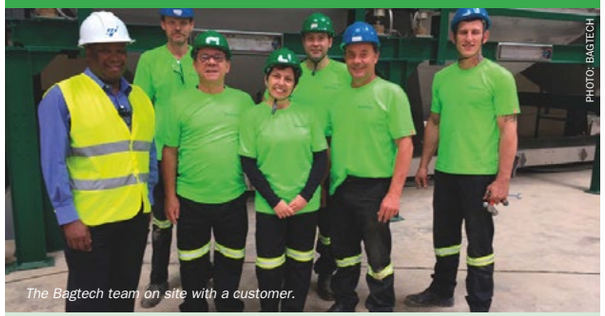
PHOTO: BAGTECH

The Bagtech team on site with a customer.

A few years ago, we spoke about how Bagtech International was integrating Industry 4.0 into our fertilizer blending and bagging plants – focusing on automation, data visibility, traceability and smarter plant control (*Fertilizer International* 504, p38).

At the time, it meant:

- Advanced PLC/SCADA integration
- Real-time production data
- Remote diagnostics
- Intelligent dosing and weighing systems
- Improved plant efficiency through smarter design.

Today, that foundation is firmly in place. But the conversation has shifted. We are now moving beyond Industry 4.0 – into Industry 5.0.

For us, Industry 5.0 is about:

- Human-machine collaboration – empowering operators, not replacing them
- AI-driven predictive maintenance and plant optimisation
- Cloud-based production intelligence and customer data portals
- Sustainable engineering through efficient material use and energy optimisation
- Smarter lifecycle support across Africa and beyond.

It's as much about resilience, intelligence, and human-centred engineering as it is about automation. Ultimately, incorporating Industry 5.0 into the blending plants we build also means they operate as future-ready production systems. ■

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Next-generation nitric acid production

The NX Stami™ Nitrates Total Recycle concept represents a significant step forward in nitric acid technology. By replacing air with oxygen and continuously recycling nitrogen, the process simultaneously lowers CAPEX, reduces OPEX, increases steam export and virtually eliminates N_2O emissions. **Paz Muñoz** of Stamicarbon (Nextchem) outlines its key advantages.

PHOTO: STAMICARBON

Visualisation of an NX STAMI™ Nitrates Total Recycle plant.

Nitric acid producers, like many industries globally, face increasing pressure to modernise their production technology – in pursuit of lower emissions, higher efficiency and reduced operating costs. Stamicarbon, the nitrogen technology licensor of Nextchem (MAIRE Group), has developed a new solution that addresses all three challenges simultaneously: the NX STAMI™ Nitrates Total Recycle concept.

This concept uses pure oxygen and continuously recycles nitrogen, unlike conventional nitric acid plants which rely on atmospheric air as the oxygen source. The result is a significantly simplified plant configuration with lower capital investment, reduced energy consumption, and near-zero N_2O and NOx emissions.

Conventional nitric acid production

Nitric acid (HNO_3) remains a crucial chemical intermediate in fertilizer production. Approximately 80% of global nitric acid production is dedicated to the fertilizer industry, where it is used to manufacture products such as calcium ammonium nitrate (CAN), fertilizer-grade ammonium nitrate (FGAN) and urea ammonium nitrate (UAN).

Production is based on the well-established Ostwald process. Ammonia is oxidised over platinum-rhodium (Pt-Rh) gauzes in the presence of excess oxygen:

$$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$$

The nitrogen monoxide (NO) formed is further oxidised:

$$2NO + O_2 \rightarrow 2NO_2$$

Nitrogen dioxide is then absorbed in water to form nitric acid:

$$3NO_2 + H_2O \rightarrow 2HNO_3 + NO$$

Conventional plants obtain their oxygen from atmospheric air, with a composition of 21 mol% oxygen and 79 mol% nitrogen, a process that inevitably requires the compression of large volumes of nitrogen. This is subsequently decompressed and discharged as tail gas, typically at a ratio of around 3,250 Nm^3 of nitrogen per tonne of HNO_3.

Nitrogen is essential at nitric acid plants as both a heat buffer and for safe burner operation. But its continuous compression and decompression contributes significantly

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to plant complexity and energy consumption, due to the extensive use of energy-intensive rotating equipment.

The Total Recycle concept

The NX Stami™ Nitrates Total Recycle concept (Figure 1) eliminates the need for continuous atmospheric air supply. Instead, the process only consumes two raw materials – ammonia and oxygen – while nitrogen circulates continuously within the system.

In this concept, nitrogen is added only during startup and then remains in the process loop during normal operation. Importantly, air compressors and tail-gas expanders used in the conventional process are excluded from the design as they are no longer necessary.

One of the most innovative aspects of the Total Recycle process is the introduction of oxygen through the bleaching column. Here, oxygen serves as the stripping medium for removing dissolved NOx from the nitric acid product. The oxygen-rich gas leaving the bleacher is routed back through the process, where it promotes NO oxidation and overall process efficiency.

The recycled gas mixture – which contains oxygen and nitrogen in similar proportions to atmospheric air – is compressed in a recycle compressor, mixed with ammonia, and sent to the burner. Ammonia oxidation then proceeds in the conventional manner over Pt-Rh gauzes.

Nitrous oxide formed on the gauzes is decomposed to nitrogen and oxygen over a secondary catalyst:

$$2N_2O \rightarrow 2N_2 + O_2$$

Process gas is subsequently cooled with the heat recovered used in high-pressure steam production.

Valuably, the Total Recycle process recovers all the available high-grade process heat as steam. It is no longer necessary to reheat tail gas before atmospheric release – because none is generated. Instead, only a very small purge stream (<0.02 tonnes per tonne HNO_3) is required to prevent nitrogen accumulation.

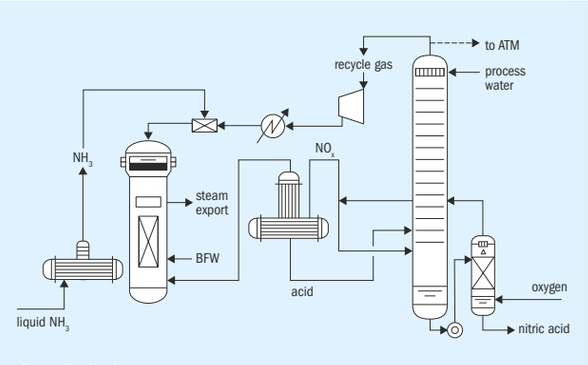
Simpler equipment, lower costs

The key advantage of the Total Recycle concept is process simplification. Several major pieces of equipment can be eliminated or significantly reduced in size, including the compressor train, oxidation/absorption column, tertiary NOx/N_2O abatement reactor and tail-gas heating system.

The Total Recycle concept eliminates the need for a compressor train, as neither air compression nor tail gas expansion is applied. Additionally, the oxygen-rich process conditions accelerate NO oxidation to NO_2, allowing the oxidation/absorption column to be almost 50% smaller than those used in conventional technologies.

The absence of continuous tail-gas discharge also eliminates the need for a tertiary abatement reactor. At the same time, steam export increases substantially – because process heat is no longer consumed in tail-gas reheating.

Fig. 1: **Stamicarbon's NX Stami™ Nitrates Total Recycle process scheme**



Source: Stamicarbon

Synergies with green ammonia

The Total Recycle concept is particularly attractive when integrated with green ammonia production.

In 'green' and 'pink' ammonia plants, hydrogen is produced via electrolysis, generating oxygen as a by-product. Much of this oxygen is produced at elevated pressure – and can therefore directly supply the nitric acid plant without additional compression. Additionally, oxygen generated as a by-product from the air separation unit (ASU), used to supply nitrogen for ammonia synthesis, can also be used in the Total Recycle process.

The total oxygen demand of this nitric acid process is approximately 1.04 tonnes O_2 per tonne of HNO_3 produced.

Near-zero N_2O emissions

Nitrous oxide remains one of the most significant environmental concerns in nitric acid production. With a global warming potential approximately 273 times greater than CO_2, N_2O emissions carry both environmental and financial consequences. In the European Union, where CO_2 emissions are subject to a penalty of approximately €88 per tonne (as per January 2026), emitting one tonne of N_2O costs around €24,000.

A conventional nitric acid plant without abatement typically emits approximately 6 kg N_2O per tonne HNO_3 (100%). Even plants equipped with highly efficient tertiary abatement technology typically emit around 0.120 kg N_2O per tonne HNO_3.

The Total Recycle concept addresses the issue differently. Instead of relying solely on end-of-pipe treatment, N_2O is fundamentally mitigated at the source through a secondary catalyst positioned beneath the Pt gauzes. Since there is virtually no continuous tail-gas discharge, overall N_2O emissions are reduced to near-zero levels.

CAPEX and OPEX benefits

Economic evaluation of the Total Recycle concept has demonstrated substantial savings. These are driven primarily by elimination of the equipment mentioned above, combined with the simplification of piping and civil works. Compared with conventional nitric acid plants, CAPEX reductions, assuming oxygen is received in a pressurised state, can reach:

- 34% compared to a conventional 325 tonnes per day (t/d) mono-pressure plant
- 25% compared to a conventional 1,000 t/d dual-pressure plant
- 26% compared to a mono-pressure plant including oxygen compression
- 7% compared to a conventional 325 t/d mono-pressure plant when a dedicated ASU is required.

> **"The Total Recycle concept offers a compelling pathway for fertilizer producers seeking both economic and environmental advantages, while supporting the industry's transition toward a more sustainable future."**

The concept remains financially attractive even in the case where an ASU is fully dedicated to supplying oxygen to the nitric acid plant – showing a lower capital investment than both a conventional mono- or dual-pressure plant.

Operating costs are also significantly reduced. Compared with Stamicarbon's already highly efficient mono-pressure technology, the Total Recycle concept offers lower ammonia consumption, lower cooling water demand, and steam export exceeding 1,200 kg per tonne HNO_3. Electricity consumption is also reduced significantly – cutting this from approximately 85 kWh to 22 kWh per tonne HNO_3 for a mono-pressure plant operating with an electromotor, for example.

Overall OPEX reductions of up to 25% are achievable with the Total Recycle concept, when compared to conventional Stamicarbon technologies, with OPEX savings rising to 30% or more compared to other nitric acid technologies available on the market.

Alternative applications of oxygen

In cases where the full Total Recycle concept cannot be fully implemented, two alternative approaches are available. One option is a partial recycle concept, which reduces emissions and enables smaller equipment.

Enriching secondary air, normally used as a stripping agent, with available O_2 in the bleaching column is another option. This is a practical route, particularly for plant revamps, as the compressor can be repurposed to supply more primary air to the burner, delivering an increase in plant capacity without significant investment.

Looking ahead

The NX Stami™ Nitrates Total Recycle concept represents a significant step forward in nitric acid technology. By replacing air with oxygen and continuously recycling nitrogen, the process simultaneously lowers CAPEX, reduces OPEX, increases steam export and virtually eliminates N_2O emissions.

Combined with the growing availability of oxygen from green ammonia production, the concept offers a compelling pathway for fertilizer producers seeking both economic and environmental advantages, while supporting the industry's transition towards a more sustainable future. ■

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Royal EMT – the family company with a truly global reach

European blending, bagging and handling equipment company EMT became Royal EMT in July this year. The 'Royal' designation was granted to the company in its 100th anniversary year by King Willem-Alexander – in recognition of EMT's outstanding contribution to the economy of the Netherlands and its international standing. **Zico Zeeman**, Royal EMT's Commercial Director, talks to *Fertilizer International* about what's been a proud and momentous year for the business and his family.

Royal EMT is celebrating a special milestone in 2026: the 100th anniversary of the official registration of the Zeeman family business. A business that started in 1913 with a grain mill in the small town of 't Zand in the province of North Holland, the Netherlands, has since grown into one of the global fertilizer industry's leading machine manufacturers.

This evolution has been overseen by five generations of the Zeeman family (*Fertilizer International* 491, p14). A focus on innovation, international markets and satisfying its customers needs, says Royal EMT, has enabled the company to continue growing over the decades while remaining a true family business.

The family's 4th generation, brothers Gustaaf and Janco, joined NJ Zeeman Diervoeders as directors in the mid 1970s and went on to found European Machine Trading (EMT) in 1989. Zico Zeeman became the 5th generation of the family to enter the business when he joined the company in 2016.

PHOTO: ROYAL EMT

Three generations of the Zeeman family receive the 'Royal EMT' designation from the local mayor at a special event in July

Both local and global

Royal EMT – which is today still located in 't Zand in the Netherlands – specialises in the development, manufacture and installation of blending, bagging and handling equipment for the fertilizer and other bulk industries. The company has installed over 650 machines in more than 85 countries worldwide.

Royal EMT is proud of its 35+ years of Dutch manufacturing excellence, with extensive capabilities ranging from standalone machines to complete and fully-automated blending plant installations. The company's equipment portfolio notably includes its custom-built flagship Weighcont continuous blender.

Recently, we sat down with **Zico Zeeman**, Royal EMT's Commercial Director, to discuss the 100th anniversary year, the history of the family business – and the future of both the company and fertilizer blending, bagging and handling.

Proud of its past and ready for the next 100 years

Firstly, Zico, CRU and *Fertilizer International* magazine would like to congratulate the Zeeman family and Royal EMT on reaching its landmark 100th anniversary and its prestigious royal designation. **How did the designation come about and how did you celebrate?**

"We received the Royal designation, which is an incredible honour for both the family and the company, as a crown on what we do. We have now also completely

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updated our logo – a new design with the crown included – so that's really nice.

"It is, of course, a hugely proud moment, both for the family and employees. The reactions we've had from suppliers and customers have been really heartwarming as well.

"You don't just get a royal designation by being around for a 100 years. You have to do a lot of work upfront to apply for it. We had to prove to the king's team we were a good quality company, responsible for a lot of business here in the Netherlands, and were internationally known as a trustworthy partner and an advocate for the country – a lot of our customers abroad wrote recommendation letters.

"To celebrate, we had the open day in July so everybody could visit the factory. We showed our production process from sales all the way through to software, electrical and mechanical engineering.

"Afterwards, we had a big ceremony where the mayor of our municipality came. We got all the family and the workers on stage and, as a kind of celebration, everybody got a book we'd written about 100 years of the Zeeman family business and EMT."

PHOTO: ROYAL EMT

Royal EMT has been commemorated in a book as part of the company's 100th anniversary celebrations.

Five generations of transformation and growth

Royal EMT's home is the North Holland community of 't Zand ('the Sand') within the municipality of Schagen. This is part of the world-famous tulip-growing heartland of the Netherlands – a traditional landscape of open fields, waterways and windmills (*Fertilizer International* 436, p20). **Could you explain to our readers the amazing origins and history of the company?**

"We were founded in 1913 by my great-great-grandfather, the first generation, who bought a windmill already located here in 't Zand to mill grain and wheat for farmers and for bakers. He also started production of animal feed. That windmill was really the basis of our company.

"In 1926, his son came into the business, registered it as an official company and mechanised the windmill. From 1926 onwards, we put a diesel motor on the milling equipment so we didn't have to rely on the wind anymore. We went from supplying farmers and customers around our area and started to expand and expand.

"Later on, my grandfather came into the company in 1952. He was really an entrepreneur and led the company for almost 40 years. In 1987, he took two dictionaries, a Dutch-English and an English-Dutch dictionary – because he didn't speak much English – and went to the United States to visit three blending equipment manufacturers.

> **"The Royal designation is, of course, a hugely proud moment, both for the family and employees. The reactions we've had from suppliers and customers have been really heartwarming as well."**

"That's where our partnership with Doyle started. From there, we started to develop our own high-speed blending and bagging machines. In 1988, we had our first sale with Doyle, and became their European partner, later their African partner, and we also started European Machine Trading.

"Because we had 100s of electric motors running in our animal feed factory, we had lot of experience in the production of machines, as well as being knowledge about fertilizers. We combined all that and started to introduce our own blending and bagging machines into the market – next to machines from Doyle whom we still represent– and from there started to grow.

"Later on, we renamed our factory 'EMT, Manufacturer of Blending, Bagging and Transport Equipment'. We started to grow our market, first into West Europe and then East Europe after the fall of the Berlin wall. African sales also started early on, and we are in Asia, South America, Australia and New Zealand as well.

"Royal EMT is now a global supplier all over the world. At the moment, we have more than 650 machines installed in more than 85 countries worldwide.

"Gustaaf and Janco Zeeman are like the fathers of EMT. Together they really built up the machine manufacturing business. They are actually the first generation machine manufacturers and I'm the second generation. Gustaaf focused more on the sales side and Janco on the technical side.

"We stopped animal feed production, grain storage and fertilizer selling about 10-15 years ago and completely refocused the company on machine manufacturing. We shifted away from being a local animal feed and agri-dealer to being the global agricultural industry equipment producer we are today."

Blending gets bigger, more automated and precise?

Going back to the early 1990s, a typical EMT machine had an average capacity of 30 tonnes per hour. Today, blending units with ten times that capacity are available. This has been accompanied by increasing adoption of 'Big Bags' (FIBCs) in markets such as Europe. High volume blending and bagging has also become increasingly automated. Precision agriculture and demand for site-specific NPK formulations also require increasingly customised blends. **Royal EMT has been at the vanguard of many of these advances in blending over the last 30 years – what have been key trends in your view and how has the company innovated in response to these?**

"Our machine company has really been based on continuous development, continuous improvement and, by speaking with customers, making new machines to suit their requirements.

"We see a big shift in Europe – and we also see that coming up in Africa and South America too – towards more coating of fertilizers. In Europe now, urea with an inhibitor coating is almost standard.

"We've been really focused on adapting and improving our machines for fertilizer coating. That includes making portable coating machines, small skid-like units, that are easy to move and can be placed at different locations. That means you can move the machine to your product instead of moving the product to your machine.

"In-line coating is also interesting. It's quite a new development where we add liquids onto one type of product before it is blended.

"With in-line coating, there's one-time handling of the product. It goes from coating into the blend and then into the bag. So, there's a lot less deterioration of your product and dust accumulation.

"We're also doing a lot of retrofitting of existing machines. Big steps have been made in the last few years to improve output and blending accuracy.

"We have machines that are 25-30 years old now that are still working correctly mechanically. We can upgrade these with the newest software and by installing add-ons like in-line coating units. That gives us a blending and bagging machine capable of meeting today's requirements, instead of what it was bought for 30 years ago.

"We also see more projects coming up with higher capacities. For example, the last project we did for Koch in Australia is a 300 tonnes per hour blending line with liquid adding, screening, then bulk handling and truck filling capabilities.

"We're seeing more centralised blending points, with 'Big Bag' handling and a higher output capacity. We have increased our machine design to match those larger capacities, with blending lines of up to 400 tonnes per hour, for example."

PHOTO: EMT

A new, double-line, high-speed 'Big Bag' unit installed by EMT in South America earlier this year.

Made in the Netherlands

Royal EMT has stayed true to its roots by remaining a proud Netherlands-based equipment manufacturer. **How has machine manufacturing at your 't Zand base changed in recent decades and has this required investment and expansion of your local fabrication capabilities?**

"In the last five years, we've built two new production halls. This has doubled our production capacity.

"We are a European manufacturer. There are challenges that come with that. But, by staying a local, family-owned company, we can ensure that we have minimal personnel changes. Almost everyone at our factory works here for a long time – it's a good professional team – and that keeps the in-house knowledge we have.

"Some people working here have more than 30 years experience in manufacturing and production. That's very important for us. But there's also young talent coming in, especially in our engineering department where in 10 years we've moved from two to eight staff.

> **"Royal EMT is now a global supplier all over the world. At the moment, we have more than 650 machines installed in more than 85 countries worldwide."**

"In recent years, we bought a new laser cutting system to cut our own stainless steel and a new, easier metal bending system with less welding. That enhances our production capabilities by increasing the speed of people's work and enhancing the factory's efficiency.

"If we can manufacture efficiently, we can also stay price competitive. Our main focus at the factory is therefore to enhance efficiency and ensure we have the right processes for speed of manufacturing. That's something we've got really good at, and is one of our major qualities, I would say.

"Plus, we now design all our electrical panels and software ourselves, all the fabrication and design are completely in-house. We don't have external contractors putting margins on top of our equipment.

"Keeping everything in-house also makes the quality of the machines very easy to control. If there's an issue it's easy to improve because we are all working in the same building."

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ISSUE 534
SEPTEMBER-OCTOBER 2026

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The complete package

With its in-house team of mechanical, electrical and software engineers, Royal EMT provides producers worldwide with reliable and flexible machines. All systems are assembled and tested in the Netherlands, with international installation and remote services provided by the company's own technicians. **Looking back at previous articles, is the delivery of complete turnkey blending plants becoming an increasingly important part of Royal EMT's business?**

"In turnkey installations, it's not just the blending and the bagging that we focus on. It is the complete handling of fertilizer in a building. It starts from intake systems, where you have ships, trains or trucks coming in with bulk or bagged fertilizers.

"How are your raw material coming in, what quality do you need, how do you unload, do you need to have some conditioning, screening or breaking? From there, you move into warehouse filling systems, loading equipment, the type of blending and all the handling up to bagging. Then, how does the blended product go out – is it in bulk, is it in 'Big Bags', is it in small bags? It's that complete package.

"Dust protection systems are also becoming more common to protect people working in the factory. With our experience of complete handling facilities, we can also assist with that."

PHOTO: ROYAL EMT

Royal EMT's factory was crammed with visitors during its open day in July.

New markets, new innovations

Royal EMT has always been a very forward-looking business. As well as being an innovator in blending and bagging machines, the company has pioneered new markets, having been heavily involved in the development of the African fertilizer industry, for example. **Over the next decade where do you see market growth potential – and what will the blending plant of 2036 look like in your view?**

"We see big improvement possibilities in Africa. The lowest fertilizer use per hectare is in Africa – so, there's still big growth potential for African countries. Some big players are investing in Africa at the moment and we've got a couple of big projects for various African countries on our hands.

> **"We have 25-30 years old machines that are still working correctly. We can upgrade these to give us a blending and bagging machines capable of meeting today's requirements – instead of what they were bought for 30 years ago."**

"Africa is mapping the soil and, because customers then know what they want, the targeted supply of fertilizer blends is growing there. We therefore see possibilities to expand in Africa as well as in South America.

"In Europe, there's a lot of centralisation, larger companies setting up major hubs, and, of course, the move into coated fertilizers with a lot of coating machines. These are either standalone coating machines or coating machines connected to blending units. That's a trend all over the world.

"I think there will still be a market for small, local blending and bagging equipment close to the farmer, especially with more market uncertainty about the availability of fertilizer products.

"Blending is still a hot topic. I think it will remain so because of growing knowledge about crop requirements and soil nutrients. That makes blended products of even more interest to farmers.

"Machine wise, there's a shift to more autonomous control and smart software systems, These are highly efficient and precise in their blending recipes with very high quality output. That's something we're continuously improving.

"We are using AI in the factory now with a dedicated server for in-house AI development of our machines. We're also using AI for the development of the control software of our machines, allowing them to acquire the correct data, learn and make decisions. That's going to be more important in future." ■

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PHOTO: CRU/SIMON INGLETHORPE

IFA 2026 Annual Conference

Delegates from across the globe gathered in Monaco for the 2026 International Fertilizer Association (IFA) Annual Conference, 29 June – 1 July. We report on the programme highlights from this year's three-day flagship event.

Monaco old town.

Delegates could be forgiven a sense of déjà vu on arriving at the Fairmont Hotel, Monaco. This was the venue for the International Fertilizer Association (IFA) Annual Conference for the second year in a row. The event had been due to take place in Abu Dhabi in early May but was postponed and adeptly rearrangement by IFA due to the ongoing Middle East Conflict.

Fertilizers – the crisis behind the crisis

IFA's CEO **Alzbeta Klein** set the scene for this year's annual conference in an excusive editorial for the May/June issue of *Fertilizer International* magazine. In an opinion piece titled 'The crisis behind the crisis: why fertilizer belongs at the heart of the food and energy conversation', Alzbeta argues that energy, food, and fertilizer are three faces of the same system (*Fertilizer International* 532, p4).

"The Strait of Hormuz made that visible to everyone in March – and it sets the agenda for Monaco at the end of June," she wrote.

Alzbeta continued: "When that waterway came under threat in March, the world saw an energy crisis. Yet it was also a food security crisis with a thirty-day delay built in. And linking the two was a fertilizer crisis.

"Five Gulf countries – Iran, Qatar, Saudi Arabia, the UAE, and Bahrain – together accounted for 34 percent of global urea trade in 2024, 23 percent of global ammonia, and 18 percent of ammoniated phosphates. The Strait, in other words, is not just one chokepoint. It is three: oil, gas, and the fertilizers those feedstocks build."

IFA has been in dialogue with the UN International Maritime Organization (IMO) and the G7 Food Security Taskforce in recent months. Alzbeta is both passionate and eloquent in pressing for recognition and equal status for fertilizers alongside energy.

"The point we made is simple, and we will keep making it: keeping fertilizer moving through contested waters is not optional if food systems are to function. We have urged the IMO, flag-state authorities, and the marine insurance regime to recognise fertilizer cargo as essential trade alongside energy cargo, so that risk premia and routing decisions reflect that designation. And we have asked governments to resist the reflex to ban exports – a reflex that, every time it has been tried, has deepened the crisis it was meant to contain," she argues.

This is theme IFA returned to in Monday's opening session in Monaco.

Securing the fertilizer lifeline

Fertilizers are not merely an agricultural input, according to **Alzbeta Klein**, IFA's CEO. Opening the conference, she said: "They are a strategic resource, a key part

PHOTO: IFA

IFA's CEO Alzbeta Klein opens the event.

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of the food system that supports billions of people. They're truly a lifeline – hence the title of the conference."

When that lifeline is threatened, the consequences are not abstract. "They show up in food prices, in import budgets, in decisions that farmers take when they plant crops," Alzbeta said.

Early intervention on supply disruption is necessary, in her view.

"When this problem shows up in a food bank, it is way too late. The fertilizer industry keeps the product moving: through disruptions, through uncertainty, through market conditions that no one planned for. That is not a small thing – it deserves to be recognised," Alzbeta said.

She went on to set the theme for the week.

"What we are here to discuss this week is how we keep doing what we do, but better and more sustainably, and in a world that is not going to be less complicated. I am very much looking forward to all the conversations ahead," Alzbeta summed up.

The risks of a one-two punch

In the conference's opening session, **Clayton Allen**, Eurasia Group's Practice Head, United States, reviewed the panoply of risks to the world economy.

"At Eurasia Group, we specialise in geopolitical risk analysis. That's the question we strive to answer every day. We look at this from a number of different perspectives. I focus on the United States – it's the area I specialise in – however, we take a global perspective," Clayton said.

"Unlike a decade ago, the United States is viewed not as a force for global stability, or the safest market, but increasingly as the largest driver of global volatility," he suggested.

"Each year, Eurasia Group puts out our *Top Risks Report* at the beginning of January – essentially the 10 things we think are going to define the year to come. Each year, we rank these in order of the biggest risk to the least substantial within that top 10. For the last several years, the United States has been number one or two," Clayton said

This year, Eurasia Group warned of 'political revolution' within the US – although not in the sense of government overthrow.

"I mean it in terms of changing drastically, fundamentally, the way that the United States functions, both internally and in the world at large. Our view is that President Trump is trying to change every facet of US governance, every facet of the US's role on the global stage. More importantly, though, we think that ultimately that [attempt] is unsuccessful," Clayton said.

Looking ahead on tariffs, he said that fertilizer industry should expect the US administration to try and solidify many of the presidential trade deals struck in 2025.

"You're going to see a focus on the creation of a tariff regime that's durable and defensible in law. Everyone's used to waking up and seeing that tariff rates against some country have changed massively overnight – 10% tariffs become 100% tariffs, 100% tariffs become zero – that's not going to happen anymore," Clayton said.

"[Instead,] the US is switching towards a different legal structure for its tariffs that the administration can defend more easily in court. What you should take away from this is that [while] tariff volatility as a major cost or headwind for business decision-making is actually going to fade a little bit, the tariffs themselves become more durable.," he added.

Looking ahead at global risks into next year, Clayton highlighted the following:

"The war in Iran is likely to be a backdrop of lingering risks for everything else that we see. There will always be a risk that that war reignites. Shaky deal or not, we think that the GCC [Gulf Cooperation Countries], the Middle East, is going to be a more volatile place to do business moving forward," he said.

The greatest risks confronting the global economy right now might not even be conflict-related, in his view.

"The slowing of the jet stream across the Atlantic, the looming El Niño formation in the Pacific. These are things which will exacerbate water stress, climate stress, and food cost and price stress in the US, Europe and other economies," Clayton said.

He went on to warn that these uncontrollable natural risks could act to amplify the more controllable geopolitical risks in a 'double whammy'.

"Those natural trends come after several years of trade volatility, conflict volatility, price increases related to the closure of Strait of Hormuz, disruption of the Red Sea, restriction of exports from Ukraine. This one-two punch is something that I think a lot of policymakers have not internalised, [but] it is it's something that you in the audience know better than most – you see this coming years in advance," Clayton said.

The US administration and Congress discounts these geopolitical risks – erroneously in his view – seeing them as largely being 'in the rear view'.

"What they don't think about is that disruptions to ag chemicals through the Strait of Hormuz have now exceeded 90 days. They will impact crop planning, not just for this year, but for next year, possibly the year beyond," said Clayton.

"They think about the fact that, yes, food prices, grain exports have become more expensive. What they don't think about is that crop yields are potentially going to be reduced because of restricted access to input chemicals, increased input costs, but also by weather trends and patterns that they cannot control," he added.

Underlying risks will also remain, even as supposed stability resumes.

"This is a story that likely gets worse, even as you see the direct points of volatility we can control become more stable. Trade will be more stable, the Iran conflict may be over, you're going to see the Russia-Ukraine conflict potentially trend towards a less destructive path. That doesn't mean that risk goes away," said Clayton.

While warning that fertilizers were entering a period where they will be especially exposed, he said the industry also had a vital role to play in the way that governments respond.

"If you want to reach out to policymakers, make your case in the US and elsewhere, now is the time to do so," Clayton said, as US policymakers are generally receptive to dialogue with the industry, in his view.

"Most people we speak to in Congress, they don't understand these issues. But they would be very open to hearing from you exactly what risks to expect, exactly what risks are going to be coming for them," Clayton concluded.

From just-in-time to just-in-case

A follow up debate chaired by Alzbeta Klein featured the following industry panellists alongside Clayton Allen:

- **Karina Gistelinck**, President of Asset, Potash, BHP
- **Bruce Bodine**, CEO and President, The Mosaic Company
- **Stepan Yashin**, CEO, FertiStream.

"Today's panel brings together leaders from companies who span a full breadth of the fertilizer value chain, from resource extraction to production to distribution and services. Each has had to make consequential decisions over the past few months," Alzbeta said.

PHOTO: IFA

Clayton Allen of Eurasia Group gave the opening conference keynote.

She started by asking the panel about what has changed, and what has been required of them as leaders, over the past 12 weeks?

"I think what has really changed – I wouldn't say in the last 12 weeks, but probably in the last 12 months – is that volatility is something that the fertilizer industry was used to as an acute disease. From time to time, you would get a flare-up of volatility. I think now it has become a chronic disease or a chronic opportunity. It's structural and it's in everything we do," said **Karina Gistelinck**.

"BHP typically focuses on building the most efficient value chain, which we still want to do. On top of that we want to make it very resilient and flexible. So it's all about building that resilience into the value chain – and the spoiler alert is you can't do that alone. You need to work throughout the value chain with partners, with customers, with people in logistics, as well as building optionality or flexibility in the value chain," she added.

Volatility and extreme disruption have become the new normal, according to **Bruce Bodine**.

"I don't know that it's chronic and permanent [as] it seems unsustainable. Something has to give, as there will be real consequences if fertilizer underapplication due to this extreme disruption continues to happen. So advocacy, education is something we continue to do," he said.

Within the value chain, partnerships on market access and supply agreements are going to be key, Bodine suggested, both for building resilience and providing agility.

Some events remain hard to predict, though.

"We have experienced, in my 32-year career in this industry, extremes that we never imagined. In boardrooms and management teams, I know you do these ERM, Enterprise Risk Management exercises. If you did, I'd love to see who would have predicted what has happened over the last three to four months as a real outcome that you were preparing for. We were not – and I don't know many who were," Bodine said.

"At IFA, how we see this is: we have built a world for ultimate efficiency. All of you have built companies for just-in-time efficiency and the world has changed. It's became a world of just-in-case. I believe that just-in-case is a lot more expensive than just-in-time – I wonder who's going to pay for it?," said **Alzbeta Klein**.

Having strategic conviction was what mattered for Karina Gistelinck. That's because BHP's 10-20 year investment cycle will always transcend the 2-4 year political cycle.

"Strategic conviction matters more. Yes, you need to build for the just-in-case, but you need to build for the just-in-case that is aligned with your strategy. For BHP, we actually doubled down on our conviction that potash is one of the most critical pillars for food security," she said.

"[It's about] strategic conviction, discipline and execution. Once you've made a strategic choice, stay the course and be very disciplined and frugal on your execution, but make sure you do it right. Last but not least, build optionality in your value chain through partnerships – because you don't know what the just-in-case will be," summed up Karina.

Stepan Yashin describes the last three months as having been "a complete mess" from a trading point of view.

"In the past, we had efficient markets and it was relatively straightforward [as trade] flows were more or less stable. Now the market is fragmented with one-fifth of the flow going the opposite direction from what it used to be in the prior year," he said.

Consequently, costs are going up for companies that transport crop nutrients.

"What I can definitely tell you is the cost of execution is going to be higher because of freight. It's not just how many vessels flow out, but how many vessels enter the Strait of Hormuz. The cost structure is going up. We know that because this is the just-in-case scenario," Yashin said.

"You're sitting in the Strait of Hormuz and you, or the shipping companies that own the vessels, are paying charges. What our friends in the Gulf are doing, transferring nutrients via different routes, that costs money. Those trucks going to [the Red Sea port of] Yanbu cost money. So we do know that the industry's cost structure is fundamentally changing," he concluded.

Coping with structural and inherent disruption

This session featured presentations from:

- **Nicolas Michelon**, Managing Partner, Algan Partners
- **Jean-Patrick Caumont**, Director, Eyssautier-Verlingue
- **Anne-Sophie Corbeau**, Global Research Scholar, Center on Global Energy Policy, Columbia University
- **Pierre-Marie Aubert**, Director, Institute for Sustainable Development and International Relations (IDDRI).

Nicolas Michelon described the war between the US and Iran as an asymmetric 'David vs Goliath' struggle. Using trade, finance and information as weapons, Iran has the ability to wage war and significantly weaken the United States, in his view,

"Militarily speaking, Iran has lost, cannot win. Yet from day one of this new conflict, on February 28th, they have already won, because they can keep fighting the way they fight now for much longer – which the United States and Israel cannot do. You have 'grey zone' tactics – actions in the space between diplomacy and actual military conflict – this is what we are entering into now," Michelon said.

Insurance nowadays is becoming a financial tool, according to **Jean-Patrick Caumont**.

"Honestly speaking, as an insurance broker today, we are more a strategic partner, we are more a risk architect – together with you, rather than only being an intermediary as we were before. The nature of risk has changed and, actually, that's really the point," he said

Up to five years ago, cargoes, vessels and warehousing were mainly at risk from

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the weather. That has now completely changed, Caumont suggested.

"We've got sanctions, cyber attack, political violence, port congestion [risks] – and eventually detention due to sanctions or export bans. So insurance is no longer only protecting cargo, it protects your commercial continuity," he said.

Anne-Sophie Corbeau compared the on/off closure of the Strait of Hormuz to Schrodinger's cat.

"We don't really know whether it is open. It's a little bit like Schrodinger's cat – which is anywhere between alive and dead. Well, the Strait of Hormuz is anywhere between open and closed," she said.

Anne-Sophie expects a massive 'third wave' of liquid natural gas (LNG) capacity to arrive between 2025-2030.

"The third LNG wave is more than 400 billion cubic meters. Just to give you a comparison, global LNG trade in 2026 was about 600 billion cubic meters. So this is absolutely gigantic and is going to come to the market at some point," she said

"The only question is really about what extent that Qatari capacity is going to be completed and whether the Strait of Hormuz is open or not. That, of course, is something very difficult to predict – but we are moving towards a massive amount of LNG on the market," Anne Sophie added.

Consequently, she expects the US to become an even more dominant LNG exporter.

"You probably don't really appreciate how dominant US LNG has become. It is already, by far, the largest LNG exporter [with] a quarter of global LNG exports. But if you look at everything which is under construction, that [share] is going to be more than 30%," Anne-Sophie said.

Pierre-Marie Aubert urged EU policymakers to do better with crop nutrient interventions targeting three specific areas – which he described as "three pillars".

"In a nutshell, we have three pillars: securing access [to fertilizers], enhancing [nutrient use] efficiency and investing in circularity [of food systems]. We need to create synergies between those three areas of intervention," he said.

On access, Pierre-Marie said demand mandates could create a market for (and secure investment in) decarbonised fertilizers. Levelling the playing field by reviving the 2010 'halve nitrogen losses' target could also spur EU member states to invest in circularity, in his view. Lastly, linking these three 'pillars' with food sufficiency policies could also play a crucial role in reducing the overconsumption of animal protein in OECD countries, he suggested.

PHOTO: IFA

IFA's Laura Cross presented a condensed yet highly informative medium-term market outlook.

Market outlook 'wrap up'

Laura Cross, IFA's Market Intelligence Director, gave a 20-minute whistle-stop tour of the Association's latest five-year supply and demand outlook, including her take on current market conditions. She focused mainly on the demand picture.

"Nitrogen consumption remains one of the absolute fundamentals for farmers. As we get towards the end of the next five years, we expect population growth and [agricultural] productivity gains to return to being some of the most important drivers – and that's the same for phosphorus and potassium as well. When you look at the requirements in the coming five years and beyond, we do need to see continued growth in the application of those nutrients as well," Laura said.

"In the short term, the disruption in the Strait of Hormuz is clearly not fully resolved, and we've seen that have multiple impacts, both for producers and for consumers. First of all, we continue to see raw material and freight cost disruptions. Sulphur vessels [for example] are really starting to pass through the Strait now. But sulphur prices are still at record highs – so, even if availability has returned, the cost pressure is still there," she added.

When it came to the current US-Iran peace accord, given that more than two million tonnes of fertilizers and fertilizer raw materials were stranded inside the Strait of Hormuz at one point, Laura advised delegates to mark the 16th August as a date to watch in their calendars.

PHOTO: CRU

CRU distributed the May/June conference editions of Fertilizer International, Nitrogen+Syngas and Sulphur magazines to delegates in Monaco.

"To move towards a deal that could [see] a managed resumption of flows, I think it's important for us to remember that the two countries have 60 days to make that arrangement. So we need to look ahead to the middle of August – because that's where we're likely to see either a resumption in flows [through the Strait of Hormuz] at a much more normal rate or potentially going back to some of the disruption we saw before," she said.

> **"Fertilizers are a strategic resource, a key part of the food system that supports billions of people. They're truly a lifeline – hence the title of the conference,"**
>
> **Alzbeta Klein, IFA**

Cybersecurity for the fertilizer industry

The official conference programme closed by looking at a very different kind of fertilizer supply risk – cybersecurity. The session looked at what it takes to keep both products and data moving safely from plant to port to field.

Volker Andresen, IFA's Sustainability Director and session chair, suggested that cybersecurity is now a core part of supply chain resilience as fertilizer operations become more connected and exposed to new risks, such as from AI-enabled systems, for example.

Volker's conversation with **Lee Edge**, founder of GRC Edge, had a clear message for leaders: cyber risks have moved from being a technical challenge to an operational resilience issue.

Lee warned that the gap between the speed of technological development and the speed of organisational response is widening. "Organisations don't fail [on cybersecurity] because of one bad decision. They fail because they make yesterday's decisions in tomorrow's world," he said.

Supply chains are becoming more digital, more automated and more dependent on systems that organisations may not fully see, map or test, according to Lee. "Every connection we create also creates a dependency," he said.

For business leadership, this raises practical questions, in his view, such as:

- Where are we already behind?
- Where is AI being used across the organisation?
- Which critical operations would fail first under pressure?
- Do your teams know how to lead if disruption happens tomorrow?

Volker closed the session with three key takeaways:

- Cyber resilience is now a leadership challenge, not just an IT issue.
- There is no permanent security solution: resilience comes from companies continuously adapting.
- For the industry to continue to thrive, leaders in companies need to build a culture of awareness about, and resilience to, cyber threats.

Overall, the fertilizer industry needs smarter supply chains with stronger cybersecurity safeguards, governance and awareness, Volker concluded.

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Fertilizer INTERNATIONAL
COVER FEATURE

Prayon – a company built on quality, innovation and trusted partnerships

Prayon is both a pre-eminent provider of process technology (Prayon Technologies) and a leading equipment supplier (Prayon Profile) to the global phosphate industry. Notably, the company also manufactures phosphate products of exceptional purity for high-value agricultural, technical and food applications. In an exclusive interview, *Fertilizer International* spoke to **Tibaut Theys**, General Manager, Prayon Technologies, ahead of the Arab Fertilizer Association's Technical Conference in Amman, Jordan, in November.

Phosphate industry pre-eminence

Tibaut, it's a pleasure speaking with you. Prayon Technologies is synonymous with excellence and innovation in phosphoric acid production globally. Could you provide our readers with a brief overview of the company?

"The core values of Prayon Technologies are: we deliver very high-quality products, we deliver in time and we work together as a team with our customer. These are Prayon's values.

"Our other big values are trust and transparency. Trust is really the key to what we are doing and means customers are confident about the technology we are selling.

"We also build long-term partnership by being transparent with our customers. We behave with openness and integrity and are very clear about the characteristics of all our products – and would prefer to lose an opportunity rather than sell the wrong product.

"What's also very important about Prayon is that we are a producing company. What we offer our customers – based on 70 years of operating experience in Belgium – is technology by producers, for producers.

PHOTO: PRAYON

Tibaut Theys, General Manager, Prayon Technologies.

"Providing producers with the certainty they need to operate profitably is also very important to us. I believe it is one of the keys to our success.

"We offer customers the most reliable phosphoric acid technology – plant online time is very critical for us; performance is also critical for us. Producers with our technology also use proprietary items from Profile [Prayon's equipment division] at their plants. That also means we are increasingly focused on ease of maintenance.

"As a technology provider, we define ourselves by offering the best solution to our customers. Excellence is one of the targets we try to achieve. This can be seen with the five phosphoric acid processes Prayon has developed.

"Slowly but surely in the last decade, we have come to offer – not only dihydrate (DH) phosphoric acid technology – a variety of other processes that answer the specific needs of our partners, such as producing high quality gypsum, reducing their water consumption and having the ability to use low-grade rock.

"We have 130 plant references in 30 countries across the world. That matters because it shows that we are providing high quality designs and are building on the lessons learned from the past to improve our technology today.

"It's really about capturing our experience from every single phosphoric acid plant to be better for the next one. That's important because it means we can guarantee our customers a very high confidence level for project success if they work with us.

"The assurance of a successful project also means their bank financing will be accepted because Prayon is a recognised technology. Management can also be certain they will generate revenue from day one of start-up.

"Every phosphate rock contains different quantities of impurities and behaves differently. Having worldwide experience with 65 validated phosphate rock types is therefore really essential for us.

"We have developed a very large database on rock behaviour throughout the world. This knowledge means we really gain time when designing a phosphoric acid plant that's consuming a new type of phosphate rock – because just a limited number of pilot tests are needed."

PHOTO: PRAYON

Innovation: Prayon Technologies proved its magnesium removal process at the company's Technophos semi-industrial demonstration plant, Varna, Bulgaria.

Technology licensor, equipment maker and phosphate producer

Uniquely for the phosphate industry, Prayon is three companies in one, being a technology provider, equipment manufacturer and producer. Does the holistic nature of the business provide Prayon with both a depth of market understanding and a competitive advantage?

"Yes, Prayon is a phosphate producing company, has Profile as an equipment company, Prayon Technologies as a technology company and Praytech Maroc as a maintenance company. The expertise of our division, Prayon Technologies, is converting laboratory and pilot data into an industrial reality. That's really our mission.

"We have a team of expert process engineers at Prayon Technologies focused on that. The beauty is, my team knows exactly how to design an industrial plant. That means with our partner companies, straight from the laboratory tests at the beginning, we can design together an industrial plant with the highest confidence that it will work.

"As an example, Prayon has successfully developed and patented a magnesium leaching technology in collaboration with an industrial partner. The technology has been validated through pilot and industrial-scale testing and is now part of our licensing portfolio.

"For general licensing, one thing that's very important is that, with phosphoric acid, the technology itself is not extremely complicated. But at the same time you have lots of small details and know-how that needs to be well implemented during engineering, procurement and construction (EPC).

"We therefore need to have very strong and knowledgeable EPC partners whom we can work with to ensure the plant design is done perfectly. So that, once the plant is built, we're sure it's going to be a success with a quick start-up.

"For EPC, we have three general licensee partners we work with right now: De Smet Agro in Belgium, Ballestra in Italy and thyssenkrupp Uhde in Germany. We work in very close collaboration with all three – and that allows us to develop reliable solutions."

A growing technology portfolio

As the phosphate industry has evolved, Prayon Technologies has kept pace with the changing operating environment and new production challenges by innovating and expanding its process portfolio. What new technologies has the company brought to market in recent years – and what's been driving this?

"So, to be the best solution provider for our customers, innovation is one of the missions we gave to ourselves. That means we have either developed or have acquired new technologies. GetMoreP and DA-HF were developed by us, Ecophos and Puma were acquired, for example.

"These technologies provide our customers with specific advantages or valuable characteristics. GetMoreP and Ecophos, in particular, offer a very good way to valorise low-grade phosphate rock.

"The main advantage of Ecophos currently is the fact that it requires hydrochloric acid, not sulphuric acid. That makes a big difference as the price of hydrochloric acid is currently more competitive than sulphuric acid.

"The Ecophos process produces dicalcium phosphate (DCP), a very concentrated product with between 39-47% P_2O_5, depending on whether it's anhydrous or a dihydrate. From that, we can produce a very pure form of merchant-grade acid (MGA).

"This is 10 times more pure than standard MGA but 10 times less pure than purified phosphoric acid (PPA). That means it's an interesting starting point if you want to produce perfect battery- or fertilizer-grade monoammonium phosphate (MAP).

"From a sustainability viewpoint, we are also looking at the agronomical benefits of directly using DCP as a fertilizer. It's soluble in citric acid and partly soluble in acid soils.

"We know from the literature that DCP has been used as a fertilizer in the past. It has very controlled nutrient release and could be used directly on certain soils.

"The Ecophos process could therefore valorise low-grade phosphate rock to make a high P_2O_5 fertilizer without having all the energy needs of merchant-grade acid. Moreover, its water-soluble content can be easily increased in a controlled manner by a small nitric acid addition to make concentrated NP.

"I'm so impressed by the creativity of my Prayon team. That's what's fun and what I enjoy. I'm always waiting to see what they're going to invent for me today, which good ideas, crazy ideas they will come up with!

"I believe innovation creates innovation. In the sense that the more you know about the technology, the more you are able to create new technology. Essentially, the more we know, the more we can find a solution.

"In practical terms, the more you understand an issue entering into a new project, the more you're able to see how to solve it. It's about creating knowledge, a database, about how we can help our customers, about how we can provide value to our customers.

"Our team spends between 15-20% of their time just on innovative projects. Basically, most of the licensing fees we acquire are dedicated to developing new solutions.

"I believe that the people best positioned to develop innovative solutions

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and improve existing processes are the members of our own team. They are in direct touch with both the plants we have designed for customers and with Prayon's own production plant.

"This gives them a deep understanding of our customers' operational challenges and enables them to identify practical opportunities for improvement and develop solutions that address real industrial needs.

"Our team works closely with the engineering teams of our partners, as well as with our internal R&D experts. That's a unique position which allows them to bridge the gap between research and industrial application – transforming ideas and laboratory test results into robust, full-scale industrial solutions.

"As a result, our team's capabilities combine operational knowledge, engineering expertise and innovation. That makes them ideally suited to drive continuous improvement and advances in technology across our processes."

> "What's also very important about Prayon is that we are a producing company. What we offer our customers – based on 70 years of operating experience in Belgium – is technology by producers, for producers."

Leadership role on sustainability

Prayon was celebrated as circular economy pioneer during a recent visiting by Walloon government minister Yves Coppieters. Phosphogypsum reuse and the decarbonisation of phosphate production are also now being taken seriously at the highest levels in our industry. Prayon – and Tibaut personally – have been very engaged with this agenda. **Are you pleased with the leadership role of the International Fertilizer Association (IFA) on both circularity and decarbonisation?**

"Really it's a personal passion about phosphogypsum (PG). I am amazed by all that can be done with PG and how we can valorise it in different ways.

"In India, it's used a lot as a fertilizer additive – just look at Paradeep Phosphates Limited, PPL. They sell PG at a good price. Once it's granulated and mixed with other nutrients, it's a very good fertilizer.

"In Belgium, we generate a very clean phosphogypsum. That allows us to make plaster out of our PG and use it as a retardant in cement and as a soil conditioner.

PHOTO: CRU

Tibaut speaking passionately about opportunities for phosphogypsum reuse and the 'waste to inventory' agenda at CRU's Phosphates+Potash Expoconference in Paris in April.

"I believe the decarbonisation roadmap was a brilliant initiative from IFA and the European Bank for Reconstruction and Development (EBRD). It has valuable science-based recommendations about what we need to do to decarbonise our industry – and has also come up with different solutions that can be applied now or in the future.

"What's really remarkable is that, to some extent, if you want to decarbonise the phosphate and potash industry, there are many things that already exist if you look at current technology.

"Most phosphoric acid producers burn sulphur to make sulphuric acid and generate electricity. So, the industry already has a source of low-carbon electricity. Mining can also be improved by using more electrical equipment.

"If right now we want to build a zero carbon plant to make fertilizers like diammonium phosphate (DAP) and NPKs, without CO_2 emissions or using fossil fuels, all the technology exists. Is it feasible? – yes, it can be done. Is it economical? – I don't think so. The question instead is about the political willingness and the economics.

"There is certainly willingness in the phosphate industry. We want to give the best possible earth to the next generation. The difficulty is how to act on climate change today, without jeopardising business, and have a bright future for our children tomorrow.

"My personal conviction is that we will go much further on sustainability. One of the reasons is profitability. For example, if you look at phosphogypsum globally we generate five tonnes for every tonne of P_2O_5. Depending on the location, its quality and usage, this can be sold at an interesting price.

"If you stack PG it costs about $10 per tonne. But, if you can sell it hypothetically at $40, the revenue then becomes $40 minus the $10 disposal cost – bringing the total revenue to $250 per tonne of P_2O_5. It's sustainable and profitable.

"I believe the by-product fluorosilicic acid is going to be the next big thing the phosphate industry will be looking at; we need to do something. While many people right now are neutralising fluorosilicic acid, there are more valuable possible applications, such as valorising it to make hydrofluoric acid (HF), DCP or other products."

MENA region partnership

The Middle East and North Africa (MENA) region remains a major hub globally for phosphate production and investment. What are the key partnerships for Prayon within the region?

"The majority of the world's phosphate reserve are in the region, starting in Morocco in this big curve going up to Saudi Arabia. So, definitely, all the Arabic countries are very important for us and the phosphate industry.

"Participating in and presenting at the Arab Fertilizer Association's Technical Conference is really key to what Prayon is doing. We can have very interesting and exciting discussions with people when we attend.

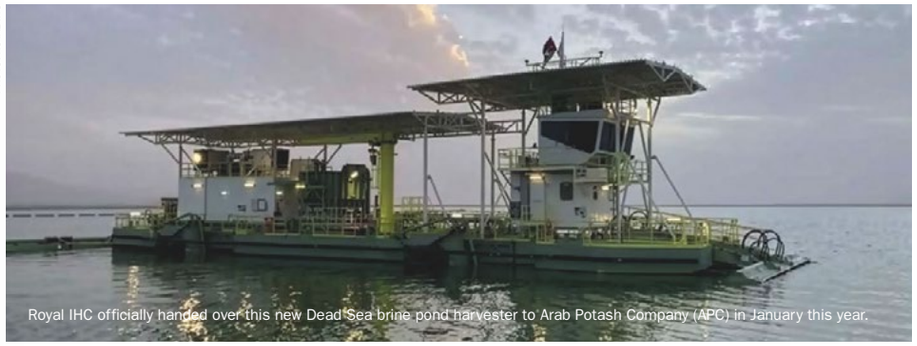
"We are absolutely convinced that it's very important to be able to collaborate with the AFA. We are developing together a workshop around phosphoric acid, here in Belgium in December, to present the latest technology and make it a success.

"I would even say it's an honour for us to be able to work with the top Arabic phosphate producers. It's our mission to provide them with the best possible technologies to feed the world." ■

Arab Potash Company plans its biggest expansion in 20 years

CRU's **Ashmita Sen** and **Humphrey Knight** visited Arab Potash Company's (APC) Safi production plant and its primary export terminal at Aqaba, Jordan, towards the end of 2025. The site visit was timely – as it coincided with the start of the company's largest capacity expansion in more than 20 years.

PHOTO: ROYAL IHC



Royal IHC officially handed over this new Dead Sea brine pond harvester to Arab Potash Company (APC) in January this year.

Introduction

Arab Potash Company (APC) launched a major strategic expansion in 2025. Known as the Southern Expansion Project, this involves a substantial enlargement of its Dead Sea evaporation pond network. It follows the conclusion of a decade-long production debottlenecking programme by the company.

APC typically operates very close to full capacity – unlike many of its larger potash producing peers. The planned 2030 entry date for its latest capacity expansion will, however, arrive as part of a global wave of new potassium chloride (muriate of potash, MOP) capacity additions. That could make maintaining current high levels of utilisation challenging for the company.

Current baseline capacity

Arab Potash Company is the world's eighth-largest MOP producer by effective capacity with this currently standing at just under 2.9 million tonnes per annum (t/a). APC operates an integrated production complex at Safi, just south of the Dead Sea (385 metres below sea level).

The company manages an extensive solar evaporation pond system on the Jordanian side of the Dead Sea (Figure 1). This covers around 120 km² currently and supplies harvested crude salts to three downstream processing facilities.

APC pumps brine from the Dead Sea into a cascading network of ponds. These use solar evaporation to progressively concentrate the dissolved salts. The solar ponds are continuously managed to promote carnallite ($KMgCl_3 \cdot 6H_2O$) formation using salt dredgers. These remove NaCl as water evaporates. Over time, this allows the upgraded brine to be directed to 11 carnallite ponds.

Once the required concentration is achieved, the resulting carnallite slurry is recovered from beneath the brine using specialised pond harvesters (Figure 2). The harvested slurry is then pumped via booster stations and floating pipelines to APC's refineries at the Safi production complex: the Hot Leach Plant (HLP) and two Cold Crystallization Plants (CCPI and CCPII), where it is processed into standard, fine and granular grade MOP.

About 90% of potash produced at APC's Safi complex is destined for export markets. Jordan's single maritime outlet, the Port of Aqaba, is APC's primary export

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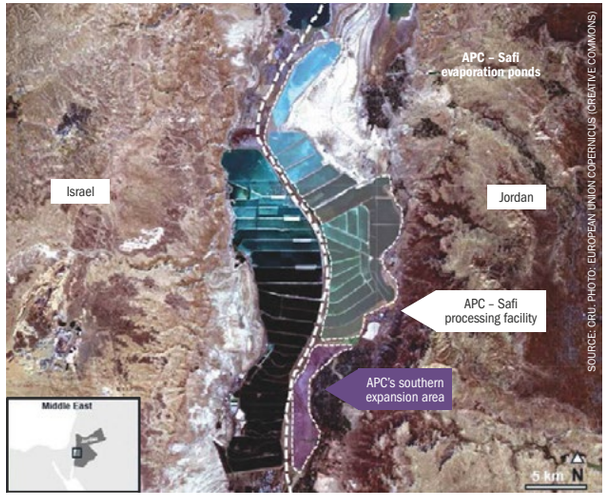

Fig. 1: Overview of APC's Dead Sea potash operations

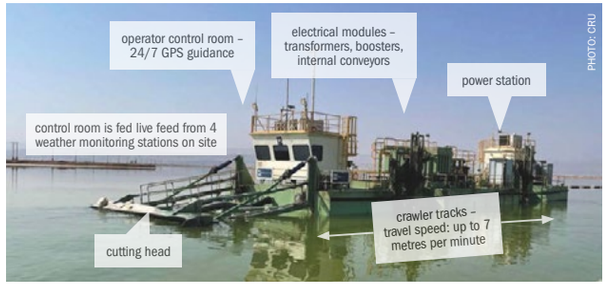

Fig. 2: APC's specialised harvester in operation on Carnallite pond-3 at Safi

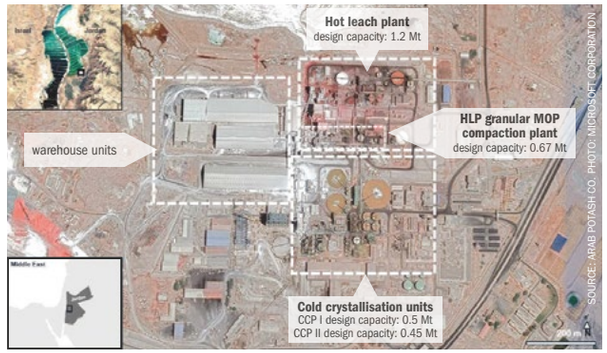

Fig. 3: APC's Safi processing plants

gateway, making the Safi-to-Aqaba logistics corridor a critical route to market. Finished product is transported predominantly by truck, a journey of around 220 kilometres, with a reported delivery frequency of roughly 110 truck movements per day.

On arrival in Aqaba, trucks are unloaded into two potash storage sheds for onward export: KCl 1 and KCl 2 – each with an effective capacity of around 390,000 tonnes. From storage, potash is transferred to shipping vessels via an extensive enclosed conveyor network. This links the sheds to the industrial port conveyor system for onward transport to the export berths. Around 124 port personnel are employed to support APC's shipping operations at Aqaba.

Additionally, a smaller share of production is delivered directly from Safi by road to serve Jordan's domestic market and nearby regional customers, including Saudi Arabia.

Role of JIPC at the port of Aqaba

Export shipments are executed through the Jordan Industrial Ports Company (JIPC), the industrial terminal operator at the Port of Aqaba. JIPC is a 50:50 joint venture between APC and Jordan Phosphate Mines Company (JPMC), a large regional phosphate producer, which also operates dedicated infrastructure for phosphate rock handling. The terminal occupies an area of 68,770 m² and is served by three cargo jetties (Figure 4). These fully serviced berths can each handle vessels up to 100,000 dwt and provide dedicated infrastructure for the bulk mineral and chemical trade. While APC and JPMC share the port's operational platform and capabilities each company markets and ships its products independently.

Why is APC scaling up?

Historically, APC's capacity additions have been periodic and stepwise, with the last major step-change associated with the commissioning of the second Cold Crystallization Plant (CCP II) in 2010. Since then, more recent production expansions have been largely incremental – driven primarily by debottlenecking, reliability improvements and operating discipline.

In 2020, Veolia announced that it was replacing existing crystallizers with its new HPD® crystallization technologies to expand production capacity "at a leading potash fertilizer plant in Jordan" (*Fertilizer International*

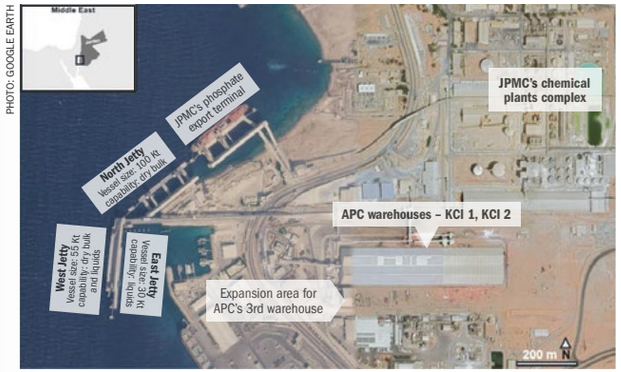

Fig. 4: Jordan Industrial Ports Company Aqaba complex

495, p12). Although APC was not named explicitly, the upgrades formed part of a contract "to modernize a refinery on the southern shores of the Dead Sea, to better process the carnallite feedstock and extract water-soluble potash fertilizer". These upgrades were part of company plans to increase potash production "from carnallite … pumped from the Dead Sea and evaporated in solar ponds", according to Veolia.

Against that backdrop, APC appears to have pushed the current system close to its practical capacity limit over the period 2019-2024, with operations running at consistently high operating rates. Site observations point to high operating efficiency and infrastructure renewals – particularly in the processing plants – suggesting there is now limited upside left from incremental fixes alone.

In that context, the strategic logic for expansion is straightforward. To materially increase potash output, APC needs more ore feed, brine processing and crystallisation area: i.e., more physical solar pond capacity. The company seems to have reached the end of the road on marginal gains, leaving expansion of the pond system as the primary option left to unlock the next stage of production growth.

What does the expansion roadmap look like?

Arab Potash Company has stated an ambition to increase potash production capacity to 3.5 million t/a in the medium term. This strategic expansion is underpinned by optimising the exploitation of its Dead Sea concessions. For example, the company's Eastern Expansion Project in the Dead Sea, concluded in 2025, is expected to deliver an uplift in annual production capacity of approximately 120,000 t/a in the medium term.

Looking ahead, APC's next growth lever is the Southern Expansion Project. This $1.1 billion strategic investment was inaugurated by Jordan's Prime Minister, Jafar Hassan, in a ceremony in May last year. The Southern Expansion Project involves the construction of new evaporation ponds, a state-of-the-art potash production plant and a granular potash unit. The project was slated to start in 2026 and is scheduled to be completed within four years.

Fig. 5: **APC's MOP output steps up in 2030 and beyond as new capacity lands**

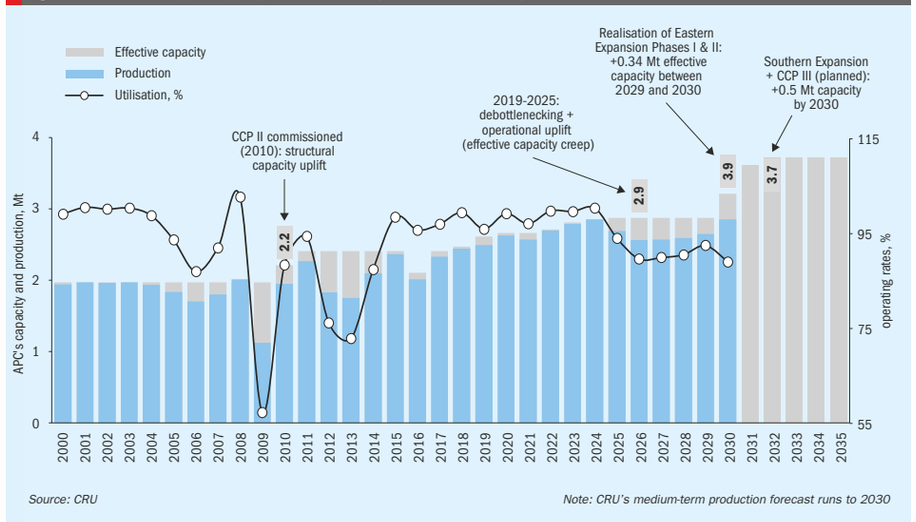

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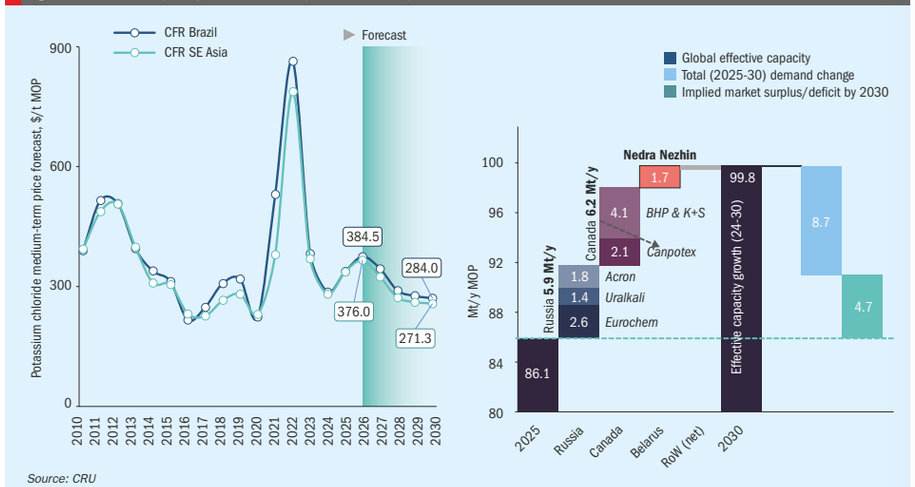
Fig. 6: **A wave of capacity additions will pressure MOP prices in the medium-term**



Source: CRU

APC was finalising the detailed engineering design, as of the end of 2025. The project is projected to add around 530,000 t/a of incremental capacity. CRU forecasts that the expansion uplift will be fully realised beyond 2030 (Figure 5), as the new capacity is expected to ramp up gradually, reflecting the staged commissioning of the additional pond area and associated infrastructure.

Post-expansion target operating capabilities

APC's principal expansion plans are anchored in its upstream front-end solar evaporation pond system. Yet delivering this growth will also rely on a parallel energy programme.

The company currently operates a gas-turbine power station (54 MWh), while a second on-site power station is under construction to support the transition from a 'grey' to a 'green' energy supply. This shift is particularly relevant for the current diesel-dependent dredging fleet. The new build is also intended to strengthen steam availability for process requirements, including supply to the HLP unit.

Alongside these strategic upgrades, ongoing renewal across associated infrastructure was evident on site during CRU's visit, with numerous processing assets appearing recently upgraded. From an operational standpoint, APC currently runs 11 carnallite ponds supported by nine harvesters. At the time of the visit, a tenth harvester was in procurement from Royal IHC to bolster harvesting capacity and align the brine harvesting operation with the planned MOP production ramp-up. This was subsequently delivered in January (see first page photo).

APC's expansions are not limited to the Ghor Al-Safi complex. A key ongoing investment is the construction of a third port-side warehouse at the Aqaba. This was nearly complete at the time of the visit and was expected to add roughly 450,000 tonnes of additional storage capacity before the end of 2025. Like KCl 1 and 2, the new warehouse will be dedicated to high-throughput, low-loss loading operations, and is fitted with dust extraction systems, stacking equipment, reclaimers and scrapers. Based on our observations during the site visit, operational efficiencies at the port are high, with minimal product loss observed during handling and ship loading activities.

> **"APC's expansion builds on a brine-based cost position that is among the most competitive globally. In theory, scaling the solar-pond complex should drive economies of scale and push APC further down the cost curve."**

Additionally, JIPC is undertaking a strategic expansion of the Aqaba industrial terminal through 2027. This is designed to lift total handling capacity to around 10 million t/a, supported by capital investment of JD145 million. The current expansion plan includes the addition of a third export line by 2026 – a threefold increase from the single ship-loading line originally operated at the port in 1994.

This new line will allow the terminal to load two granular potash vessels simultaneously, significantly improving throughput and reducing vessel waiting times. As part of the upgrade, two dedicated screening systems will be installed – one for each vessel.

A wave of capacity expansions

The potash market is set to absorb a wave of new MOP supply between now and the early 2030s. This will keep competition intense and price support limited.

APC will have to contend with additional traffic from a busy project pipeline led by Russian producers and major new projects elsewhere – including Nedra Nezhin (Belarus), Talitsky (Acron), Usolsky (EuroChem) and Jansen (BHP) (Figure 6). CRU expects global MOP output to rise from 75.6 million t/a in 2025 to 82.3 million t/a in 2030, with new capacity continuing to outweigh incremental demand.

The consequence is a forecast surplus of 4.7 million t/a of effective MOP capacity globally. For APC, the near-term implication is clear: there is limited scope for sustained upward price momentum while this surplus capacity persists. On the flip side, sustained lower prices should be advantageous for the company – APC being a lower-cost MOP producer – if this discourages higher-cost potash suppliers from serving long-haul export markets.

APC's expansion builds on a brine-based cost position that is among the most competitive globally. In theory, scaling the solar-pond complex should drive economies of scale and push APC further down the cost curve.

Conclusions

Having carried out significant production debottlenecking, Arab Potash Company has effectively exhausted the scope for meaningful low-capex optimisation. With operations at Safi historically running at high utilisation rates, the existing system is now close to its practical limit. Further growth therefore depends on one thing: physical expansion of pond area.

While APC's strategic logic is clear sighted, the timing of its capacity additions is perhaps less favourable – although this is mitigated somewhat by the company's competitive cost position.

Additional tonnes are set to enter a looser global potash market, as new capacity from Canada and the CIS outpaces demand growth through the second half of the decade. In that context, APC's expansion appears operationally necessary, but any economic upside is likely to be diluted by a more crowded and less supportive market.

In CRU's view, the Southern Expansion Project should strengthen APC's long-term operating position, but only after colliding with a weaker market backdrop.

Dive deeper

This article summarises the CRU Insight 'Arab Potash Site Visit: Jordan MOP producer plans biggest expansion in 20 years' published by our industry-leading *Fertilizer Week* news, analysis and pricing information service. Request a free demo here:

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For a deeper dive into the potash industry cost curve and market dynamics please contact the authors below.

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PHOTO: MOSAIC

Decarbonising the phosphate and potash industries

A roadmap on phosphate and potash decarbonisation, developed by ERM and Systemiq in collaboration with the International Fertilizer Association (IFA), was published in July. This highlights affordable near-term options – and the need to deliver more costly, deeper decarbonisation out to 2050.

Mosaic's Riverview phosphate plant, Florida, United States. The site celebrated its 100th anniversary in November 2024.

The global potash and phosphate industries have been offered practical, science-based guidance on greenhouse gas emissions (GHG) reduction in a newly-published roadmap. This covers the whole value chain, from raw materials and production through to transport, trade and agricultural use (Figure 1).

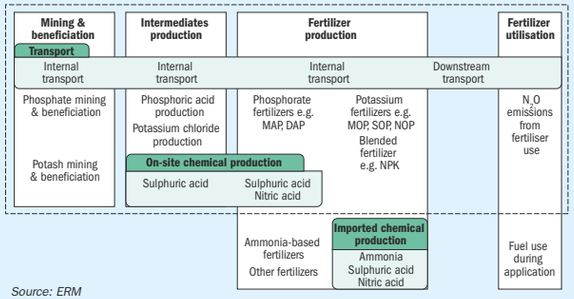
The roadmap – *Decarbonizing the Phosphate and Potash Fertiliser Industry* – sets out how these two sectors can cut their emissions in line with the Paris Agreement, while maintaining fertilizer affordability, supply resilience and food security[1]. It is an initiative of the European Bank of Reconstruction and Development (EBRD) and was developed by sustainability consultancies ERM and Systemiq in collaboration with the International Fertilizer Association (IFA).

The phosphate and potash sectors were consulted extensively about the roadmap over a nine month period, through a series of workshops, surveys, one-to-one consultations and reviews by an advisory group.

The roadmap is designed to help fertilizer producers, investors and policymakers assess both the near-term and long-term levers for decarbonisation and identify the enabling conditions for this transition. It also balances the trade-offs between the speed of action on decarbonisation versus its cost and the impacts on food system stability.

Deep emissions cuts by the potash and phosphate industries, while possible, will require shifts in production systems, regulation and infrastructure, according to ERM.

Fig. 1: **Scope of the phosphate and potash industries roadmap**



Source: ERM

Enablers of decarbonisation

The roadmap identifies four key enablers of phosphate and potash decarbonisation. These levers could deliver significant emissions reductions as part of a long-term transition, advises ERM, if technical, cost and policy barriers are removed:

1. **Low-carbon energy** underpins the system. For production, the use of renewable electricity, power purchase agreements (PPAs) and low-carbon heat are necessary to displace fossil-based power and steam, with alternative fuels playing supporting roles, where viable.
2. **Carbon capture and storage (CCS) and electrification** can also unlock process emissions reductions. CCS in phosphoric acid production in combination with targeted process electrification provide key routes for abatement of the sector's most complex emissions.
3. **Nutrient use efficiency** is the primary downstream lever. Precision agronomy, 4R practices (right source, right rate, right time, right place) and enhanced efficiency fertilizers (EEFs) can cut emissions without compromising yield or soil health.
4. **Non-sulphur production pathways** could become long-term strategic options. The diversification of phosphate production via alternative process pathways is being driven by rising competition from battery raw materials and heightened geopolitical volatility.

PHOTO: MOSAIC

Mosaic's Esterhazy potash mine in Saskatchewan, Canada, is currently the world's largest and most advanced.

The case for urgent action

Early action on decarbonisation by phosphate and potash producers will be critical, says ERM, to avoid long-term emissions from new assets and infrastructure. Acting sooner will also unlock extra investment, spur new technologies and help forge the partnerships needed to decarbonise the sector at scale.

The roadmap highlights several near-term measures that can help reduce production emissions. These include energy efficiency improvements, heat recovery, renewable electricity procurement and mining equipment decarbonisation.

Overall, ERM sees the roadmap as very much a positive that provides "an opportunity to boost competitiveness, resilience and food system stability". Achieving its objectives on decarbonisation will require:

- Coordinated action across industry, finance and government, underpinned by policy certainty, investment and deployment of low-carbon technologies.
- Agri-food companies, retailers and producers working closely together to create demand for low-carbon fertilizers and unlock decarbonisation investment.
- Investors scaling-up innovative funding mechanisms that support the transition.
- Policymakers providing clear long-term signals and the enabling infrastructure.
- Producers accelerating deployment of priority emissions reduction technologies.
- Standards setting that reduces fertilizer-related emissions while safeguarding agricultural productivity.

Richard Platt, partner at ERM, said: "By decarbonizing the phosphate and potash industry, we have a strategic opportunity to help drive a transition that strengthens competitiveness, resilience, and food system stability in a rapidly changing world. If we want a sustainability transition that can withstand geopolitical stress, the next phase must focus on real value chains, real risks, and real investment conditions."

Value chain emissions

Global emissions from phosphate and potash production and use totalled 448 million tonnes carbon dioxide equivalent ($MtCO_2e$) in 2024. These are divided between 94 $MtCO_2e$ associated with raw materials, 60 $MtCO_2e$ associated with production (15%), 7 $MtCO_2e$ associated with downstream transport and 287 $MtCO_2e$ associated with agricultural use (60%) (Figure 2).

Under business as usual scenarios, total phosphate and potash emissions are set to reach 553 $MtCO_2e$ per annum by 2050, an approximate 25% increase from today, with limited scope for efficiency improvements to offset rising demand.

Breakdown by industry

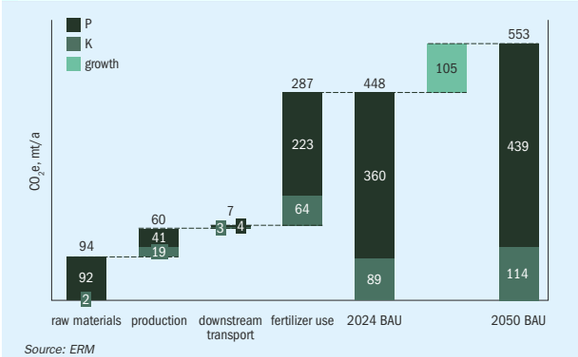
The value chains of the phosphate and potash industries contribute 360 $MtCO_2e$ and 89 $MtCO_2e$, respectively, to the present day emissions total of 448 $MtCO_2e$. Production emissions for both industries also differ as a percentage of total value chain emissions, making up a larger share for potash.

For the phosphate industry, production emissions account for 11% of total value chain emissions, with process emissions and electricity being the major hotspots. Emissions associated with phosphate raw materials (feedstocks) also contribute significantly.

Emissions from potash production, in contrast, make up 21% of total value chain emissions. These are dominated by fuel use and electricity consumption. Raw material emissions are generally less significant.

Ammonia can be a particularly significant contributor to raw material emissions for both industries. Ammonia production

Fig. 2: **Global phosphate and potash industry value chain emissions, 2024 versus 2050 under a business as usual (BAU) scenario**



Source: ERM

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emissions are, however, restricted to the manufacture of the sector's four main nitrogen-containing products: monoammonium phosphate (MAP), diammonium phosphate (DAP), compound NPKs and potassium nitrate (NOP).

Overall, although the proportion of phosphate and potash value chain emissions under direct producer influence is small, addressing these emissions is still of strategic importance, ERM advises.

"The impact of leaving production emissions unaddressed will increase the investment risks associated with producers as these emissions may increasingly translate into financial impacts on balance sheet/profit-and-loss statements and reduce their competitiveness as climate related regulations become more stringent," the roadmap states[1].

Reducing production emissions

The roadmap shows that an 89% reduction in phosphate and potash production emissions – from 60 $MtCO_2e$ to 7 $MtCO_2e$ – is technically feasible under a 'net zero by 2050' scenario (Figure 3). Achieving this would, however, require large-scale changes to production systems and regulation, and also involve significant economic and environmental trade-offs. Additionally, the technologies needed to decarbonise fuel use and address process emissions are at varying stages of maturity and would require demonstration and scale-up.

The roadmap highlights fossil fuel use, electricity use, process emissions, heat recovery and internal transport as the key areas for production emissions reduction, as these are under the operational control of phosphate and potash producers. In terms of fuel use, the consumption of natural gas or fuel oil in drying processes and diesel in mining equipment is most significant.

Electricity decarbonisation is a crucial lever for emissions reduction across both phosphate and potash production. For potash producers, decarbonisation of electricity is a particularly critical, given the industry's sizeable power and heat emissions.

Drying processes are a major source of fuel emissions, particularly for the phosphate industry. Rock drying require temperatures of up to 1,000°C, according to the roadmap, while fertilizer product drying temperatures are typically between 400-700°C.

Electrification is seen as a key lever for drying decarbonisation but only when combined with a changeover to renewable electricity. Fuel switching (e.g. sulphur, biomass or biomethane) is also an option. Looking ahead, the use of radio frequency drying, heat pumps, heat batteries and post-combustion CCS, as well as switching from froth flotation to electrostatic separation, may become viable in the long-term.

PHOTO: CRU

ERM's Daniel Saxton and IFA's Stephen Bell presented the initial findings of the decarbonisation roadmap at CRU's Phosphates+Potash Expoconference in Paris in April.

Mining equipment emissions can be reduced via operational efficiency improvements, fleet electrification using low carbon electricity, or by powering vehicles with low-carbon fuels such as hydrotreated vegetable oil (HVO). If feasible, transporting minerals and product materials on conveyors using renewable electricity or switching to slurry pipelines are other options.

In potash production, much of the fixed infrastructure is already electrified. That leaves the adoption of low-carbon power sources and the gradual electrification of diesel-powered mobile fleets as major mining goals. In phosphate production, which is typically based on open-pit mining, diesel-powered mobile equipment remains more common due to operational requirements. That makes fleet electrification, supported by low-carbon fuels, a key pathway for reducing emissions.

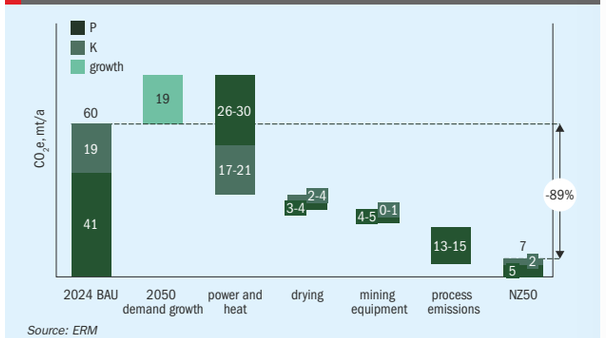
Electrifying the internal movement of phosphate and potash mining materials – by conveyors, electric haulage or rail – can further reduce emissions, subject to site-specific and logistical constraints.

Process emissions, especially those relating to phosphoric acid (CO_2) and nitric acid production (N_2O), can be addressed initially through abatement strategies and process efficiency improvements. Phosphoric acid is a key intermediate for phosphate fertilisers, while nitric acid is required for NOP production. These emissions sources are likely to represent the most significant long-term decarbonisation challenge for the industry, according to the roadmap.

Further reductions in process emissions from phosphoric acid production will rely on CCS. This could involve:

- Bolt-on CCS units for existing acid plants
- Advanced acid leaching techniques that capture high-purity CO_2

Fig. 3: **There is potential for an 89% emissions reduction in phosphate and potash production from 2024 business as usual (BAU) under a 'net zero by 2050' scenario (NZ50)**



Source: ERM

- The Merseburg process or calcination of phosphogypsum to capture CO_2 with sulphuric acid regeneration
- Carbonate mineralisation methods.

Significant technical, logistical, geological and economic barriers are, however, likely to prevent CCS adoption in the near-term, the roadmap advises.

Near-term action

Achieving the decarbonisation goals set out in the roadmap will depend on early action through the rest of this decade and into the early 2030s. This includes action by producers in the following areas:

- **Mining and beneficiation**. In the near term, emissions reductions could be delivered through battery electric, trolley assist systems in open-pit mining, and the use of HVO or other low carbon liquid fuels for light-duty engines.
- **Efficiency initiatives**. These include heat integration, equipment upgrades, insulation and better heat recovery from sulphuric acid production. These measures reduce both fuel and electricity demand and are critical enablers for subsequent electrification and power de-carbonisation.
- **Process heat and drying**. Emissions reductions measures include efficiency improvements and the use of combined heat and power (CHP), as well as partial electrification and fuel switching, where feasible.
- **Process emissions**. Opportunities are limited in the near term with N_2O abatement from nitric acid production and process optimisation being the main focus.
- **Waste emissions**. Early actions include water recycling and better PG management via gypsum valorisation and co-product recovery.
- **Low-carbon electricity**. Ahead of grid decarbonisation, phosphate and potash producers can reduce their electricity related emissions through on-site renewable electricity generation, PPAs and energy attribute certificates (EACs).

The cost challenge

The overall cost of decarbonising phosphate and potash production – to meet a net zero goal by 2050 – is likely to fall within the $235-320 billion range globally. This value illustrates the massive scale of the challenge to decarbonise production emissions. The figure also excludes the cost of associated infrastructure upgrades. Neither does it factor in the required policy support and demand signals needed to attract the necessary investment.

More positively, to help guide investment and set priorities, the roadmap assesses decarbonisation options using a global marginal abatement cost curve (MACC). This highlights the main bankable low-cost and negative cost options in the near-term – such as energy efficiency, process optimisation, renewable electricity generation, and selective electrification where cheap low carbon power is available. Delivering deeper decarbonisation will, however, eventually require the pursuit of higher cost options – particularly alternative production routes, CCS and full electrification. ■

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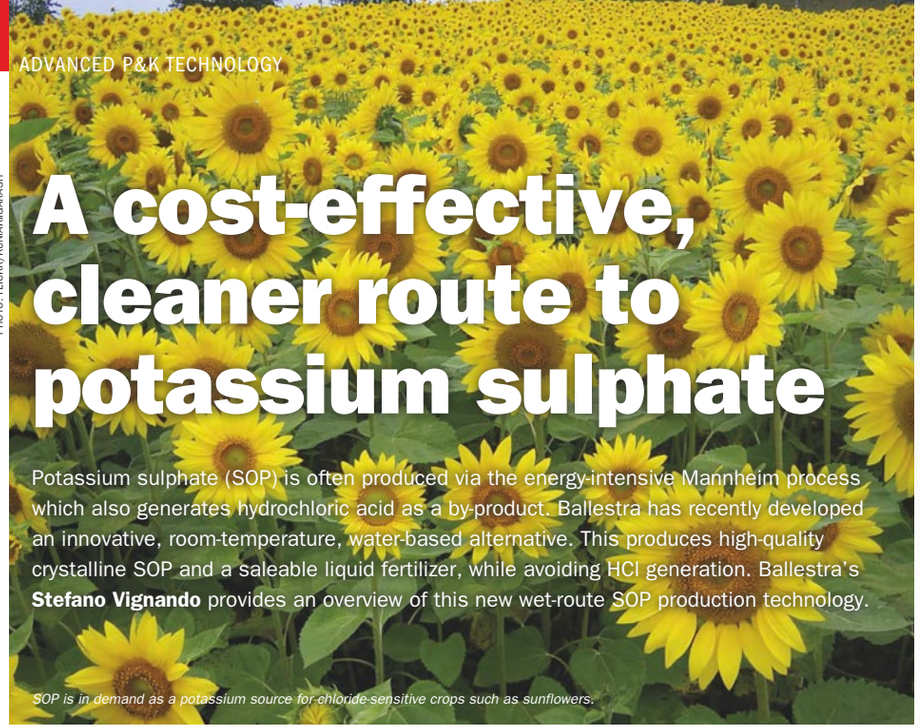


PHOTO: FLICKR/KUNIAKIGARASH

A cost-effective, cleaner route to potassium sulphate

Potassium sulphate (SOP) is often produced via the energy-intensive Mannheim process which also generates hydrochloric acid as a by-product. Ballestra has recently developed an innovative, room-temperature, water-based alternative. This produces high-quality crystalline SOP and a saleable liquid fertilizer, while avoiding HCl generation. Ballestra's **Stefano Vignando** provides an overview of this new wet-route SOP production technology.

SOP is in demand as a potassium source for chloride-sensitive crops such as sunflowers.

Potassium sulphate (SOP, K_2SO_4) is a premium, chloride-free source of potassium. One of the major production routes, the high-temperature Mannheim process, is energy-intensive and generates hydrochloric acid (HCl) as a by-product. Ballestra has developed a room-temperature, water-based 'metathesis' SOP process. This has been validated at bench-scale, avoids generating HCl entirely and yields a second saleable liquid fertilizer alongside crystalline SOP.

This article describes this novel SOP production process, as well as the test campaign behind it, and shows how it compares with the Mannheim route in terms of feedstock consumption, capital cost and realised revenue.

Ballestra and the SOP opportunity

Ballestra SpA is a Milan-headquartered technology licensor and engineering contractor with a leading position in the detergent, surfactant, soap and inorganic chemicals industries – the latter including sulphuric acid, phosphoric acid and fertilizers. The company supports projects from process design through commissioning to after-sales technical assistance. Backed by a worldwide sales network, it operates four offices together with four laboratory and pilot installations globally.

Ballestra recently became part of Nextchem, the sustainable technology company of MAIRE Group This has broadened the Group's technology offering, with Ballestra's potassium, sulphur and phosphate technologies now sitting alongside Nextchem's industry-leading nitrogen technology portfolio.

Adding to its existing chemical technologies, Ballestra has developed a wet-route process for an important specialty fertilizer product: potassium sulphate – traditionally known as sulphate of potash (SOP). The process offers a practical alternative to the long-established Mannheim route.

WHY POTASSIUM SULPHATE MATTERS

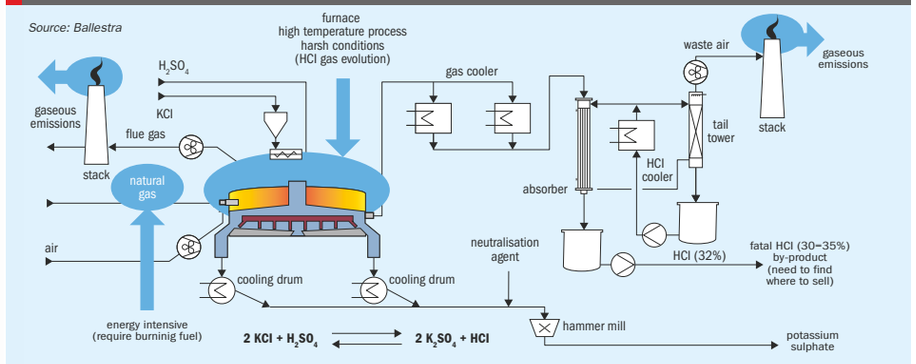
Potassium sulphate (SOP, K_2SO_4) is one of the most valuable forms of specialty potash. In agriculture, it is ideal for chloride-sensitive crops as it provides potassium without introducing chloride. Alongside potassium, it also supplies sulphur, an essential plant nutrient for protein synthesis and enzyme function.

SOP's agronomic benefits include:

- **Growth**: supports plant development and strengthens root systems.
- **Quality**: improves the quality of fruits, vegetables and straw.
- **Resistance**: helps plants withstand pests, disease and environmental stresses such as heat and low humidity.
- **Yield**: promotes greater flower and fruit production.
- **Chloride-free**: essential for potatoes, grapes, lettuce, onions, strawberries, tomatoes, beans, peas, sunflowers, soybeans, barley, tobacco and sugarcane.

This nutrient profile makes SOP indispensable for high-value, chloride-sensitive agriculture. High demand for SOP, and its price premium over potassium chloride (MOP, KCl), should support new sources of supply via reliable, cost-competitive production technology. ■

Fig. 1: **The Mannheim furnace process: high-temperature reaction of potassium chloride and sulphuric acid, with hydrogen chloride gas absorption and tail-gas scrubbing.**



The conventional Mannheim route

The Mannheim process is the traditional, technically-proven secondary production route for SOP. It reacts potassium chloride with sulphuric acid in a high-temperature furnace (Figure 1):

$$2KCl + H_2SO_4 + \text{heat} \rightarrow K_2SO_4 + 2HCl$$

This reaction yields potassium sulphate as the marketable product and gaseous hydrochloric acid as a by-product. The HCl generated must be absorbed and then valorised or disposed of. Ballestra has extensive experience in designing Mannheim plants and can supply the design skills needed to minimise wear-part replacement and maximise plant life.

Despite its maturity, the Mannheim process has four structural drawbacks that increasingly weigh on plant economics and environmental performance:

- **High energy consumption** – continuous heating at about 600–700°C, with fuel accounting for an important share of operating cost.
- **Corrosion** – HCl generation requires acid-resistant materials and raises maintenance costs, with metal parts subject to accelerated wear.
- **Environmental burden** – HCl gas emissions require dedicated scrubbing systems, which add capital cost, operating cost and CO_2 emissions.
- **By-product management** – Originally, the Mannheim process was used to produce HCl, today the 30–35% HCl solution must be captured and then used elsewhere or sold, a commercial variable that can affect plant profitability.

Typical Mannheim figures show the scale of these constraints. A single furnace produces around 30 tonnes per day (t/d) of K_2SO_4 (chloride < 1%), together with 1,100–1,200 kg of 30–35% HCl per tonne of SOP. It consumes roughly 560–570 kg of 98.5% H_2SO_4, 825–850 kg of KCl, 64–77 kg of natural gas and 100–110 kWh of electrical power per tonne of product.

Ballestra's wet-route process

Ballestra set out to develop a milder SOP production route that would: eliminate the use of a furnace, avoid HCl generation, and therefore eliminate the by-product disposal issue, by generating a second saleable fertilizer co-product.

The result is a room-temperature, water-based metathesis* process (Figure 2):

$$2KCl + (NH_4)_2SO_4 \rightarrow K_2SO_4 + 2NH_4Cl \text{ (in solution)}$$

**Chemical double displacement*

The process exploits the reciprocal salt-pair equilibrium of the four-component system $(NH_4)_2SO_4 + 2KCl \rightleftharpoons K_2SO_4 + 2NH_4Cl$ in water, as first characterised in detail by Hill and Loucks (1937). Across the relevant temperature range, potassium sulphate is the least soluble species. It therefore precipitates as a pure crystalline solid, while the remaining nutrients stay in solution as a nitrogen-potassium-sulphur (NKS) liquid, the mother liquor.

Because the reaction proceeds in water at room temperature, this wet route requires no thermal energy input and produces no gaseous emissions. The precipitated K_2SO_4 is separated, milled and screened to market specification. The mother liquor is recovered as a ready-to-use liquid fertilizer or blending component.

Two products, two markets

The wet route yields two distinct fertilizer streams. The K_2SO_4 solid is a high-grade and essentially chloride-free form of SOP. The chloride does not disappear. Instead, it passes into the mother liquor, which contains 9–12% chloride as a result. This liquor can be marketed as a liquid fertilizer for chloride-tolerant crops, in contrast to the chloride-sensitive crops served by solid SOP. Typical compositions of both are shown in Table 1.

Table 1: **Typical composition of the two wet-route product streams**

Component	Solid K_2SO_4 (% wt.)	Mother liquor (% wt.)
K_2O	48–50	4–6
N	3.3–5.0	4–6
SO_3	44–46	5.2–7.0
Cl^-	<< 1	9–12
Moisture / water	0.5–2	balance

Source: Ballestra

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Production and specific consumptions

Reagent and utility consumption are summarised in Table 2. The wet route yields one tonne of solid K_2SO_4 (Cl^- < 1%) and about 4.4 tonnes of mother liquor.

One point deserves highlighting: the wet route is more feedstock-intensive than the Mannheim route, consuming 1,160 kg of potassium chloride per tonne of SOP versus 825–850 kg /t for the Mannheim process. This issue is discussed further in the economics section.

From the lab to the plant: the R&D test campaign

Ballestra has investigated the wet route repeatedly at bench scale across every variable necessary for a bankable industrial design. That includes:

- Raw-material specification and particle size
- Reaction and precipitation behaviour
- Solid-liquid separation
- Mass-balance closure
- Product quality and crystal habit.

The R&D test campaign ran in two phases:

Firstly, **batch operations** in glass beakers were carried under controlled dosing – to map solubility behaviour, stoichiometry and achievable yield across a range of raw-material qualities.

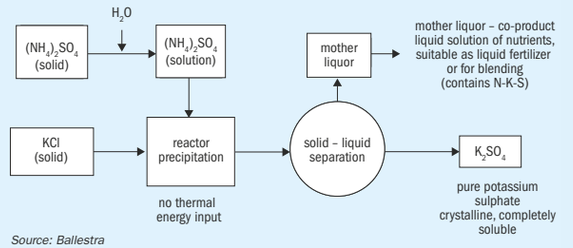
Secondly, once the chemistry and separation steps were understood, the work then moved to a **bench-scale simulation rig** for continuous solid-liquid separation (Figures 3 and 4). This functioned as a scaled-down physical representation of an SOP plant, with dosing pumps, agitated reaction vessels arranged in series, and a centrifuge

Table 2: **Wet-route reagent and utility consumption. The process requires no thermal energy input and does not consume natural gas.**

Chemical / utility	Specific consumption per t SOP
$(NH_4)_2SO_4$	1,140 kg
KCl (60–62% K_2O)	1,160 kg
Process water	3,100 kg
Electrical power	77.5 kWh

Source: Ballestra

Fig. 2: **Ballestra wet-route process scheme: potassium chloride (KCl) and ammonium sulphate ($(NH_4)_2SO_4$) react in aqueous solution; potassium sulphate (K_2SO_4) precipitates and is separated, milled and screened, while the mother liquor is recovered as a co-product liquid fertilizer.**



Source: Ballestra

Fig. 3: **Conceptual scheme of the continuous bench-scale simulation: ammonium sulphate solution (A) and KCl (K) are continuously dosed into agitated reaction vessels (M) in series, reproducing the residence time and mixing of a full-scale continuous plant**

Source: Ballestra

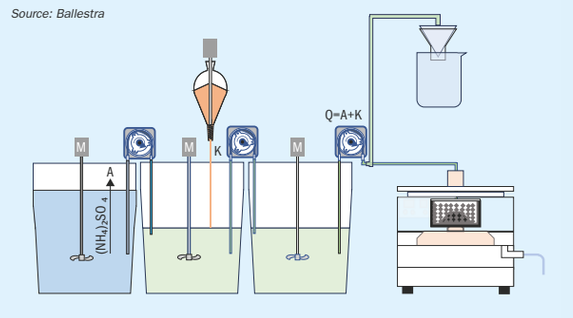
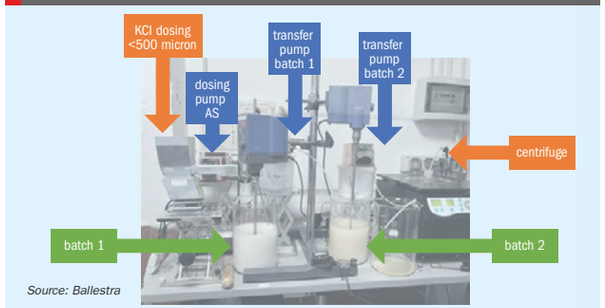


Fig. 4: **The continuous bench-scale rig in operation: ammonium sulphate dosing pump, calibrated KCl screw feeder (< 500 µm), two agitated vessels in series and a centrifuge for continuous product discharge**



Source: Ballestra

In the continuous bench-scale rig, the two feedstocks, ammonium sulphate solution and precisely metered potassium chloride, were introduced in parallel. Transfer pumps moved the reacting suspension between two agitated vessels arranged in series, giving a residence time of roughly 25 minutes per vessel.

After an initial stabilisation period, the system ran continuously. Product was withdrawn by centrifugation at regular intervals over a run of more than six hours. Samples from both vessels were taken to track ion concentrations and confirmed steady-state conditions.

The results validated the wet-route SOP process in every respect:

- **Mass-balance closure** – the overall solid and liquid balance over the full 410-minute run closed to within 1.3%. The ionic species in both the solid product and the mother liquor were charge-balanced, confirming no unaccounted losses.
- **Yield** – the experimental SOP yield reached 74–79% by weight, above the 63–66% theoretical yield calculated from SOP solubility at 25°C. This is consistent with the lower operating temperature of about 20°C, at which achievable yield rises. One sample reached 89%.
- **On-spec product without washing** – even before any washing stage, the centrifuged SOP complied with typical commercial specifications, with chloride below 1% by weight and a $K_2O/SO_3/N$ profile in line with market-standard SOP.
- **Stable mother liquor** – the composition of the co-product mother liquor remained essentially constant throughout the run and closely matched the earlier batch campaign, underlining the robustness of the chemistry.
- **Particle size** – the discharged product was concentrated in the 250–500 µm range, with a mild coarsening trend over the run. The fraction above 500 µm rose from about 8% at one hour to 16% at six hours, consistent with well-formed crystalline SOP.

The tangible outcome of these trials is genuine crystalline SOP generated directly by a continuous rig. Under the microscope, the product appears as well-formed, robust crystalline aggregates (Figure 5) – a free-flowing, storable material of the kind the wet route is designed to deliver at scale.

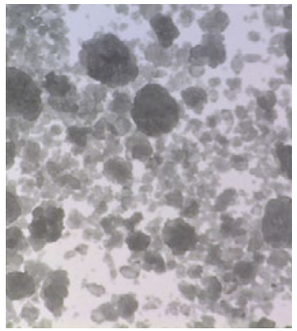


PHOTO: BALLESTRA

Fig. 5: Micrograph of the crystalline potassium sulphate from the continuous rig.

Taken together, the two-stage campaign – from the initial exploratory batch trials to the continuous simulation with full instrumentation – provides this SOP wet-route with an unusually high degree of experimental grounding for a process at this stage of development. It also provides a robust basis for scale-up to a full industrial plant.

The economics: consumptions, capital cost and revenue

The wet route versus the Mannheim route is best assessed on a like-for-like basis of 10,000 tonnes per annum (t/a) product output with residual chloride content < 1%. For this comparison, the capital costs and principal operating parameters are set out side by side in Table 3. (Please note that the investment case for the wet route becomes increasingly attractive at higher production capacities.)

For product value, the realised revenue (not margin) per tonne of SOP for both routes are reported in Table 4. In the Mannheim route, the HCl by-product is credited as a co-product and natural gas is charged as a cost. In the wet route, the second stream is assigned to the NKS liquid fertilizer.

From revenue to margin

The wet route consumes more of the key raw materials per tonne of SOP product output: about 1,160 kg of KCl and 1,140 kg of ammonium sulphate, against roughly 837 kg of KCl and 565 kg of sulphuric acid for the Mannheim route (Table 5).

Table 3: **Mannheim route vs wet route for SOP production: capital cost and key operating parameters.**

Parameter (10,000 t/a)	Mannheim	Wet route
Equipment / plant price (engineering and procurement estimate)	€11–13 million	€6–8 million
Natural gas cost	€20–50/t SOP	none
CO_2 (fuel combustion)	~200 kg/t SOP	none
Electrical power	100–110 kWh/t SOP	77.5 kWh/t SOP

Source: Ballestra

Table 4: **Mannheim route vs wet route for SOP production: realised revenue per tonne of SOP (indicative market prices).**

Route / stream	Quantity	Value
Mannheim – SOP	1 tonne	$800
Mannheim – HCl (31%)	1.16 tonne	$116
Mannheim – natural gas	80 Nm³	$–40
Mannheim – realised revenue		$876/t SOP
Wet route – SOP	1 tonne	$800
Wet route – liquid fertilizer	4.4 tonne	$220
Wet route – realised revenue		$1,020/t SOP

Source: Ballestra

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ISSUE 534
SEPTEMBER-OCTOBER 2026

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Any full economic comparison must therefore weigh these feedstock costs, which favour the Mannheim route, against the wet route's lower energy, maintenance and emissions-abatement costs, as well as the absence of the HCl offtake risk. The net balance is site-specific – being dependent on local prices for KCl, ammonium sulphate, sulphuric acid, energy and the HCl offtake.

A key strategic point is that the wet route's second stream should be marketable. Being a liquid NKS fertilizer, it should be valued by the same customer base as SOP, whereas Mannheim's HCl by-product needs to be placed on an unrelated market outside of the operator's control. That can make it as much a liability as an asset. The wet route also offers materially lower capital cost, no gas consumption, no CO_2 emissions from fuel combustion, and lower power demand.

Table 5: **Feedstock intensity of the wet route versus the Mannheim route for SOP production. The wet route trades sulphuric acid for ammonium sulphate and uses appreciably more KCl.**

Feedstock per t SOP	Mannheim	Wet route
KCl (60–62% K_2O)	825–850 kg	1,160 kg
Sulphuric acid (98.5% H_2SO_4)	560–570 kg	—
Ammonium sulphate	—	1,140 kg

Source: Ballestra

A compact, ready-to-build plant

The full-scale wet-route SOP plant has been engineered into a compact footprint of roughly 60 by 20 by 12 metres (Figure 6). This should make it relatively straightforward to integrate alongside existing potassium chloride and ammonium sulphate handling facilities.

Product end markets

Because it is chloride-free, the solid SOP makes an ideal potassium source for chloride-sensitive crops:

- Grapevine, citrus, potato, tobacco, strawberry
- Beans and peas (legumes)
- Fruit trees – peach, apricot, avocado
- Onion, garlic and other chloride-sensitive vegetables and fruit.

Whereas the mother liquor – a chloride-containing liquid NKS fertilizer – can be directed to chloride-tolerant crops such as:

- Cereals
- Oilseed crops
- Sugar beet, cabbage and other brassicas, celery, chard, asparagus, coconut palms, and many vegetables and fruit.

This liquid fertilizer should be well-suited to fertigation and hydroponics, as well as being valuable for quick corrections of crop nutrient deficits and for targeted nutrient supplementation.

Conclusions

The Mannheim process remains a widely-used and technically-proven industrial method for potassium sulphate (SOP) production. But its high energy consumption, corrosion, harsh operating conditions, environmental footprint and by-product burden are increasingly hard to justify in a market that rewards efficiency and sustainability.

Ballestra's wet route replaces a process based on high-temperature furnace chemistry with a room-temperature, water-based metathesis reaction instead. It eliminates hydrochloric acid generation and gaseous emissions, removes thermal energy input, and generate a market-ready liquid fertilizer as a secondary product. It produces crystalline SOP with market-standard purity at lower capital cost and with lower energy and maintenance demand, while delivering a higher realised revenue per tonne.

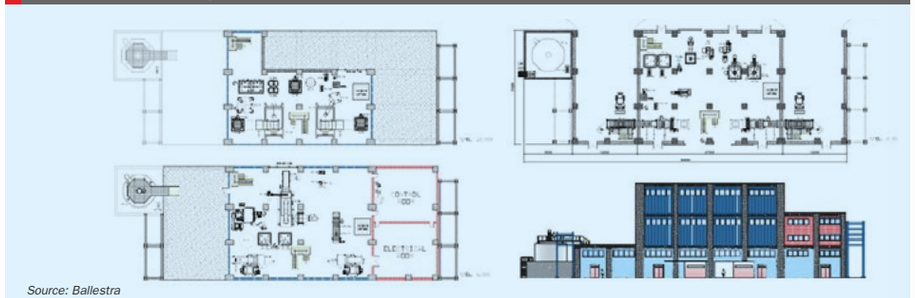
Because the wet route is more feedstock-intensive, any net margin advantage remains site-specific and should be tested against local reagent and energy prices. Even so, the direction of travel on capital cost, emissions and by-product risk is favourable.

These developments reflect Ballestra's broader strategy of placing efficient, environmentally-responsible process innovation at the centre of its offer to the fertilizer and chemical industries. They also give producers a cost-effective route to more sustainable SOP production. ■

Reference

Hill, A. and Loucks, C., 1937. The reciprocal salt-pair $(NH_4)_2SO_4 + 2KCl \rightleftharpoons K_2SO_4 + 2NH_4Cl$ in water and in ammonia-water at 25°C. *Journal of the American Chemical Society.*

Fig. 6: **General layout of a Ballestra wet-route SOP plant with an approximate footprint 60 by 20 by 12 metres. Front elevation and floor plans shown.**



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Integrating REE recovery into phosphate processing flowsheets

Phosphate producers have an opportunity to pursue rare earth element (REE) recovery from phosphogypsum (PG). Treating PG as a strategic resource, by unlocking its critical mineral potential, is a way of converting a liability into a cleaner, saleable product. **Lyndsay Tran**, **Khanh Pham** and **Gabriela Olvera** of Hatch look at the options for REE recovery from PG and their relative merits.

PHOTO: HATCH

The search for rare earth elements (REEs) outside of conventional ore deposits encompasses secondary and unconventional sources — including phosphate industry by-products.

Introduction

Rare earth elements (REEs) are a group of 16 chemically similar metallic elements that play a key role in permanent magnets, catalysts and electronics. They include 15 lanthanides, plus yttrium, and commonly occur together in natural mineral deposits. In 2018, REEs were officially designated as critical minerals by the US government.

Current global mining and refining of REEs is highly concentrated, being limited to a small number of operations and jurisdictions. To counter this, many governments have accelerated efforts to secure their own domestic supply chains due to rising REE demand from electrification and national defence. This has involved expanding the search for REEs outside of conventional ore deposits to encompass secondary and unconventional sources – including phosphate rock and phosphate industry by-products.

The phosphate ore mined for use in phosphate fertilizer production contains varying amounts of REEs locked within apatite. This natural rock feedstock is digested with sulphuric acid during wet-process phosphoric acid production. During this process, calcium sulphate ($CaSO_4$) is formed and precipitates in large volumes as a phosphogypsum (PG) by-product.

Between 70-85% of the original rare earth content of the apatite partitions into the PG. As a consequence, this phosphate industry by-product has received increased research attention over the past decade due to the significant opportunity to recover these REEs commercially.

Not scarce – just difficult to isolate

Rare earth elements are chemical similar. Indeed, the near-identical configuration of their outer electron shells causes them to behave as a single chemical entity. The group is commonly subdivided into light REEs (LREEs, La-Sm) and heavy REEs (HREEs, Eu-Lu and Y). HREEs are more valued, as they are generally less abundant than LREEs, and offer a higher market premium.

Conventionally, rare earth elements are sourced from deposits such as bastnasite, monazite and ion-adsorption clays. Despite their name, rare earths are not scarce in an absolute sense. Cerium, for example, has an abundance comparable to copper in the Earth's crust. Instead, the 'rare' in rare earths refers to the fact that they rarely occur in high concentrations and, historically, have been difficult to isolate and purify into individual elements.

RARE EARTH MARKETS AND END USES

Demand for rare earths is being driven by a few major applications. The most important application is permanent magnets, with these constituting roughly 95% of total rare earth consumption by value in 2025[1].

NdPr (or NdFeB) permanent magnets are made from an alloy of neodymium-praseodymium, iron and boron, with dysprosium and terbium often alloyed-in to impart performance at high temperatures. They are strongest type of permanent magnets available commercially.

Catalysts are another significant market for rare earths. Major types include lanthanum and cerium-based fluid catalytic cracking catalysts and automotive emission-control catalysts. Other significant uses include alloys for rechargeable batteries and optical glass for smartphones, displays and other applications.

For permanent magnets, demand is concentrated in three major sectors:

- **In electric vehicles**, NdPr magnets are preferred for traction motors due to their high energy density and resistance to demagnetisation at high temperatures.
- **In wind turbines**, permanent-magnet direct-drive generators are favoured over the traditional gearbox-coupled design, as eliminating the gearbox removes the most failure-prone component in a drivetrain[6]. This is a significant consideration, especially for offshore installations where access to maintenance is limited and downtime is costly.
- **In defence applications**, NdPr magnets are used in guidance, steering and actuation systems for munitions, aircraft and naval vessels. Demand from this sector is heavily reinforced by government stockpiling efforts. The US Defense Logistics Agency, for instance, is building a strategic stockpile of critical minerals to develop defence systems including several rare earths[7].

It is generally the last category, the defence sector, that has changed the need to secure a rare earth supply chain from a commercial planning question into a matter of national security and policy. A critical mineral supply chain that is majority-controlled by a single country – as is the case for REEs currently – poses geopolitical risks for other countries, particularly in national defence, and threatens their ability to build up domestic reserves.

In 2024, China and Myanmar collectively accounted for 83% of global HREEs mining and 76% of global LREEs mining, with China also holding additional stakes in overseas mines[1]. In downstream processing, China also represented 91% of global refined output and 94% of permanent magnet production[1].

The combined demand from the EV, wind and defence sectors has turned rare earth supply into a matter of national policy in multiple jurisdictions around the world, driving a deliberate push to decentralise the supply chain. Several governments, particularly the United States, have responded with direct financial and policy support aimed at establishing independent domestic value chains. Three companies, MP Materials, USA Rare Earth and Arafura Rare Earths, are among those receiving financial incentives and policy support. ■

Phosphogypsum: a strategic source of rare earths

Rare earth elements are known to occur in phosphate rock due to their isomorphous substitution for calcium in the apatite lattice. Minor amounts are also present as discrete mineral inclusions within the ore, such as monazite, xenotime, allanite, and rare earth carbonates[12].

Published literature reports typical REE concentrations in apatite in the range of 0.01-0.1% by weight[3]. While modest compared to conventional REE resources, the total concentration can be significant considering the global throughput and consumption of phosphate rock by the phosphate industry. Several studies have also reported a higher proportion of HREEs in phosphate deposits, compared to conventional rare earth ores, a favourable characteristic given their higher market value.

Tracking where REEs report and partition as they travel through a conventional wet-process phosphoric acid plant helps identify where the recovery opportunity lies (Figure 1). Studies on REE distribution have found that less than 10% of the apatite-derived REE content reports to the tailings stream during beneficiation[13]. Following acidulation and filtration, approximately 70-85% of the REEs partition to PG, while an estimated 15-30% reports to clarifier sludge[11]. The phosphoric acid product itself retains a comparatively small fraction, typically less than 1,000 ppm[14]. Consequently, given this distribution, PG has been the primary focus of REE recovery research within the wet-process flowsheet.

PG has, however, long been considered a regulatory liability for phosphate producers. PG can contain residual phosphoric acid, high moisture content and naturally occurring radionuclides, such as uranium, thorium and radium. In the United States, PG is classified under EPA guidelines as Technologically Enhanced Naturally Occurring Radioactive Material (TENORM).

Wet-process phosphoric acid production generates roughly 4-5 tonnes of PG per tonne of phosphoric acid produced. Estimates from the International Fertilizer Association in 2025 put annual PG output at 245 million tonnes[2].

While PG can be treated via dewatering, impurity removal and other processing steps, the treatment costs are often significant compared to the value of the clean gypsum. Consequently, long-term stacking remains the most cost-effective approach for many phosphate producers.

Rare earth recovery thus provides an opportunity to create a value-added REE co-product while reducing the land requirements for gypsum stacking. Given the 245 million tonnes of PG generated annually[2], the total recoverable REE inventory could be significant. This would allow for meaningful valorisation of a material that has historically been considered a waste stream.

Methods of rare earth recovery from PG

Recovery from PG has been studied extensively at laboratory scale, and a number of pilot projects have been completed[5,11,15]. However, no process or technology has been successfully commercialised to date. That is partly because rare earth co-recovery has historically been less economically attractive than it is today.

The main technical constraints across all recovery pathways and options are mineralogy and chemistry. PG is often resistant to acid attack because it is

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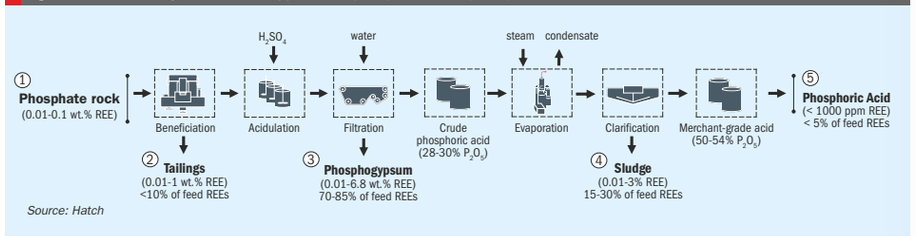
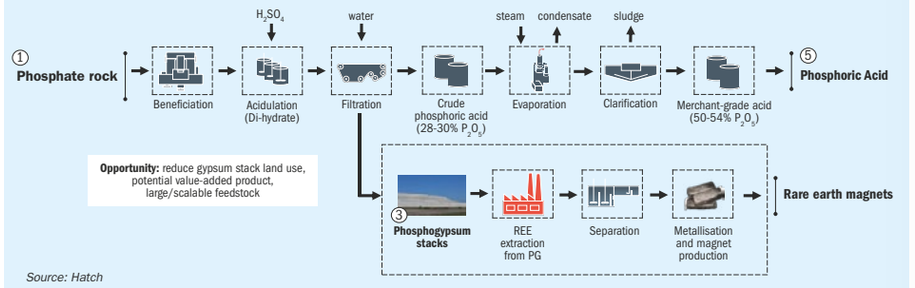
Fig. 1: **REE-containing streams in a typical wet phosphoric acid (WPA) flowsheet**



Source: Hatch

Fig. 2: **Incorporation of REE recovery from phosphogypsum (PG) into a wet phosphoric acid (WPA) flowsheet**



Source: Hatch

contained within the fraction of the phosphate ore that remains undissolved during the initial acidulation.

Physical beneficiation is also limited in its ability to recover rare earths: PG particles are often very fine, which can hinder further liberation through grinding or flotation. Any process aggressive enough to liberate rare earths also tends to co-extract radionuclides and other impurities, requiring radioactivity management within the flowsheet. This can have direct implications for capital and operating expenses (CAPEX and OPEX), as well as health, safety and environmental (HSE) management.

Most published studies on REE recovery focus on PG taken directly from the filters. While recovery from stacked PG has also been studied, this is technically more difficult, as the mineral structure of PG can change due to recrystallisation over time[15].

Many hydrometallurgical processes have been studied over the past decades. Methods include direct acid leaching, resin-in-pulp (RIP) extraction, bioleaching and solvometallurgy. In parallel, various pretreatment strategies, such as carbonate conversion and hemihydrate/anhydrite conversion, have been developed to enhance REE recovery efficiency.

The following section focuses on the two most common REE recovery methods for PG – direct acid leaching and RIP – and discusses carbonation pretreatment as a means of improving extraction performance.

Direct acid leaching

Most published work on acid leaching of PG focuses on the use of sulphuric acid, due to both its low cost and availability for most phosphate producers. Prior to leaching, physical pretreatment of the PG feed, including mechanical activation or ultrasonic treatment, is often adopted to increase access to rare earths ahead of the acid contact.

In terms of morphology, a large percentage of the REEs present in PG occurs within the gypsum crystal lattice as an isomorphous substitution for calcium[11]. This stable, structurally-bound REE is resistant to leaching under high-sulphate, acidic conditions. However, a small percentage of the REEs present also occurs as an amorphous phase adsorbed onto particle surfaces. This is comparatively easy to leach from PG – and therefore the most readily recoverable fraction of the total REE present.

Reported leaching efficiencies for REEs from PG vary widely across the literature, ranging from around 20-90%. Removal efficiency is highly sensitive to liquid-to-solid (L/S) ratio, acid concentrations, temperature and residence time.

Higher REE recoveries are generally achieved through a combination of high L/S ratio and extended residence time, as this allows more dissolution of gypsum. However, these requirements increase reagent consumption and equipment sizing, both of which contribute to higher OPEX and CAPEX, respectively.

To overcome the challenges associated with sulphuric acid, there has been ongoing research on alternative acid leaching with hydrochloric acid (HCl), nitric acid (HNO_3) and even phosphoric acid (H_3PO_4).

Sulphuric acid is, however, typically the least expensive of the three acid leaching options, on a cost-per-mole-of-H^+ basis. It is also commonly produced on site at phosphoric acid production sites. Its marginal cost, therefore, is usually closer to the internal production cost than to the merchant price.

Table 1: **Summary of results in the literature[5] for rare earth element (REE) extraction from phosphogypsum (PG) via leaching with sulphuric acid**

Country	REO, wt.-%	Leaching conditions					Leaching efficiency, %
		Leaching reagent	Conc., wt.-%	Temp.,°C	Time, h	L/S, mL/g	
Russia	0.6	H_2SO_4	10–15	40	6	2/1	52
Egypt	0.022	H_2SO_4	30	25	8	1/1	30
Russia	0.414	H_2SO_4	0.5–4.0	25	3,025	2/1	57.1– 68.2
USA	0.034	H_2SO_4	25; 96	72	1	20/3	49
Egypt	0.048	H_2SO_4	30	25	3	2/1	12.5
Canada	0.02	H_2SO_4	50-60	80	2	8/1	23
USA	0.0218	H_2SO_4	33	50	3.5	4/1	43
Spain	0.0345	H_2SO_4	4.8	25	2–8	20/1	41–58
USA	1	H_2SO_4	2	25	24	50/1	76.9– 93.7
Brazil	0.5	H_2SO_4	6	42	1	20/1.7	67.8
Brazil	0.5	H_2SO_4	22	55	20 min	20/1.7	90

Source: Hatch *Note: see Xie et al. (2023) for full citation list.*

In comparison, neither hydrochloric nor nitric acid are readily available at phosphate production sites. Their use would therefore require external purchase and the delivery of corrosive acids via pipes or trucks, along with the necessary storage, handling and containment infrastructure.

Phosphoric acid leaching of PG has been investigated less extensively, although the available literature suggests that a high L/S ratio is required due to the chemical stability of the REEs present. The on-site availability of phosphoric acid is advantageous, as is the opportunity for plant integration by recycling.

The large volume of phosphoric acid required for leaching is, however, likely to incur extra capital costs, due to the additional equipment capacity and the larger recycle loop needed to maintain the plant's phosphoric acid production. Furthermore, the integration of recycled acid would introduce extra (and potentially unwelcome) complexity at an existing wet phosphoric acid plant.

Table 2: **Summary of results in the literature[5] for rare earth element (REE) extraction from phosphogypsum (PG) via leaching with alternative acids**

Country	REO, wt.-%	Leaching conditions					Leaching efficiency, %
		Leaching reagent	Conc., wt.-%	Temp.,°C	Time, h	L/S, mL/g	
South Africa	6.8	HNO_3	2.0a	20	48	3/1	57
Egypt	0.022	HNO_3; $Ca(NO_3)_2$	2.0–3.0a; 0.8a	25	8	1/1	76
Egypt	0.022	HNO_3	2.0a	25	8	1/1	46
Egypt	0.022	HCl	4.0a	25	8	1/1	30
Russia	0.45	HNO_3	1.0–3.0b	—	8–12 min	4/1–5/1	85–86.1
USA	0.034	H_3PO_4	25b; 96b	72	1	20/3	49
Egypt	0.048	HNO_3	3.0a	25	3	2/1	43.3
Egypt	0.048	HCl	2.0a	25	3	2/1	11.9
Canada	0.02	HNO_3	1.5a	80	2	8/1	57
Canada	0.02	HCl	1.5a	80	2	8/1	51
Canada	0.0317	HCl	1.5a	85	1	15/1	80–99
Spain	0.0345	HNO_3	3.0a	25	2–8	20/1	75–86
USA	1	H_3PO_4	0.22a	25	24	50/1	5–85
China	0.02	HCl	1.65a	25; 60; 80	2	10/1	52; 66; 78
China	0.02	HNO_3	1.65a	30; 60; 80	2	10/1	58.5; 75.9; 83.4

Source: Hatch *Note: see Xie et al. (2023) for full citation list.*

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Resin-in-pulp extraction

Resin-in-pulp (RIP) is another commonly investigated technology for rare earth recovery from PG. Both strong cation exchange resins and chelating resins have been tested for REE adsorption using this approach.

In the RIP process, resin is contacted with PG slurry and sulphuric acid in a continuously stirred tank reactor (CSTR). Gypsum has low solubility in acidic slurry and, as it dissolves and recrystallises, a small fraction of REEs continuously enters solution and becomes available for capture.

The resins used in this process are selected to have a high affinity for dissolved REEs with functional groups that preferentially bind to REE ions relative to other dissolved species.

After capture, the REE loaded resin is separated from the barren PG by screening based on particle size. The barren PG solid is filtered while the filtrate and wash solution are recycled to the loading step.

The loaded resin then undergoes elution, typically with sodium chloride (NaCl) or similar alternatives. During elution, sodium ions exchange with REE ions and desorb them into solution. The resin is then regenerated using an acid wash, typically with sulphuric acid, and finally recycled to the loading step.

Studies have shown that resin-in-pulp can achieve REE recoveries from PG of up to 75%[4]. The equipment required for this process is scalable and not uncommon in other hydrometallurgical industries, such as gold and uranium recovery.

Compared to direct acid leaching, the RIP process has a much lower acid consumption, with potential opportunities for acid recycling. However, carrying out ion exchange at scale generally requires consistent feed conditions to control the cycle. Consequently, pretreatment may be required in a commercial flowsheet – adding to the capital costs of the project.

Carbonation pretreatment

This method involves carbonation with salts such as soda ash (Na_2CO_3) or ammonium bicarbonate (NH_4HCO_3) to pretreat the PG ahead of leaching. The carbonation reaction converts calcium sulphate into calcium carbonate. This is advantageous as the REEs can be more easily leached when present in carbonate.

In this method, PG slurry is fed to a stirred tank reactor and contacted with a carbonate salt. The resulting REE-bearing carbonate slurry is filtered, producing a solid cake and a filtrate rich in sodium sulphate or ammonium sulphate. This filtrate stream has potential as a value-added product, especially for the fertilizer market.

The filter cake containing rare earth carbonate is then leached with acid. Leaching efficiency is improved, compared to direct leaching of untreated PG under comparable L/S ratio, temperature and reaction time conditions. One study that converted calcium sulphate to calcium carbonate, through carbonation with sodium carbonate, managed to leach up to 87% of the REEs present using citric acid[5].

Despite this, carbonation pretreatment is more reagent-intensive than direct leaching. This is due to the stoichiometric consumption of carbonate reagents, with one mole of reagent being required per mole of PG treated. By contrast, the consumption of sulphuric acid in direct leaching is primarily controlled by REE dissolution and associated gangue reactions.

Also, instead of producing a potentially saleable gypsum by-product, carbonation pretreatment converts PG into calcium carbonate and sodium sulphate, both of which may have limited commercial outlets – depending on purity, logistics and local market demand.

Technical and economic barriers

Increasingly, many critical minerals are being sourced from non-conventional, lower-grade resources in order to meet projected demands, with lithium recovery from clays and brines and cobalt recovery from mine tailings being two examples. Rare earth recovery from PG therefore reflects this broader industry trend. Yet, historically, several techno-economic barriers have limited the development of phosphogypsum as a REE resource.

From a technical standpoint, REEs are difficult to isolate from their PG host due to the underlying chemistry and mineralogy. This constraint stems from gypsum's low solubility in sulphate-rich acid media and the tendency of rare earths to substitute within the gypsum crystal lattice.

From an economic standpoint, processing these by-products also carries costs that are not always apparent. Carbonation pretreatment, for example, recovers REEs at high efficiency but converts PG into a different by-product that carries its own handling and disposal costs.

PHOTO: HATCH

Rare earth recovery thus poses an opportunity to create a value-added co-product while reducing the land requirements for phosphogypsum stacking.

Additionally, for these types of mid-stream recovery processes, existing plant facilities must be modified to accommodate the new process routes. This poses a risk to the recovery and quality of the primary product, especially when extra levels of complexity are added, such as recycle streams.

The time is now

Historically, the lowest-cost option available to producers for handling and storing PG has been gypsum stacks. This default assumption is no longer true, however, with new regulatory and economic drivers encouraging the greater valorisation of PG.

The push to diversify rare earth supply has led to major economic incentives being specifically aimed at lowering the market entry barrier for new participants. Since 2020, government-led funding for rare earth projects has reached the multi-billion-dollar range[7]. This includes investments, loans, promised funds, trade deals, etc.

In 2025, the US Department of Defense took a $400 million equity position in MP Materials, paired with a ten-year offtake agreement guaranteeing a $110/kg price floor for NdPr products[7]. USA Rare Earth also secured up to $1.6 billion in US government funding, alongside $1.5 billion in private sector investment in early 2026, bringing the total available capital for their integrated mine-to-magnet strategy to roughly $3.1 billion[8].

In Australia, Arafura Rare Earths has advanced its Nolans project with a $1.6 billion funding package backed by export credit agencies in the United States, Canada, Germany and South Korea[9]. Nolans is particularly relevant to this discussion because its ore body contains significant phosphate minerals alongside its rare earth content, enabling the co-production of merchant-grade phosphoric acid (MGA) to offset mining costs.

Guaranteed price-floors and offtake agreements have helped de-risk rare earth recovery projects and protect producer margins from oversupply, price crashes and broader market volatility.

Government R&D funding aimed at establishing rare earth processing outside of China is also specifically relevant to PG. In December 2025, the US Department of Energy's Office of Critical Minerals and Energy Innovation issued a notice of funding up to $134 million to support demonstration-scale facilities to recover rare earths from unconventional feed streams, including feedstocks from acid mine drainage, mine waste or other deleterious materials[10]. These types of programmes present significant funding opportunities for research and development into REE recovery from PG.

Competitive advantages for phosphate producers

Global demand for phosphoric acid is increasing from two directions, both of which will ultimately contribute to increasing PG generation: firstly, conventional fertilizer applications and, secondly, lithium iron phosphate (LFP) battery production. This extra demand will ratchet up the pressure on phosphate producers as they face increasing scrutiny over their land use and closure liabilities for gypsum stacks.

More positively, tighter environmental regulation of phosphogypsum may push phosphate producers to pursue rare earth and radionuclide recovery as a way to convert a liability into a cleaner, saleable product. What is potentially beneficial for these projects is the higher proportions of HREEs in phosphate ores, a factor which materially increases the potential revenue from the rare earth co-product.

A large driver of cost in many mining and metallurgy projects is often the cost of mining the resource in the first place. The main advantage with pursuing rare earth extraction from PG, therefore, is that the primary mining and beneficiation are already covered by the existing phosphate production process. This means the incremental capital and operating cost associated with rare earth recovery may be significantly lower than for a greenfield project.

Lastly, and perhaps most importantly, phosphate producers can bring a competitive edge to this market. While the current high influx of investment is enabling junior miners and start-ups to develop rare earth projects, incumbent phosphate producers bring industrial maturity, access to skilled labour, project execution experience and established supply chain networks. For new participants, in contrast, establishing these capabilities can require additional cost and time.

Phosphate producers are therefore well placed to tap into the REE opportunity, and leverage their existing assets, while addressing the growing PG by-product problem within their own operations.

Hatch is here to help

Hatch is uniquely positioned to help new and existing phosphate producers navigate the technical and commercial transition into rare earth co-production. In 2018, Hatch was engaged by Arafura Resources as the lead engineering study manager for the Nolans project and completed the definitive feasibility study (DFS) in 2019. Recently, Hatch was awarded the engineering, procurement, and construction management (EPCM) contract for Nolans in Arafura's final investment decision (FID) published in May 2026.

Hatch brought a similar depth of experience when entering a strategic partnership with USA Rare Earth in 2023 – by supporting the construction of two rare earth separation and magnet production facilities in Texas and Oklahoma. Hatch's extensive experience across both the phosphate and rare earth sectors enables us to offer clients complete engineering solutions, from prefeasibility through procurement to construction. ■

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Vateris: a new route to premium SOP

Novel technology from UK start-up Vateris combines potassium hydroxide with gypsum and captured carbon dioxide to deliver high-purity potassium sulphate (SOP). Samples from the company's pilot plant are currently being assessed as part of an early stage collaboration with leading fertilizer sector players. **Nicolas White**, Commercial Director, Fertilizers, at Vateris outlines the company's innovative and sustainable production process and this promising new source of SOP for high-end agriculture and other markets.

A crossroads moment

Today, the global potassium sulphate (K_2SO_4, SOP) market finds itself at an interesting crossroads.

Demand for chloride-free potash fertilizers continues to grow, driven by the expansion of high-value horticulture, precision agriculture and water-soluble fertilizer applications. At the same time, producers face increasing pressure to reduce their carbon emissions, manage energy costs and secure a reliable supply of raw materials.

Against this backdrop, UK technology company Vateris is advancing a new approach to SOP manufacture that addresses several of these challenges simultaneously.

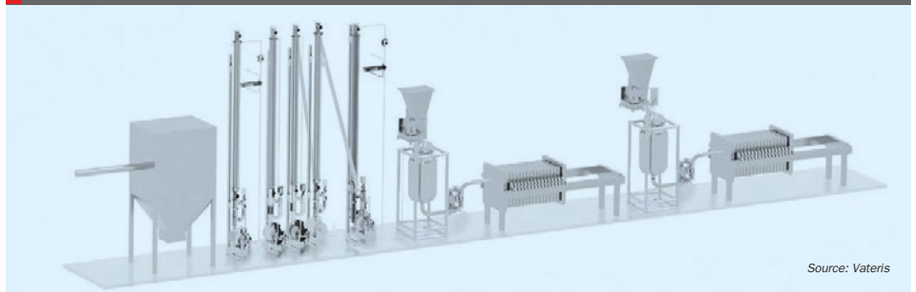
Founded in Nottingham in 2021, Vateris has spent several years developing and scaling-up a novel patented process (Figure 1). This combines gypsum, potassium hydroxide and captured industrial carbon dioxide to produce two valuable products: high-purity SOP fertilizer and a specialist calcium carbonate material for the construction sector.

Although still in the scale-up phase, the company believes its technology has the potential to establish an entirely new production route for SOP, providing the market with an additional source of premium, chloride-free potash, while simultaneously incorporating carbon dioxide into useful products.

PHOTO: CRU

Vateris' pilot production plant, Nottingham, UK.

Fig. 1: **Schematic of Vateris' pilot process. This novel patented technology combines gypsum, potassium hydroxide and captured industrial carbon dioxide to produce two valuable products: high-purity SOP fertilizer and a specialist calcium carbonate material for the construction sector.**



Source: Vateris

Looking beyond conventional production

SOP is produced commercially using a variety of technologies, each with its own advantages and limitations.

The Mannheim process remains the dominant production route globally and has proven itself over many decades. Alternative sources include naturally-occurring sulphate-rich mineral deposits, as well brine-based operations and production based on the glaserite process using sodium sulphate feedstocks, including waste streams.

What Vateris offers is a very different proposition.

Rather than relying on sulphuric acid as the sulphate source, advantageously, the company's process uses gypsum (calcium sulphate, $CaSO_4.2H_2O$) instead. Carbon dioxide captured from industrial emissions is then incorporated into the process, ultimately becoming part of the company's trademarked calcium carbonate co-product.

The process can consume either mined primary gypsum or secondary by-product sources. The latter includes the large volumes of phosphogypsum (PG) generated by the fertilizer industry during phosphoric acid production – PG being one of the most widely available sulphate-bearing materials in the world.

Vateris calculates that approximately 250 kg of CO_2 is permanently sequestrated by their production process (as calcium carbonate 'GypCarb' product) for every tonne of SOP produced.

This ability to transform what would otherwise be an industrial emission into a valuable raw material sits at the heart of the company's technology platform. Indeed,

PHOTO: VATERIS

Nicolas White, Commercial Director, Fertilizers, Vateris.

an independent *Climate Impact Forecast Validation Study* conducted by Impact Forecast concluded that the process has the potential to remove significantly more greenhouse gases than it generates. The study concluded that:

"By developing carbon negative vaterite as a supplementary cementitious material that turns concrete into a carbon-absorbing material and producing a fertiliser co-product, the company offers a scalable solution that removes 2.8 times as much greenhouse gases as it emits."

The result is a production system that addresses two industries with substantial decarbonisation challenges: agriculture and construction.

Quality at the centre

For fertilizer manufacturers, distributors and growers, however, product performance remains the primary consideration. Vateris has therefore placed considerable emphasis on the quality characteristics of its SOP product.

Independent analysis of material produced from the pilot process – carried out by SGS – has shown potassium content exceeding 52% K_2O, a sulphur percentage of just above 18% and a chloride concentration well below 0.5%. Impurity levels are also reported to be comfortably within the limits established by the EU's Fertilising Products Regulation.

The use of potassium hydroxide as the potassium source plays a vital role in this quality profile. Unlike potassium chloride, it introduces no chloride into the process, helping create a highly pure final product.

Vateris has adopted the slogan 'Purity Redefined' for its SOP offering, reflecting its aim to deliver a product suitable for the most demanding fertilizer and industrial applications. Purity is particularly valued in the rapidly growing water-soluble fertilizer (WSF) market, where dissolution

PHOTO: CRU

High quality SOP produced by Vateris from its pilot production plant in Nottingham UK.

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characteristics and low insoluble content are becoming increasingly important.

Modern fertigation systems – used to deliver dissolved nutrients to crops via drip irrigation – leave little margin for inconsistency. Growers require WSFs that dissolve rapidly and completely, avoiding the filter blockages and irrigation issues that can result from excess insoluble material. Fertilizer blenders likewise demand high-purity SOP products that can be incorporated seamlessly into premium formulations.

Vateris believes its recrystallisation process can deliver both strong chemical specifications and the physical performance required by these increasingly demanding applications.

Addressing supply chain challenges

The planned market entry by Vateris also looks timely.

Its arrival comes at a time of growing discussion about SOP's long-term supply security and its production economics. Energy costs, for example, remain a major consideration across Europe.

At the same time, sulphur and sulphuric acid markets are currently experiencing extreme market tightness and price volatility, creating additional uncertainty for producers that rely on these feedstocks. Notably, the sulphur price has exceeded $1,000/t at times this year.

The fact that Vateris, by utilising gypsum as its sulphate source, is not exposed to sulphur and sulphuric acid supply shortages and pricing provides a competitive advantage.

Its technology also operates at ambient temperature, unlike the high-temperature reaction conditions associated with conventional SOP technologies such as the Mannheim process. This should offer meaningful energy advantages as the technology scales up.

Importantly, Vateris is not positioning itself as a replacement for existing production routes. Instead, the company sees itself as an additional provider of SOP, via its patented technology, at a time when demand for premium low-chloride fertilizers continues to expand.

Currently, global SOP demand is growing at around 2-3% annually, with some higher-value, water-soluble market segments expanding even faster. As a result, many industry observers expect additional SOP production capacity will be necessary over the coming decade.

Making commercial scale-up a reality

Like many successful industrial technology ventures, Vateris' journey has progressed through a series of carefully managed development stages.

The company's pilot facility in Nottingham is already producing representative SOP material for customer evaluation and application testing. Current pilot capacity is around 50 kg per day, providing sufficient volumes for qualification programmes with prospective partners and off-takers.

The next milestone is the construction of a demonstration plant, currently targeted for 2027. This facility is expected to produce up to two tonnes per day of SOP, creating the opportunity for broader market testing and early commercial sales.

This demonstration phase is needed to provide prospective customers with the confidence that comes from operating at a meaningful industrial scale – generating the performance data necessary for larger commercial projects.

Looking further ahead, Vateris plans to commission its first full-scale commercial production plant during 2028-2029. Initial SOP design capacity is expected to be approximately 50,000 tonnes per annum, with further expansion anticipated thereafter.

Over the longer term, the company sees a pathway to production volumes of up to 300,000 tonnes of SOP annually by 2033 through multiple plant operations and potential licensing partnerships.

> **"An essential success factor in our scale-up is partnerships with established manufacturers. We're already exploring joint industrial development with our strategic investor Holcim, for example. As we enter our next phase, we're seeking that same relationship with a major fertilizer industry player," Jeremie Rombaut, Chief Commercial Officer, Vateris.**

Building strategic partnerships

One notable aspect of the Vateris story is the calibre of industrial partners already involved.

The company has attracted investment and support from major players in the construction materials sector, including Holcim, reflecting confidence in the potential of its calcium carbonate co-product.

There is also growing interest from the fertilizer industry. In this sector, Vateris is actively seeking strategic relationships spanning product offtake, supply chain collaboration, industrial co-location opportunities and investment partnerships. Several fertilizer sector offtake agreements have already been signed, with other discussions ongoing.

The company believes these partnerships will play a key role in accelerating commercial deployment of its SOP technology, while ensuring that future production capacity aligns closely with market requirements.

An innovative technology worth watching

The fertilizer industry has never lacked innovation. Yet very few new SOP production platforms have emerged with the potential to operate at significant scale.

That fact alone makes Vateris an interesting company to watch.

Its combination of readily available feedstocks, carbon utilisation, ambient-temperature processing and the production of a high-purity SOP product offers a distinctive addition to the industry's technology portfolio.

Clearly, much work remains to be done. Demonstration plants must perform, commercial economics must be proven at scale and long-term partnerships must be secured.

But, if the company succeeds in translating promising pilot plant results into industrial reality, the market will gain something increasingly valuable: a new source of premium SOP that combines product quality, supply chain resilience and a significantly lower carbon footprint.

For a fertilizer sector tasked with feeding a growing population – while reducing its environmental impact – that is a proposition likely to attract considerable attention in the years ahead. ■

CMD

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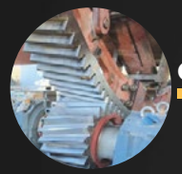
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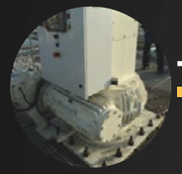
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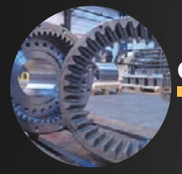
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CMD Gears – perfecting thickening and clarification

CMD Gears is the French market leader in mechanical power transmission. In the phosphate industry, the company enjoys an excellent reputation for its drive heads used in thickeners and clarifiers. These provides the main rotational and translational movement for the mixing rake in large settling tanks several tens of meters in diameter. CMD's durable and reliable drive heads are based on DURAND® gearboxes, featuring classic 'Archimedes' worm drive geometry (ZA profile), and are particularly suitable for low-speed operation. Robustness and precision are essential for the proper functioning of these installations.

Sedimentation–a natural phenomenon

Settling is a liquid-solid separation technique based on sedimentation. This phenomenon allows suspended particles to settle from a liquid under gravitation.

During settling by gravity, suspended matter sinks to the bottom of tanks where it forms a sludge. This is then collected by pumping it from the bottom of the (usually conical shaped) tank. The exact process used differs depending on whether the aim is to increase the concentration of solids (thickening) or to obtain a clear liquid from a diluted suspension (clarification).

Recovering solids and clarified water

Phosphate rock sourced from a variety of deposits is used in the manufacture of fertilizers. Globally, major producers specialise in phosphate extraction, processing and sales.

Phosphate fertilizer production consumes large quantities of water, exactly how much depending on the ore type and processing operations such as froth flotation. To address this problem and avoid excessive consumption, increasing emphasis is being placed on water recycling during settling.

Typically, smaller particles (fines) and flotation rejects are sent to the settlers during beneficiation – these unts being used to thicken the sludge and recover the clarified water. As already stated, recovery is based on particle sedimentation, with the falling speed of particles varying according to their density.

Over time, particles move to the bottom of the settler and the clear liquid rises to the surface. The settling operations is improved by adding a flocculent to the feed to speed up the sedimentation process. Decantation then provides both clear liquid flows and a solids-rich sludge.

Once processed, the phosphate rock concentrate is then delivered to the chemical plant to be transformed into phosphoric acid (merchant-grade or purified) and finished fertilizers.

PHOTO: CMD GEARS

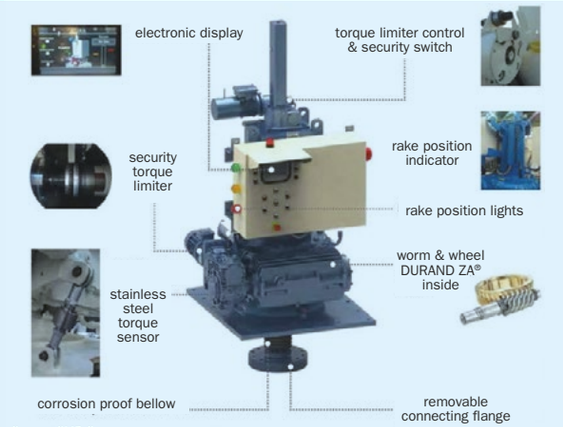
CMD Gears drive heads: purely mechanical model (blue paintwork) for a French OEM who will then integrate the electrical components; complete model (white paintwork) equipped with a control cabinet, motors and sensors for direct delivery to the customer.

CMD Gears – the go-to company for drive heads

CMD Gears has been designing and manufacturing drive heads for the phosphate industry for over thirty years. Nearly two hundred systems have already been installed, mainly in North Africa and Asia.

CMD's drive head systems (Figure 1) are installed above settling tanks and are used to rotate and move a rake (a shaft fitted with blades) up and down, thereby agitating the slurry stored within the tank. Incorporating worm gear reducers based on the DURAND® ZA profile, CMD's drive heads combine maximum load capacity with an exceptionally long service life.

Fig. 1: **Key features of the drive heads manufactured by CMD Gears**



Source: CMD Gears

The drive head can rotate the rake horizontally and move it up and own vertically (translation) simultaneously or independently. Each drive head incorporates motors with enhanced protection features to withstand the phosphate industry's harsh operating environments. The motor-to-gearbox connections are also fitted with torque-limiting couplings to safeguard the drive system in the event of an overload.

In addition to these mechanical safeguards, a torque measurement system is integrated to monitor load conditions in real time. Depending on the torque thresholds, warnings and actions are triggered automatically.

CMD Gears supplies an electrical control cabinet to operate the drive head and manage the various sensors. The sensors monitor the vertical position of the rake, real-time torque values and indicate when the torque threshold is exceeded.

The drive head operates in several modes:

- **Local operation** – an operator next to the unit controls the rotation or translation of the rake horizontally and vertically.
- **Remote operation** – an operator controls the system from the control room using all the data sent from the drive head unit.
- **Semi-autonomous mode** – the rake moves up or down depending on changes in torque.

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ISSN: 0015-0304

Design and production:
TIM STEPHENS

Printed in England by:
Buxton Press Ltd
Palace Road, Buxton, Derbyshire, SK17 6AE

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ISSUE 534
SEPTEMBER-OCTOBER 2026

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