ESPP SCOPE Newsletter n°160 – July 2026

This SCOPE Newsletter summarises key discussions and outcomes from the CRU Phosphates and Potash Conference, held in Paris, 13-15 April 2026, bringing together industry leaders, market analysts, policy stakeholders and technology providers, and the online workshop organised by ESPP to contribute to the IFA ongoing work on an action roadmap for direct and indirect climate emissions from the phosphate and potash fertiliser industries, 16 April 2026, with over fifty participants.

CRU Phosphates+Potash Expoconference 2026

The CRU Phosphates+Potash Expoconference 2026 in Paris brought together around 400 delegates, confirming its role as a key global platform for market intelligence and industry networking. Combining both commercial and technical agendas, the event provided a comprehensive overview of the phosphate and potash sectors across market dynamics and operational developments. Discussions took place against a highly volatile global backdrop marked by geopolitical tensions, supply disruptions and fertiliser price instability, while the technical programme focused on innovations and technologies aimed at improving efficiency, margins, environmental performance and production capacity.

CRU Phosphates Conference website. The next CRU's Phosphates+Potash conference will be held in Rome, 16-18 March 2027, alongside Nitrogen+Syngas and Future of Fertilizers expo-conferences. Abstract submission is open to 21st August 2026.

Market outlooks

Fertilisers

Humphrey Knight, CRU, analysed the major disruptions affecting global fertiliser markets following the escalation of the Middle East conflict and the resulting closure of the Strait of Hormuz to most marine traffic. While energy markets have attracted most public attention, fertilisers have experienced some of the most direct impacts, especially phosphates, ammonia, urea and sulphur, due to the Gulf region's central role in global exports.

Fertilizer affordability deteriorates

Nitrogen fertilisers have recorded the sharpest price increases since the start of the conflict, while phosphate and potash prices have risen more moderately. However, the main concern is fertiliser affordability (expressed as the ratio between crop prices and fertiliser prices) rather than absolute price levels. Unlike during the Russia-Ukraine crisis, higher fertiliser prices are not being supported by rising crop prices, as the Middle East is not a major grain-exporting region. As a result, CRU's fertiliser affordability index has deteriorated back to levels comparable to the most challenging periods of 2022.

Phosphate margins and raw material pressure

Rising sulphur and ammonia prices are increasingly compressing phosphate producer margins (the difference between finished fertiliser prices and key raw material costs), reversing the favourable economics that had supported high phosphate production throughout much of the 2020s. DAP and MAP prices, currently around USD 800–900/t, remain exceptionally high by historical standards, although elevated raw material costs are beginning to undermine producer profitability. In addition, traditional price advantage of superphosphate products such as TSP and SSP is narrowing as indirect market effects spread across the value chain.

Chinese export restrictions effect global supply

The tightening of the phosphate market was identified as a structural issue extending beyond the Middle East crisis itself. Chinese export restrictions on DAP and MAP are the dominant structural driver, with exports potentially falling below 3 Mt/y in 2026 after China announced restrictions until at least August. At the same time, Chinese domestic phosphate production remains at record levels, while export restrictions have extended to additional phosphate-containing products. However, many Chinese producers are now facing negative margins as sulphur costs rise above government-controlled DAP prices, creating uncertainty regarding future Chinese production and export policies. In addition, US phosphate production continues to decline structurally, particularly in Florida, due to deteriorating phosphate rock quality and resource depletion. Other major producers, including Morocco, Russia and Saudi Arabia, appear unable to rapidly increase output to compensate for the shortfall.

Although several phosphate projects remain under development, little additional DAP/MAP capacity is expected before the late 2020s. Chinese export policy therefore remains the key uncertainty shaping global phosphate availability. While CRU's base case assumes some recovery in Chinese exports from 2027 onwards, the outlook remains highly uncertain and tighter restrictions cannot be excluded.

Phosphate rock

Maria Gamboa-Delgado, CRU, presented CRU's phosphate rock market outlook, identifying a structural shift in the global grade mix as the main driver of phosphate rock price divergence since 2021. Increased availability of lower-grade material alongside tightening high-grade supply has created a persistent premium for high-grade rock, a trend expected to continue over the medium term. The impact of the Middle East conflict on phosphate rock markets was described as indirect but significant, particularly through rising transport costs, sulphur and ammonia costs.

Diverging supply dynamics between low and high-grade rock

Phosphate rock prices rose sharply from late 2021, reaching record levels in 2022 before easing through 2023–2025. The P_2O_5 content has become the key differentiating factor (not heavy metal contaminant levels), with high-grade rock maintaining historically elevated price levels while lower-grade prices have returned closer to historical averages. Morocco's phosphate rock exports declined after 2021, falling from historical averages of around 10 Mt/y/year to below 7 Mt/y, while exports increasingly focused on four key strategic markets: Turkey, Mexico, India and the EU. At the same time, lower-grade supply expanded significantly through increased production from Jordan, Egypt, Algeria and other producers, whereas high-grade supply remained structurally constrained following the sharp reduction in Russian exports after the invasion of Ukraine, with European buyers most affected. The net result is a simultaneous increase in lower-grade rock availability and a structural tightening of high-grade supply.

Structural shift in the global grade mix

This change in global grade composition is the central structural market development. Producers are increasingly diverting high-grade ore towards domestic downstream production rather than export markets, while lower-grade categories account for a growing share of global trade. For instance, from 2017 to 2024, Moroccan exports of lower-grade rock more than doubled, while high-grade supply remained broadly stable. In Jordan, lower to medium-grade supply held steady while high-grade exports declined significantly. Although total product tonnage remains relatively stable, global phosphate supply is effectively tightening if measured in tonnes of P_2O_5 rather than tonnes of rock, sustaining the current premium for high-grade rock.

Integrated producers to drive future demand growth

Global phosphate rock production capacity is expected to expand significantly by 2030 (net capacity additions of 31 Mt compared to 308.9 Mt for 2025), including major projects in Saudi Arabia, China and Algeria. However, most new production is expected to support domestic downstream industries rather than export markets. Demand growth is therefore expected to be increasingly driven by integrated producers, while high-grade supply is likely to remain structurally tight over the medium term, due to domestic consumption.

Andy Jung, Mosaic, presented the current phosphate market from the perspective of a major integrated fertiliser producer, focusing on producer margins, raw material costs and global supply risks.

He highlighted the combined impact of rising sulphur and ammonia costs, Middle East supply disruptions and Chinese phosphate export restrictions on producer margins and global fertiliser availability and affordability. Phosphate producer economics deteriorated sharply from late 2025 onwards as raw material costs increased faster than finished fertiliser prices. He warned that prolonged disruption of the Strait of Hormuz could significantly reduce global fertiliser supply in 2026, with potential consequences for global grain production and food security. He additionally highlighted the growing interest among phosphate producers in critical minerals recovery (see the section on critical minerals), and Mosaic is evaluating rare earths and other critical minerals recovery opportunities both in Brasil and Florida. He reminded that the US phosphate industry was historically also a significant uranium producer.

Feed Phosphates

Alan Lec'hvien, Phosphea (Roullier Group), presented an overview of the global feed phosphate market and the main trends shaping animal feed production and phosphorus demand. Global feed production continues to grow steadily, reaching 1.3 billion tonnes in 2024, with Asia representing almost half of total production.

China remains the world's largest feed producer, while India is also becoming an increasingly important market. Europe was identified as the only declining regional market globally, with feed production decreasing by around 1% annually due to changing dietary habits and lower consumption of animal proteins, although the market still represents close to 200 Mt/y. Spain remains the leading European producer and the seventh largest globally.

Poultry feed accounts for almost half of global feed production, while demographic growth and rising incomes continue to support demand for animal proteins worldwide. At the same time, feed markets are increasingly affected by inflation, geopolitical tensions, animal disease outbreaks, environmental concerns and changing consumption patterns, particularly in Europe.

Feed phosphates remain an essential component of animal nutrition despite representing only around 0.5–1% of feed formulations for monogastric animals. The global feed phosphate market currently stands at around 7 Mt/y and is characterised by significant structural overcapacity, with approximately 11 Mt/y of installed production capacity globally. Europe alone has around 2 Mt/y of capacity for a market of only 1.1 Mt/y.

Feed phosphate prices are primarily driven by phosphoric acid and P_2O_5 prices, alongside currency fluctuations and the intensity of regional competition. Feed-grade phosphoric acid supply remains particularly challenging, as only a limited number of producers are able to meet the strict impurity limits for fluoride, cadmium and arsenic. The feed sector is therefore increasingly competing for high-quality phosphoric acid supply with fertilisers, food, technical phosphates and the growing LFP battery sector.

PHOSPHEA, part of the Roullier Group (ESPP member),, whose largest subsidiary is Timac Agro (fertilisers, biostimulants), operates five feed phosphate production plants, in Tunisia, Spain, Serbia, Brazil and France (Saint-Malo, Brittany), with a combined production capacity of around 1 Mt/y. The company purchases all of its phosphoric acid externally. Beyond standard feed phosphates, PHOSPHEA also develops higher value-added nutrition products tailored to specific animal species and applications. See ESPP Scope Newsletter n. 155

Elemental phosphorus (P_4)

Robert van Spingelen, ESPP, and Willem Schipper, Willem Schipper Consulting, examined the global elemental phosphorus (P_4) market, strategic industrial applications and current supply chain vulnerabilities.

Elemental phosphorus market and strategic applications

Although P_4 represents only around 2% of global phosphate use by volume, it accounts for a higher commercial value due to its role in specialised downstream chemicals. Around half of global P_4 demand is linked to glyphosate production (herbicide), while the remainder is used in high-value applications which are only possible by elemental phosphorus chemistry.

P_4 has a strategic importance across several industrial sectors: it is notably required for the production of $LiPF_6$, the standard electrolyte salt used in lithium-ion batteries, as well as for photovoltaic-grade silicon doping and several organophosphorus compounds used in electronics, aerospace and metal extraction (see also ESPP SCOPE Newsletter n. 136 and n. 159)

Global production is concentrated in four main regions: China, Vietnam, Kazakhstan and the United States. The United States is a largely closed system, with most production absorbed domestically, primarily for glyphosate manufacturing. China remains the largest producer but processes most of its P_4 domestically into downstream derivatives (part of which is exported), with high export taxes designed to discourage raw P_4 exports. Vietnam has consequently become the main export supplier for international markets, while Kazakhstan supplies primarily Europe and India. India is one of the fastest-growing P_4 markets globally, driven by expansion of its chemical and battery industries.

P_4 prices increased sharply from pre-2020 levels of around USD 2 000 – 3 000/t to USD 4 000 – 6 000/t during the 2022 commodity spike, before partially easing thereafter. However, the P_4 market experienced significant disruption in 2026 due to issues affecting Vietnamese producers, combined with shipping route disruptions and structurally declining P_2O_5 grades in Vietnamese phosphate rock. These factors reportedly contributed to an approximately 50% increase in Vietnamese P_4 prices during 2026. Building new P_4 capacity remains particularly challenging due to the highly specialised nature of phosphorus furnaces, the dependence on specific phosphate rock qualities and the very high electricity requirements of the P_4 production process (thermal reduction of P_2O_5 to P_4).

P_4 as a Critical Raw Material in the EU

P_4 is currently listed as a Critical Raw Material under the EU Critical Raw Materials Act. As said, the EU is fully import-dependent for elemental phosphorus, sourcing mainly from Vietnam and Kazakhstan, while simultaneously relying on P_4 for several strategic sectors including renewables, batteries, electronics, aerospace and fire safety applications. The ongoing reassessment of the EU Critical Raw Materials list represents an important opportunity to strengthen recognition of both P_4 and purified phosphoric acid as "Strategic" Raw Materials for European industry. ESPP is actively involved in discussions at EU level, including participation in the CRM Week 2025, the SCRREEN reassessment of the CRM list, coordination of a joint industry positions on the strategic importance of P_4, and currently 'testing' of P_4 as potentially an EU "Critical Molecule" under the Critical Chemicals Alliance

To reduce import dependence and strengthen supply security, several emerging technologies are currently being developed in Europe with the aim of recovering elemental phosphorus (P_4) or organo-phosphorus precursors from secondary phosphorus-rich materials and waste streams, including projects such as Flashphos, ThermusP, Tohoku University (all ESPP members).

Sign the Joint Declaration calling for Phosphorus (P_4 and derivates) and Purified Phosphoric Acid to be in the EU Strategic Raw Materials List: contact info@phosphorusplatform.eu

Sulphur

Viviana Alvarado, CRU, presented an overview of the global sulphur market, concluding that sulphur prices, currently at their highest levels since 2008, are being driven by a structural supply deficit started in 2023 and further exacerbated by the Middle East conflict. Although the conflict intensified market tensions, prices had already been increasing strongly since 2025 due to supply disruptions in Russia, maintenance at Kazakhstan's Kashagan field and strong demand growth from Indonesia's nickel sector.

Global sulphur production grew by only 0.3% year-on-year in 2025, reflecting disruptions in Russia and stagnating Middle East supply. For 2026, Middle East sulphur production is expected to decline by around 1.3 Mt/y, with Qatar particularly affected as 70–80% of production capacity is reportedly offline. While new gas-related projects in the United Arab Emirates and Saudi Arabia are expected to support recovery from 2027 onwards, the outlook remains highly dependent on the evolution of the regional conflict.

The phosphate sector remains the largest sulphur consumer globally and is currently facing severe affordability pressure. In China, the sulphur/phosphate affordability ratio has risen to around 141%, compared to a 10-year average of approximately 40%, while sulphur prices have become higher than domestic DAP prices, a historically unusual situation. Chinese phosphate producer margins have consequently become negative, while OCP has reportedly brought forward maintenance at some facilities and Brasilian SSP producers have reduced or halted operations. By contrast, the metals sector, particularly nickel processing in Indonesia, has remained relatively resilient despite higher sulphur prices.

The Middle East currently accounts for around 45% of global sulphur export supply, with approximately 17 Mt/y exposed to disruption through the Strait of Hormuz. Despite the conflict, regional sulphur production continues and significant volumes are currently accumulating as inventory. Once export routes fully reopen, this stock build-up could partially ease price pressure, although CRU expects sulphur prices to remain structurally elevated even if some correction occurs.

Batteries

Sam Adams, CRU, and Mariana Fortuna, CRU, presented an overview of lithium iron phosphate (LFP) battery demand and its implications for phosphate markets. Although LFP currently represents a relatively small share of total phosphate demand, it is emerging as a fast-growing and high-value segment.

LFP ($LiFePO_4$) is used as cathode material in LFP batteries, requiring around 2 kg-LFP per kWh or 1.16 kg-P_2O_5 per kWh. Battery quality LFP can be produced from purified phosphoric acid or technical monoammonium phosphate, and not from P_4.

Electric vehicles (EVs) remain the largest market in absolute terms, but energy storage is the dominant growth driver, supported by falling system costs and increasing focus on energy security and grid resilience. Growing applications include solar energy storage, AI data centres and residential storage systems.

China dominates the LFP supply chain

China continues to dominate almost the entire LFP value chain, from phosphoric acid processing through to cathode and battery production. Most global phosphate demand related to LFPs is expected to remain concentrated in China over the next 5–10 years, where LFP demand could account for around 10% of domestic phosphate rock consumption within five years. However, the Chinese market is currently experiencing a "bullwhip effect", with battery cell and cathode production expanding significantly faster than actual installations, creating inventory build-up and market distortions. This overproduction is also temporarily increasing phosphate chemical consumption.

A major technological shift is also underway with the development of fourth-generation LFP cathodes, characterised by more densely compacted materials enabling either faster charging or higher energy density. China has imposed export restrictions on the equipment and know-how required to manufacture these advanced cathodes, effectively limiting producers outside China to older third-generation technologies. At the same time, an LFP supply chain outside China is gradually emerging, particularly in the US and South East Asia, driven by geopolitical supply chain diversification strategies.

Opportunities and challenges for Western phosphate suppliers

The speakers identified iron phosphate production as the key bottleneck in the global LFP supply chain, with almost all commercial-scale production currently located in China, as Fe-sulfate is a byproduct of the titanium industry in China. Chinese competitiveness is supported by very low production costs and close integration with domestic chemical industries. As a result, many non-Chinese projects continue to rely on Chinese precursor imports even when downstream battery manufacturing occurs elsewhere.

For Western phosphate producers, the main opportunity was identified as lithium dihydrogen phosphate (LiH_2PO_4), a precursor material for next-generation LFP cathodes, produced from purified phosphoric acid. Demand for this material is constrained mainly by limited supply capacity, while higher purity requirements may support premium pricing. However, qualification timelines for new battery materials remain very long, meaning that strategic partnerships between lithium, phosphate and cathode producers need to be established well in advance of commercial production.

Sustainability

Stephen Bell, IFA, and Daniel Saxton, ERM, presented about the Global Low-Carbon Roadmap for the Phosphate and Potash Fertiliser Industry, which is a project fully sponsored by the EBRD and being developed by ERM with support from Systemiq.. Building on the success of IFA's past collaboration with EBRD to develop the IEA's 2021 Ammonia Technology Roadmap, the project seeks to establish technology pathways and emissions methodologies tailored specifically to the phosphate and potash industries. As part of IFA's wider Fertilizer Industry Decarbonization Initiative, the project was launched in 2025 and will conclude in June 2026.

Fertiliser production and use account for a substantial share of food-system greenhouse gas emissions, while existing decarbonisation frameworks still lack phosphate- and potash-specific guidance. The roadmap covers a broad range of emission sources including mining energy use, electricity consumption, phosphoric acid process emissions, transport and use-phase emissions.

Near-term decarbonisation measures identified include energy efficiency improvements, heat recovery and renewable electricity integration, while longer-term options involve electrification of drying processes, carbon capture technologies and alternative phosphoric acid production routes. The roadmap also highlighted growing concerns over future sulphur availability, as increasing competition from battery metals production and other industries could affect the economics of conventional sulphuric acid-based phosphate production.

The speakers additionally stressed the importance of financing mechanisms and policy support, including concessional funding, CBAM-related measures and environmental attribute certificates linking downstream emission reductions with lower-carbon fertiliser production.

Jens-Michael Bergmann, TOMRA Sorting GmbH, and Yassine Taha, UM6P (Université Mohammed VI Polytechnique), presented a pilot project in Morocco focused on recovering value from phosphate mine waste rock through sensor-based ore sorting technologies. The initiative forms part of broader circular economy and "near-zero waste" ambitions of OCP, targeting large waste rock stockpiles historically accumulated over decades of phosphate mining. More than 20 million tonnes of phosphate mine waste rock are currently stockpiled annually at OCP's Benguerir mine alone, containing coarse low-grade phosphate material with P_2O_5 levels around 11%. The objective of the pilot plant is to recover a marketable phosphate product while simultaneously producing silica-rich fractions and secondary mineral streams suitable for applications in construction and agriculture.

The project uses TOMRA's X-ray Transmission (XRT) sorting technology, which separates particles based on differences in X-ray attenuation related to their atomic composition and density. The dry sorting process enables phosphate-rich apatite material to be recovered from silica-rich chert and other waste lithologies without the use of water. The pilot operation comprised a mobile screening plant installed at an OCP waste rock stockpile and an XRT sorting plant located at the UM6P experimental mine site, with a processing capacity of approximately 50 t/h for particle sizes between 20 and 60 mm.

According to the pilot results presented, the process upgraded phosphate content from c. 11% P_2O_5 in the feed material to ca. 18% P_2O_5 in the recovered phosphate-rich fraction, while significantly reducing silica content. P_2O_5 recovery from the feed was around 85%. These results demonstrate the potential of sensor-based ore sorting to unlock value from historical phosphate mine waste streams while supporting OCP's circular economy and resource-efficiency objectives.

Technology and innovations

Anna Dikova and Axel Yakub, Technophos, presented the company's pilot-scale phosphate processing and technology development platform focused on valorising low-grade phosphate ores, tailings and complex phosphate materials. Technophos has a fully equipped R&D centre in Varna, Bulgaria and develops and scales technologies from laboratory level up to semi-industrial demonstration scale (from TRL 2-3 to TRL 5-7), supporting process validation and reducing scale-up risks for industrial projects. Technophos focuses on technologies to process low-grade phosphate rock unsuitable for conventional wet-process phosphoric acid production. For instance, soft digestion with diluted hydrochloric acid, Technophos has demonstrated the production of dicalcium phosphate (DCP) from ores with low P_2O_5 content, high silica and high impurity levels, as well as from beneficiation tailings and slimes. The product is suitable for feed-grade application or for phosphoric acid production. Pilot and semi-industrial trials reportedly achieved phosphorus recovery yields around 75–85% in the examples cited.

Dikova and Yakub also presented work on chemical beneficiation, selective impurity removal, membrane purification technologies and custom-designed pilot equipment for filtration and process optimisation. The overall objective is to recover additional phosphate content from difficult raw materials and industrial waste streams while improving resource efficiency and sustainability within the phosphate industry.

Timothy Cotton, Novaphos, presented several "unconventional" phosphate production approaches aimed at improving supply security, reducing dependence on high-grade phosphate rock and sulphur, and enabling smaller or more regional phosphate projects. Conventional wet-acid process, while highly optimised and still dominant globally, face increasing constraints linked to phosphate rock quality, sulphur supply, phosphogypsum disposal and the need for large-scale operations.

Several case studies were presented:

- reprocessing old phosphate tailings in Florida to recover phosphate using modern flotation technologies. The project has already produced and sold commercial grade material, with upgrades underway and operations expected to restart in 2027 at around 1 Mt/y/year of concentrate production;
- offshore phosphate dredging in Mexico (PhosAgMex), using marine dredging technologies already established in other sectors. The project is currently progressing through environmental and regulatory approvals before moving towards production;

- production of “smart” phosphate fertilisers such as PhoSul, combining phosphate rock and sulphur to improve phosphate availability and reduce input needs;
- Novaphos’ thermal process (previously known as JDC, see ESPP SCOPE Newsletters n°s 141 and 86), designed to convert low-grade phosphate rock or mine tailings into relatively high-purity phosphoric acid without sulphuric acid and without generating phosphogypsum;
- Novaphos process aimed at recovering sulphur from phosphogypsum while producing calcium silicate as a potentially valuable co-product for construction applications.

Juan Hailer, Ingetecsa, presented the company’s pilot plant and testing capabilities for phosphate and feed phosphate production processes. Ingetecsa, a Spanish engineering company specialised in drying, cooling and solids handling technologies, develops modular pilot-scale systems for process optimisation, product validation and scale-up testing. The presentation highlighted flexible pilot configurations covering pre-reaction, main reaction, granulation, drying, cooling, milling, sieving and de-dusting operations for feed phosphates. In the piloting process, individual process steps should be tested separately rather than through fully continuous pilot lines, allowing better optimisation of formulations, additives, process parameters and equipment design.

Ingetecsa presented pilot capabilities for several feed phosphate products, including dicalcium phosphate (DCP), mono-dicalcium phosphate (MDCP), monocalcium phosphate (MCP), magnesium phosphate and sodium calcium phosphate in powder, microgranular and mini-granular forms, and the mobile pilot units installed in 40-foot containers, allowing on-site product testing, validation and small-scale production runs directly at customer facilities.

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Lelik Harmayanto Purbawinasta and Delphia Luthfiananda, Petrokimia Gresik, presented operational optimisation work carried out at the company’s phosphoric acid plants in Indonesia after shifting from high-grade to lower-grade phosphate rock in order to reduce raw material costs. The company highlighted that phosphate rock represents around 70–80% of phosphoric acid production costs, while phosphoric acid itself accounts for 40–60% of NPK production costs. Petrokimia Gresik operates two hemi-dihydrate phosphoric acid plants with combined capacity of 400 kt/y P_2O_5. This process is highly sensitive to phosphate rock quality, making the transition to lower-grade rock operationally challenging. Lower-grade rock increased silica and impurity levels, creating operational problems as abrasion of rotating equipment, screen overload, heat exchanger scaling and sludge formation.

They company therefore implemented a series of process modifications to address these issues, including silica removal through settling tanks, lower pump speeds to reduce abrasion and extend pump life, replacement of rock screening systems with new ones with higher tilt angles, chemical cleaning of heat exchangers using hexafluorosilicic acid recovered on-site, and integration of thickeners to reduce sludge formation. These optimisations allowed the plants to successfully process lower-grade phosphate rock while significantly improving operational stability and increasing phosphoric acid production rates by around 39–52%.

Text not validated by speakers.

Alexandre Andrade, Metal7, presented roller screening technology for phosphate fertiliser granules as an alternative to conventional vibrating screens. The presentation focused on reducing maintenance, dust, noise and product losses associated with vibrating screening systems. Roller screens operate without vibration, using rotating rollers to separate material through adjustable gap openings. The company presented test work on dried TSP granules aimed at removing fines below 2 mm. Results showed screening efficiencies above 90%, with fines in the final product reduced from around 25% in the feed to 0.7–2.5%, depending on screen configuration. The company stated that the technology has already been widely deployed in iron ore pelletising for decades and is now being adapted for phosphate fertiliser applications with relatively limited modifications.

Phosphogypsum

Phosphogypsum (PG) is the main by-product generated during wet-process phosphoric acid production. It consists predominantly of calcium sulphate dihydrate ($CaSO_4 \cdot 2H_2O$) and contains residual impurities including unreacted phosphate, fluorides, silicates, organic matter, trace metals and naturally occurring radionuclides. Approximately 4–6 tonnes (dry basis) of PG are generated per tonne of P_2O_5 produced. Fresh PG typically contains 15–30 wt% moisture, depending on the production process and dewatering conditions. Global phosphogypsum production is estimated at around 250 Mt per year (dry basis), yet only around 15–35% is currently valorised, mainly in low-value applications such as soil amendments or limited construction uses. The remaining material is commonly stockpiled in large gypstacks, creating long-term environmental liabilities, storage costs and regulatory challenges, particularly related to groundwater contamination, dust emissions and naturally occurring radioactivity.

Tibaut Theys, Prayon, discussed the growing challenge of phosphogypsum (PG) management and the increasing focus on valorisation pathways. Regulatory frameworks remain one of the main barriers to wider PG reuse. In some regions, particularly the United States, PG is still classified as hazardous waste, severely limiting valorisation opportunities, while the sector increasingly needs to treat PG as a by-product rather than as waste, with applications adapted to local conditions and gypsum quality.

Several valorisation routes were presented, including mine backfilling (common in China), use in road and railway foundations, agricultural applications, construction materials, sulphuric acid recovery, rare earth extraction (from some types of gypsum, see also the *Critical Minerals section below*) and recovery of radioactive elements (radium) for medical applications. Agricultural use was identified as one of the largest and most mature applications, particularly in Brasil where PG is widely used as a sulphur source and to reduce aluminium phytotoxicity in acidic soils. Phosphogypsum quality remains the key factor determining possible applications, particularly impurity levels such as radioactivity, P_2O_5, fluorine and heavy metals. Prayon presented several technologies aimed at improving gypsum quality, including dihydrate-hemihydrate conversion processes and chemical cleaning technologies capable of reducing heavy metals and radioactive impurities. Economic viability of valorisation processes remains a major challenge given the relatively low market value of gypsum products. Help of experts, support from authorities and partnership in the industry are needed for shifting from viewing PG as a disposal problem toward considering it as a potential secondary raw material.

Jan van Esch, GEA Niro, presented technologies for improving PG quality and enabling wider industrial reuse. Phosphogypsum quality requirements vary significantly depending on the final application. Uses such as underground applications are less sensitive, while applications including cement or plasterboard require much lower phosphorus, acidity and chloride contents. He presented ways of improving solid-liquid separation technologies to remove soluble impurities from PG and obtain higher-purity products. Among these: centrifuges, wash columns and melt crystallisation-based systems. Wash column technologies were presented as a promising route capable of significantly improving impurity removal while reducing wash water consumption and acid dilution compared to conventional filtration systems.

Van Esch also presented examples from other industries where wash column technologies achieved substantially higher purification performance than centrifuges, and noted that pilot testing is now underway for PG applications. Cleaner PG streams could improve suitability for higher-value applications while reducing drying costs and process losses. *Text not validated by speaker.*

Mohamed Kamar, Arab Fertilizer Association (AFA), presented an approach for phosphogypsum (PG) valorisation focused on the cement industry, one of the few sectors able to absorb PG at sufficiently large scale. The route converts PG into a cementitious product, contributing both to PG management and to cement-sector decarbonisation. Depending on the metallic reductant, the process can target a calcium-aluminate cement (aluminium route) or a calcium-silicate supplementary cementitious material/pozzolan (silicon route) able to partially replace clinker.

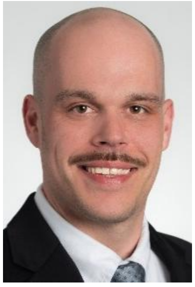
The conversion uses a metallothermic process, replacing traditional carbothermic reduction routes (expensive, energy-intensive, high CO_2 footprint) with metallic reductants such as aluminium or silicon. The reaction recovers sulphur (as SO_2 for sulphuric-acid production) while generating the cementitious material, and is exothermic, liberating recoverable energy. Compared with older carbothermic approaches, the proposed route was presented as potentially offering lower CO_2 emissions and the ability to process wet PG without pre-drying.

Preliminary bench-scale tests reportedly showed promising results, with amorphous reaction products displaying characteristics compatible with pozzolanic materials. The process also aims to utilise industrial by-products such as aluminium dross, ferrosilicon fines and silicon-cutting (kerf) waste as reductants, improving overall circularity and economics. The concept remains at an early development stage and still faces several technical and economic challenges, including reductant costs, reactor design, impurity variability, gas management and validation of cement performance. Pilot-scale testing and a techno-economic assessment are planned as the next development steps."

Critical minerals and rare hearth elements

Rare earth elements (REEs) are a group of 17 chemically similar elements that are essential for a wide range of strategic technologies, including permanent magnets for electric motors and generators (electric vehicles, wind turbines …), catalysts, batteries, electronics and defence applications. Although REEs are not geologically rare, they are rarely found in high enough concentrations to be economically extracted and are technically difficult to separate and purify. Heavy rare earths (HREEs), which are generally less abundant and higher value, are particularly important for advanced technologies.

Global demand for REEs is expected to continue growing rapidly, driven primarily by permanent magnets used in EVs, renewable energy systems and strategic industries. At the same time, the REE value chain remains highly concentrated in China, especially in downstream processing, separation and magnet manufacturing, creating increasing geopolitical and supply chain concerns. This has led governments, particularly in the United States, to significantly increase investments and support for non-Chinese REE supply chains and processing capacity.



Willis Thomas, CRU, gave an overview of the growing strategic importance of critical minerals associated with phosphate rock deposits, particularly in the context of the energy transition and with geopolitics impacting supply. Existing and upcoming phosphate rock mines could become an increasingly important secondary source of critical materials including rare earth elements (REEs), vanadium, uranium, gallium and germanium.

Critical minerals are defined not only by geology, but also by supply concentration, market opacity, limited substitution possibilities, recycling constraints and geopolitical risks. The demand for many of these materials is expected to rise significantly over the next decade due to EVs, wind turbines, semiconductors, long-duration energy storage and nuclear power.

The presentation reviewed the potential for phosphate rock deposits and phosphate processing streams to contribute to supply of several critical elements:

- REEs are identified as the most promising opportunity, particularly heavy rare earths used in magnets and strategic technologies;
- vanadium could become increasingly important due to growth in vanadium redox flow batteries;
- uranium recovery from phosphate has historical precedent but currently appears less strategic due to wider uranium availability;
- gallium and germanium remain niche but potentially valuable opportunities depending on phosphate rock composition.

Recovering critical minerals from existing phosphate operations could create additional non-fertiliser revenue streams, improve waste valorisation and strengthen Western supply-chain resilience with lower CAPEX than standalone mining projects. However, such projects introduce technical complexity, market volatility and dependence on the economics of the primary phosphate operation.

Lyndsay Tran, Hatch, explained REE recovery opportunities from phosphate processing streams, particularly phosphogypsum (PG). Phosphate ores naturally contain REEs and most of them transfer to PG and to clarifier sludge during wet-process phosphoric acid production. Literature reviewed by Hatch suggests that 70–80% of feed REEs typically end up in PG, making it the main target for potential recovery. She reviewed several PG REE extraction approaches studied in literature, including direct acid leaching (H_2SO_4, HCl, HNO_3), resin-in-pulp systems and carbonation pre-treatment. The main technical challenge is that REEs are often incorporated directly into gypsum crystal structures, making them difficult to leach efficiently. While some methods achieved relatively high recovery rates at lab scale, no process has yet been widely commercialised. Tran Hatch also highlighted why phosphate producers may be better positioned than junior mining companies to develop REE recovery projects: the phosphate rock is already being mined and processed, infrastructure and operating expertise already exist, and growing PG volumes that will be produced due to the high phosphate demand may create additional incentives to valorise gypsum streams rather than expand stack storage.

David Högnelid, LKAB Minerals, presented the company's project to recover phosphoric acid, REEs and gypsum as by-products from its iron ore operations in northern Sweden. LKAB currently mines around 80% of EU iron ore and generates apatite-bearing tailings from iron ore beneficiation, which the company now aims to valorise as part of a broader circular and critical raw materials strategy. Phosphate, along with REEs, are currently removed during iron ore processing because phosphate is undesirable in steelmaking. Rather than depositing the separated apatite-rich material in tailings ponds, LKAB plans to recover it through a new apatite beneficiation plant at Malmberget (north Sweden), followed by hydrometallurgical processing in Luleå. The planned process uses hydrochloric acid in a circular loop to produce phosphoric acid, REE concentrate and high-purity gypsum suitable for the construction industry. LKAB highlighted that the phosphoric acid produced from its igneous apatite iron ore contains very low cadmium levels and is intended for high-end applications. Planned production capacity is approximately 170 000 tonnes P_2O_5 per year, linked to iron ore extraction volumes at the Malmberget mine (see eNews newsletter n. 26)

The presentation also highlighted the Per Geijer deposit near Kiruna, described as Europe's largest known rare earth deposit, with significantly higher phosphorus and REE concentrations than LKAB's current ore bodies.

Three LKAB projects — Malmberget, Luleå and Per Geijer — were designated Strategic Projects under the EU Critical Raw Materials Act in 2025 (see ESPP eNews 97). LKAB is currently constructing an €80 million demonstration plant in Luleå, expected to start commissioning in 2026 ahead of a potential full-scale industrial complex planned for 2028–2031.

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Webinar on climate impacts of phosphate fertiliser use

Summary of an online workshop organised by ESPP to contribute to the IFA ongoing work on an action roadmap for direct and indirect climate emissions from the phosphate and potash fertiliser industries, 16th April 2026, with over fifty participants.

Low-carbon roadmap for the phosphate and potash fertiliser industries

Stephen Bell, International Fertilizers Association (IFA), and **Rupert Simons, Systemiq,** explained that IFA has around 500 members worldwide, including the fertilisers industry, related companies and organisations, service providers, research organisations, NGOs, and more. IFA actively works on the sustainable production and use of plant nutrients, including supporting research (e.g. Scientific Panel on Responsible Plant Nutrition).

There is demand for low carbon inputs across the food chain and IFA has supported global guidance for reducing climate emissions from nitrogen fertilisers in 2021 (Ammonia Technology Roadmap, Scope 1 and 2 emissions *) and in 2022 (Reducing emissions from fertilizer use, Scope 3 emissions *).

This work is now extended to phosphate and potassium fertilisers, with the aim of developing by summer 2026 a **Low-carbon Roadmap for the Global Phosphate & Potash Fertilizer Industry** (to be previewed at IFA's "Cultivating Tomorrow" conference, 3-4 June 2026, and published in the following weeks), see in ESPP eNews n°103. The aim is to define science-based ambitions for industry, covering both fertiliser production and use. This is funded by the European Bank for Regional Development, and delivered by ERM and Systemiq. Four stakeholder workshops have been organised, including one dedicated to sustainable phosphate production and use in Morocco.

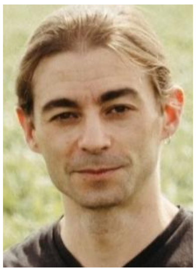
Initial results suggest that maybe a quarter of P and K fertiliser emissions are embedded in raw materials used in their production, and over half are from nitrous oxide emissions related to fertiliser use. P or K fertilisation on their own do not directly result in nitrous oxide emissions (although some emissions may be generated because P or K fertilisation can stimulate plant growth and soil microbial activities which can increase nitrogen metabolism and so nitrous oxide emissions). These attributed nitrous oxide emissions are because P and K are generally applied in blended and compound DAP, MAP and NPK fertilisers, for which the nitrogen content can lead to nitrous oxide emissions by transformations in soil. These emissions can be reduced by around - 50% improving crop Nitrogen Use Efficiency and by around - 25% with use of nitrification inhibitors. Further reductions can be achieved by system changes such as changes in diet, use of nitrogen-fixing crops in agricultural rotations, but these cannot be counted to fertiliser industry Scope 3 emissions reductions.

The Roadmap will call for actions from the fertiliser industry (including emissions reporting, investment and user support), from governments (in particular, incentivise Nutrient Use Efficient improvements and incite food system changes) and from the agriculture and food chain (standardise Scope 3 purchasing criteria and reporting and provide financial support for low emissions fertilisers).

The need for more research into greenhouse gas impacts resulting from phosphate fertiliser use was underlined, in particular increased carbon storage in crops and soil and climate emissions resulting from phosphorus losses to surface waters.

Patrick Heffer, International Fertilizers Association, noted that Phosphorus Use Efficiency (PUE) is also important because improving PUE will enable lower phosphate fertiliser consumption, and so reduced emissions from production etc., as well as reducing phosphorus losses to surface waters. He noted that PUE has improved significantly worldwide over the last decades (based on the FAOSTAT Cropland Nutrient Balance database).

Phosphorus fertiliser use can reduce nitrous oxide emissions



Andrew Margenot, University of Illinois Urbana-Champaign, presented preliminary data on links between phosphate fertilisation and nitrous oxide emissions in conditions representative of the US Corn Belt, which covers around 35 million hectares of the Midwest USA and produces around a third of global maize and soya.

The results are an inadvertent outcome of work on nitrous oxide emissions from ammonium phosphate fertiliser use (Margenot & Lee, 2023) where mono- and di-ammonium phosphate (MAP, DAP) and magnesium ammonium phosphate (struvite) were tested at two scales: replicated field (6 site-years) and 20 kg greenhouse pot experiments, in conjunction with P only (potassium phosphate) and without P (i.e., negative control). Soils had adequate to high phosphorus based on Mehlich-3, so no crop response was expected from the P application which was intended to balance crop P removal (maintenance application). Results suggest small increases to no changes in nitrous oxide with P input in soil with lower organic content, but a nearly one third reduction of nitrous oxide losses (-1.7 kg N_2O-N/ha) with P input in soil with higher organic content.

Mathew Scholz, US Sustainable Phosphorus Alliance, noted that Gebremichael et al. 2022 showed, in temperate grasslands, reduced nitrous oxide emissions with long-term P fertilisation (25 years), but in some cases increased carbon dioxide emissions (because of stimulation of soil respiration), see summary in ESPP eNews n°85.

Phosphorus losses to waters and aquatic methane emissions

Pierre Regnier, Université Libre de Bruxelles, and **Pete Raymond, Yale University**, outlined current knowledge on impacts of phosphorus loading on methane emissions from lakes.

See also the ESPP SCOPE Newsletter n°135 special issue on aquatic methane emissions and climate change.

Methane accounts for around one third of anthropogenic greenhouse warming. The updated IPCC (International Panel on Climate Change) 2025 methane budget (https://doi.org/10.5194/essd-17-1873-2025) has increased the estimate of methane emissions from "natural" inland water systems to around 250 Mt-CH_4/y, of which around half are estimated to result from human activities (artificialisation and reservoirs, eutrophication). These numbers are very uncertain. Estimates for lakes are based on data from less than two hundred lakes, compared to around 1.4 million lakes worldwide (2.7 million km^2) reported in global databases, which are highly varied. Lake methane emissions are also driven by climate warming and are overall thought to have been increased by a factor of 3 – 4 x from historic levels.

Different models of lake methane emission mechanisms can help improve emission estimations and predictions. Models combined with available data suggest that lake methane emissions in northern temperate and high-latitude regions are driven mainly by climate change, whereas in tropical regions the main driver is eutrophication. Methane emissions from lakes in the EU are probably currently decreasing as phosphorus loadings to surface water have been reduced.

David Bastviken, Linköping University, Sweden, presented further understanding of links between phosphorus inputs and methane emissions from aquatic systems.

Experimental evidence shows that aquatic methane emissions are promoted by fresh organic matter produced by primary production in the water, which in turn often is phosphorus limited. More phosphorous-rich aquatic systems also being more productive tend to emit more methane. Methane production requires anoxic conditions and is based on sequential organic matter degradation by first fermenting and then methanogenic microbes. Microbial methanogenesis is reduced by sulphate, iron-III and manganese in seawater, which limit methane production in marine waters (because these ions benefit non-methanogenic bacteria which can outcompete methanogenic bacteria).

Methane emissions from aquatic ecosystems occur via many pathways of which two potentially large ones are episodic, e.g. release of bubbles from sediments and emissions upon lake mixing. In hydropower reservoirs, emissions can also occur by hydro-electric turbine degassing. The net emission is also influenced by methane oxidation in the aquatic systems, which can remove large fractions of the methane before it reaches the atmosphere. Methane oxidation can take place in sediments and in water both in summer and in winter underneath ice.

Despite little direct evidence of a link between phosphorus inputs and methane emissions, studies do show that chlorophyll levels are linked to methane emissions, and the phosphorus – chlorophyll link is well proven.

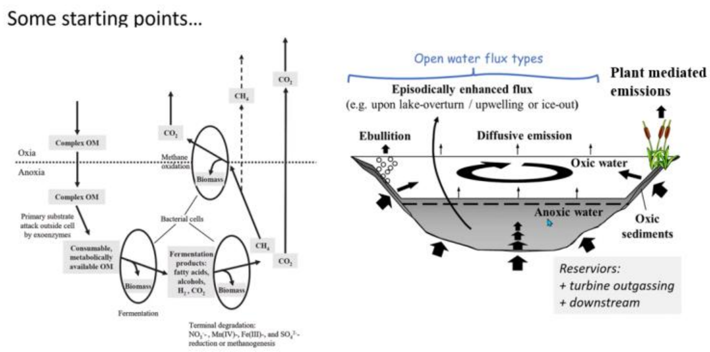
In a recent paper, Wang et al. 2026 estimate that human activity has multiplied methane emissions from rivers by around 2.5x worldwide. They estimate methane emissions from nutrient-enriched rivers at near 10 Mt-CH_4/y and that this could be reduced by a quarter to one half by reducing phosphorus and ammonium nitrogen inputs to these rivers.

Other links to aquatic greenhouse emissions

In **discussion**, the question of possible **impacts of phosphorus losses to water on aquatic CO_2 burial** was raised. In some cases, studies show that nutrient inputs to lakes can increase net carbon burial. However, webinar participants suggested that the impact on climate is probably small compared to methane emissions, because organic carbon in sediments of eutrophic lakes is generally low, showing low carbon sink effect over time. Relevant studies and discussion are presented in ESPP eNews n°105.

Participants raised the question of possible **inhibition by phosphate inputs to waters of conversion of oxic phosphonate to methane**. This was considered to be probably not significant because levels of phosphonate in natural waters are low.

Recent modelling of **continental shelf seawaters** suggest that here nutrient inputs (from river systems) may lead to carbon sinkage, but also possibly to N_2O emissions. This is however complex because of interactions with marine sediments.



Conclusions

From this webinar presentations and discussions, the following general conclusions can be drawn:

- Impacts of anthropogenic phosphorus losses to surface waters are probably a significant contribution to climate change
  - methane emissions are responsible for maybe 25-30% of global warming
  - a quarter to a third of anthropogenic methane emissions result from anthropogenic nutrient losses to surface waters

  → thus, a**nthropogenic nutrient losses are responsible for maybe 10% of anthropogenic climate change**
- Estimates of methane emissions from waters are very uncertain, and **estimates of the impact on these of nutrient losses even more highly uncertain**. More research is needed to develop better data and predictive tools.
- Methane emissions may be particularly driven by nutrient losses in **tropical regions**. Methane emissions from surface waters in Europe are probably falling because nutrient losses have been reduced.
- Because nutrient losses do not result directly from phosphate fertiliser use, but are related to crop and soil management, and also come from other sources (e.g. sewage, manure), **resulting methane emissions cannot be accounted to fertiliser industry Scope 3** (but could possibly be accounted to Scope 3 for agriculture).
- Phosphate fertiliser use also impacts greenhouse emissions from fields (e.g. in some cases reducing nitrous oxide loss, or increasing CO_2 sinkage or release) but data is today inadequate. In reality, **phosphate fertiliser is almost always applied with nitrogen, and climate impacts of this accompanying nitrogen will generally be much more significant**.

ESPP online workshop on "Climate emissions from phosphate fertiliser use", 16th April, watch on YouTube [here]

** Scope 1 emissions are greenhouse gases from a company's own assets. Scope 2 emissions are those from production of electricity supplied to the company. Scope 3 emissions are all other indirect emissions resulting from the company's operations, (e.g. from employees driving to work), resulting from production of materials or services used by the company, resulting from downstream use of the company's product (e.g. from cars sold by a manufacturing company, over the car's life). See discussion at https://climate.mit.edu/explainers/scope-1-2-and-3-emissions*

ESPP members