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BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England

Tel: +44 (0)20 7793 2567

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New Kingisepp plant



North African phosphates

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Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Big Easy ideas



The International Fertilizer Association (IFA) is bringing its Global Technical Symposium back to the United States this spring. Taking place in early April in New Orleans, Louisiana, the event will be hoping to build-on last year's record-breaking attendance.

Fertilizer International is once again pleased to support the Global Technical Symposium as IFA's official media partner. The 2019 Symposium will look at how United Nations Sustainable Development Goals are likely to affect fertilizer production out to 2030.

While the industry largely knows what the desired end-point is for sustainable fertilizer manufacturing – the decarbonisation of production and a step-change in water, energy and resource efficiency – how to get there is less clear cut.

Ironically for an event being held in the Big Easy, the future challenges facing fertilizer producers are anything but that. If only there was one big easy idea that allows business to operate sustainability, giving equal weight to people, planet and profit.

Well, in fact there might be. It's called the circular economy – and IFA's New Orleans Symposium has dedicated a whole session to looking at how it applies to fertilizer production.

Currently, our take-make-dispose economy is largely linear, with about 80 percent of the mined and harvested materials that are made into products being thrown away within a couple years. The idea behind the circular economy is simple: it is about capturing and keeping resources in economic circulation rather than sending them to landfill. In a circular economy, products are designed to be made again through repeated cycles of disassembly, refurbishment and remanufacture.

The major fertilizer manufacturers are starting to think circular too. In January, Yara International and Veolia agreed to combine their business might to scale-up nutrient recycling (see page 8). The new partnership hopes to begin closing the nutrient cycle by joining together the start and the end of today's linear food production chains.

The two partners will collaborate on new business models for high-quality fertilizer production based on nutrient recycling. They are also looking to create reverse 'food-to-agriculture' value chains by collecting and processing food surpluses in cities.

McKinsey & Company – by diligently scoping the potential environmental and economic benefits – has done much to convince multinationals and large corporations of the merits of the circular economy. An initial report for the Ellen MacArthur Foundation in 2012 estimated EU-wide savings of \$340-380 billion annually from adoption of the circular

economy by makers of vehicles, washing machines and mobile phones.

The consultancy giant turned its attention to food, drink and clothing in its subsequent 2013 report. This concluded that switching to a circular economy could save the consumer goods sector as much as \$700 billion globally in resource costs.

The UK's Ellen MacArthur Foundation has also long championed the circular economy. The Foundation's latest report *Cities and Circular Economy for Food* was released to coincide with the World Economic Forum in Davos in January.

The report highlights the fact that cities will consume 80 percent of global food production by 2050. It goes on to make a case for a shift towards 'regenerative' food production located in and around our major cities. The adoption of such an approach could potentially unlock annual benefits worth \$2.7 trillion to the world food system, the report estimates. The associated environmental benefits include greenhouse gas emission savings of 4.3 billion tonnes CO₂ equivalent.

Taken at face value, this kind of disruptive innovation is completely anathema to the conventional model of mineral fertilizer production. Yet, on closer examination, many of the ideas and business models contained within the report are almost identical to those being proposed by Yara and Veolia. The emphasis on collecting and processing food surpluses in cities and developing organo-mineral fertilizers for peri-urban agriculture is very much the same.

The closure of nutrient loops being pioneered by Yara is also at the heart of what the *Cities and Circular Economy for Food* report is championing. "Discarded organic resources can be turned into an array of valuable products," the report proposes. "From low-tech organic compost to innovative, high-value bio-materials, nutrient looping can help regenerate peri-urban farming areas and create new economic activity in the city."

It is clear that some major fertilizer producers such as Yara agree.

The fertilizer production technologies and business models of the future are only now emerging – their viability untested. What we do know, though, is that inventiveness and collaboration become imperative during times of change. Given the need for imagination and improvisation, IFA's convening of the Global Technical Symposium in New Orleans, the home of jazz, suddenly makes sense.

S. Inglethorpe

Simon Inglethorpe, Editor

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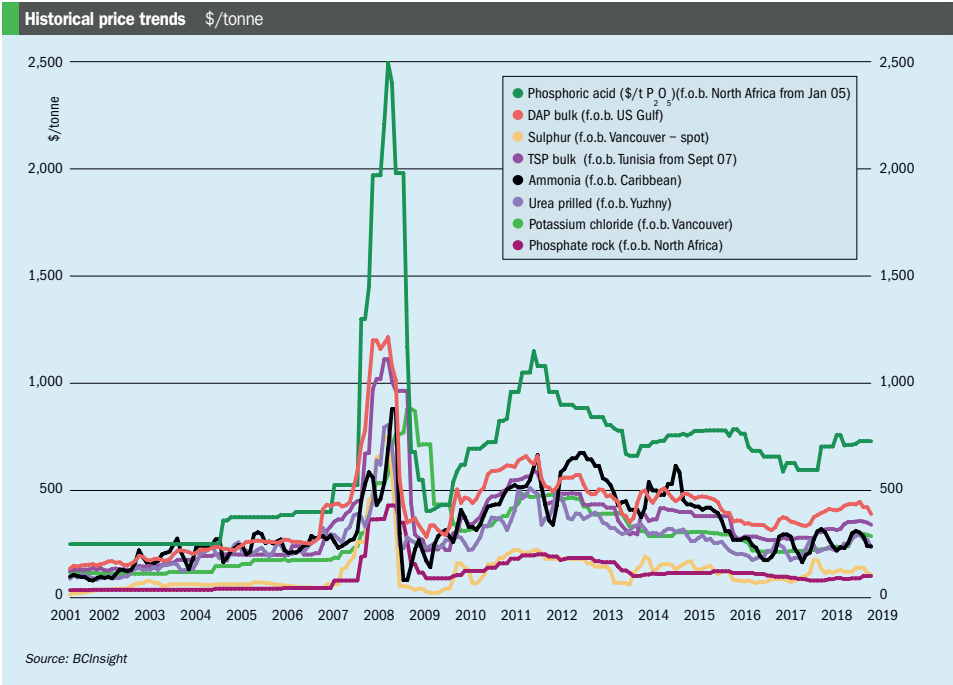
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Market insight courtesy of Argus Media

Urea: The market finally found some stability at \$235/t f.o.b. Middle East in March, a fall of \$50/t from the \$285/t level seen at the start of the year. Chinese export availability this winter has been much higher than the market had anticipated, because of the milder winter and increased gas inventories compared to winter last year. China shipped 1.9 million tonnes in total between October 2018 and January 2019, almost 600,000 tonnes up on the same period last winter. Iranian urea continues to ship to buyers willing to skirt US sanctions. The Chinese re-export channel used to ease Iranian exports into South Asia last year appears to have all but closed.

The urea market also saw the opening of four new urea plants at the turn of the year: Arcon's Novgorod VI in Russia, Chambal's Gadepan III in India, Garabogaz in Turkmenistan and Socar in Azerbaijan. Together these plants will provide additional urea capacity of almost four million tonnes this year.

Ammonia: The market stabilised in February. There is also optimism that the current spate of tamarounds could provide more weeks of stability, despite March/April being the market's traditional quiet spring period. Turkish buying has been robust over the past month. This has helped stabilise Yuzhny prices and Atlantic markets west of Suez. Disappointing fall and spring ammonia applications in the Midwest cornbelt, however, mean that stability is the best the market can hope for.

At the time of writing, Sorfert's ammonia line was still down for maintenance, along with SAFCO III in Saudi Arabia and QAFCO I in Qatar. Output from Trinidad, in contrast, remains at a high level, with spot cargoes from the Caribbean covering lost output from Algeria over the last month.

Phosphates: The market was soft through January and February with major import markets remaining out of season. On average, major DAP benchmarks fell to below \$410/t f.o.b. in February, down from \$410-450/t

f.o.b. in 2018's last quarter. China and US Gulf benchmarks dipped below \$400/t f.o.b.

OCP settled 2019 phosphoric acid contracts with its Indian partners at \$750/t, an \$18/t discount on the previous settlement.

Chinese producers continue to focus on the domestic market due to a lack of global demand. In Brazil, MAP demand remains weak, as it is still slightly early for the upcoming soybean season. In Australia, flood damaged caused Incitec Pivot shut its 975,000 t/a Phosphate Hill plant, adding some bullish sentiment to Oceania.

Potash: Upward spot price momentum in some key markets slowed in early 2019. In February, the standard Vancouver MOP price levelled off at \$288/t f.o.b., for example, and the granular MOP reference in Brazil was also down a dollar at \$353/t cfr. The seasonal lull in MOP demand has been longer this year, particularly in Brazil. The Southeast Asia tender season has also disappointed. Greater buying interest has, however, now resumed in Europe and Brazil. In Europe, granular MOP prices gained \$7/t in January-February, reaching \$308/t f.o.b.

Chinese SOP and MOP exports have both risen on the removal of fertilizer tariffs at the beginning of 2019. MOP and SOP exports increased to 36,000 tonnes and 7,000 tonnes, respectively, in January for, rising from virtually zero in the same month last year. China has a large volume of unutilised SOP capacity and low SOP prices. There is high risk of some Chinese SOP production making its way in to the international market, to the detriment of international prices.

Sulphur: Global prices initially softened through January and February before stabilising and finally rebounding slightly. Major markets have now experienced their fourth consecutive monthly price drop. February Middle East price postings reflected sluggish demand and weakness in downstream Chinese and Indian markets. March heralded a turning point, though. Producers posted stable-to-firm sulphur prices for the month, ranging \$106.50-\$108/t Middle

East f.o.b. China spot prices also ticked up slightly at the end of February. However, sentiment needs to improve further before a significant price recovery is seen. On the trade front, China's sulphur imports for 2018 dropped four percent, falling to below 11 million tonnes for the first time since 2014. The rise of Chinese domestic sulphur supply from the country's oil and gas sector is expected to continue to erode import requirements.

Market price summary \$/tonne – End-February 2019

Nitrogen	Ammonia	Urea	Ammonium Sulphate	Phosphates	DAP	TSP	Phos Acid
f.o.b. Caribbean	240	-	f.o.b. E. Europe 112-140	f.o.b. US Gulf	380-390	-	-
f.o.b. Yuzhny	260-280	230-240	-	f.o.b. N. Africa	390-432	330-350	720-740
f.o.b. Middle East	270-285	233-255**	-	cfr India	400-405	-	750*
Potash	KCl Standard	K ₂ SO ₄	Sulphuric Acid		Sulphur		
f.o.b. Vancouver	267-307	-	cfr US Gulf	90-110	f.o.b. Vancouver	100-115	-
f.o.b. Middle East	272-317	-	-	-	f.o.b. Arab Gulf	106-110	-
f.o.b. Western Europe	-	500-520	-	-	f.o.b. N. Africa	120-135	-
f.o.b. Baltic	250-320	-	-	-	cfr India	120-135	-

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

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MARKET OUTLOOK

- Urea:** In general, prices look stable over the near term. Emerging US demand should support prices in what looks set to be a very strong year for Midwest urea demand. EU demand is also expected to pick-up in the next 4-6 weeks. However, there is very little expectation that robust US demand alone can trigger a sustained recovery in urea values. This has left overall optimism for spring demand muted. The outlook beyond March is bleaker still. We are expecting a further downward price adjustment linked to a forecast supply surplus in the second-quarter. EU spot gas prices have fallen below \$6.00/MMBtu, and could decline further as weather warms in the spring. Lower gas prices (\$5.00-6.00/MMBtu) will move the urea market floor downwards towards the \$200/t level, if the urea oversupply is substantial next quarter, with further downside if gas prices fall below this range.
- Ammonia:** Market conditions look set to worsen beyond April with full production at Eurochem's Kingisepp plant scheduled for May/June. Commissioning has already started and the plant is rumoured to be operating at around 50 percent of its one million t/a nameplate capacity. Ammonia deliveries to EuroChem's Russian phos-

phate assets and Belgian nitrate and NPK assets will, however, remain the company's priority. Ammonia prices are forecast to remain stable at around \$270/t f.o.b. Middle East during March, before losing \$10-20/t of their value early in the second-quarter. Kingisepp's start-up could push Middle Eastern f.o.b. values as low as \$230-240/t by June, although robust summer demand should eventually lift prices by July. All in all, we expect ammonia to price in the \$240-270/t range over the next six months.

- Phosphates:** With the *kharif* season approaching, Indian demand will accelerate through the second-quarter from mid-March onwards. We expect DAP exports to India in the \$400-420/t cfr range, with the lower end of that range netting back to \$385-390/t f.o.b. China and Saudi Arabia. Australia should provide an outlet for Chinese DAP/MAP tonnages as Incitec Pivot's DAP plant in Australia is not expected to re-open until April-May. West of Suez, MAP demand has started to emerge in Brazil, and fundamentals should improve as soybean farmers return to the market. The strengthening of Brazil's currency against the US dollar, should improve affordability and keep the MAP benchmark above \$400/t cfr Brazil. Cargoes from MENA, China and Russia will all be vying for Brazilian

market share, given MAP's attractive premium over DAP.

- Potash:** In the near term, the recent pause in price growth in some markets looks likely to give way to firming values as demand picks up globally. The potash market is unlikely to shift into imbalance just yet, as capacity and supply gains from new MOP mines in Canada and Russia are being offset by closures and production curtailments.
- Sulphur:** Stable sentiment is expected to prevail into March and the second-quarter of the year – with potential for a price recovery if there is a significant improvement in spot markets. The downstream processed phosphates market remains a bearish factor, as does the potential for increased sulphur availability in coming months. These two factors combined may create a ceiling for any meaningful recovery.

Black Sea sulphur shipments are set to resume in April with the seasonal reopening of waterways. Expected 2019 production of 1.2 million tonnes from the Kashagan project in Kazakhstan will also add to spot market availability. Sulphur demand may receive some support from sustained tightness in the sulphuric acid market and high sulphuric acid prices – if captive sulphuric acid production is increased to meet supply shortfalls.

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NORWAY

Yara launches green ammonia and circular economy collaborations

Norway's Yara International is collaborating with the French utility company ENGIE on the use of green hydrogen technology in fertilizer production.

The two companies agreed to carry out a feasibility study together in early February. The goal is to design and integrate a green hydrogen plant with Yara's existing ammonia plant in Pilbara, Western Australia. The Pilbara region is the ideal location for the study, says Yara, due the abundance of sun and seawater – the two key constituents in renewable hydrogen production.

The ultimate goal is to convert the Pilbara plant from its complete reliance on natural gas to an ammonia plant that sources a significant share of its hydrogen needs using renewable power instead. Achieving this goal will help Yara cut Pilbara's CO₂ emissions.

The two partners have much to gain from the new collaboration. ENGIE is aiming to become a major player in renewable hydrogen, for example, while Yara is stepping up efforts towards making carbon-free fertilizers. Renewable hydrogen generation is the starting point for CO₂-free ammonia production – 'green' ammonia – which in turn is a key ingredient for carbon-free fertilizer production.

"Yara and ENGIE have the complementary expertise and experience to take on such a complex project, but the key ingredient in this venture is our mutual commitment to a healthier planet and a sustainable future," said Yves Bonte, Yara's executive vice president for new business.

"This project is in line with ENGIE's goal to be a pioneer in the new energy world, a decarbonized world, accessible to everyone everywhere," added Michèle Azalbert, the CEO of ENGIE Hydrogen.

Because renewable electricity generation from solar and wind sources is highly variable, green hydrogen looks set to become a key component of future energy networks. But reducing the costs associated with producing, storing and transporting green hydrogen will be vital for its future deployment. Valuably, the green hydrogen plant at Yara Pilbara will allow a real-world, real-time analysis of costs and processes.

"Together, Yara and ENGIE are acting to better understand how to make green hydrogen technology work. For Yara, it is of particular importance to understand how this can help us to make our fertilizers carbon-free at an acceptable cost," said Bonte, in conclusion.

Yara has also taken a first step towards integrating fertilizer production with Europe's emerging circular economy. In January, it signed an agreement with French conglomerate Veolia to develop a circular economy approach to nutrient recycling. This involves the creation of nutrient loops.

The idea is to integrate Veolia's access to growing volumes of recovered nutrients – and its expertise in organic materials handling – with Yara's mineral fertilizer production expertise and crop nutrition knowledge. The new partnership hopes to begin closing the nutrient cycle by joining together the start and the end of today's linear food production chains.

"Reducing global resource depletion and nutrient loss by increasing the recycling of nutrients such as nitrogen and phosphorus is an important task," commented Svein Tore Holsether, president and CEO of Yara. "The collaboration with Veolia is a contribution to our mission to responsibly feed the world and protect the planet."

Veolia and Yara have agreed to work together to scale-up



ENGIE's Michèle Azalbert and Yara's Yves Bonte seal the deal.

nutrient recycling. This will require new business models for high-quality fertilizer production based on nutrient recycling. The local recovery, processing, distribution and sales of nutrient products will be a cornerstone of the new circular economy approach.

The two companies will also create reverse 'food-to-agriculture' value chains by collecting and processing food surpluses in cities. This will link together the organic fertilizer expertise of Veolia subsidiary Sede Angilbaud with Yara's market knowledge of organo-mineral fertilizers and soil improvement products – for both rural and peri-urban agricultural markets. Finally, Veolia and Yara will also develop new business opportunities based on industrial symbiosis. The goal will be to integrate nutrient and chemical flows between different industrial companies and sectors, by exchanging by-products, raw materials and waste.

"We are delighted that Yara has chosen Veolia to support its circular economy strategy. Veolia and Yara already aim to have several new initiatives fully operational by 2024, including the launch of new fertilizer products and the start-up of nutrient recovery installations in several major European cities," says Veolia chairman & CEO Antoine Frérot. "The collaboration between our companies is a step closer to effectively closing the nutrient cycle."

A circular economy loop, which recycles ammonia from composting green waste and wastewater sludge, has already been set up by Yara and Veolia. The recycled ammonia is processed to produce sodium nitrate. This chemical is then reused in wastewater treatment plants to prevent odour and corrosion.

The new EU fertilising products regulation will permit and promote the use of recovered nutrients in crop nutrition products. Several EU member state are also putting in place their own national regulations limiting waste disposal and mandating nutrient recovery.

The economic potential of nutrient recycling in the European fertilizer market could be as high as two billion euros, according to some estimates.

To encourage a fundamental redesign of the food value chain, Yara and Veolia are creating an umbrella group, the Nutrient Upcycling Alliance. Farmer associations, food brands, retailers, waste stream managers, and municipal and government bodies, will all be invited to join.

FERTILIZER INDUSTRY NEWS

DENMARK

Haldor Topsoe unveils green ammonia research project

Haldor Topsoe, is collaborating with academia and industry on the new SOC4NH3 research project. The partners will together develop solid oxide cell electrolysis for CO₂-free 'green' ammonia production. The aim is to demonstrate the technology, bringing it much closer to commercial breakthrough.

Topsoe, a world-leader in electrolysis technology and ammonia production, is heading the DKK 26.8 million project. The University of Aarhus, Technical University of Denmark, Energinet, Vestas, Equinor and Ørsted Wind Power are other participants. The Danish Energy Technology Development and Demonstration Program (EUDP) is backing the project through DKK 15.9 million of funding support.

"We expect that ammonia can be used for transportation and efficient storage of energy. The greatest advantage of ammonia is that it has a high energy density which makes it an effective fuel and energy storage option – and it can thereby solve some of the most important challenges of creating a sustainable energy system of the future," said project leader, John Bøggild Hansen, senior principal scientist at Haldor Topsoe.

"In the Foulum research facility we will demonstrate an especially efficient technology which will enable us to produce ammonia solely by using certified windpower, water and air. The method is much more climate-friendly than conventional ammonia production which today makes up as much as one per cent of the world's total energy consumption and CO₂ emissions," said Lars Ottosen, head of biological and chemical engineering, University of Aarhus.

"We see an interesting potential in using ammonia for creating more stable green energy production – one that can be stored – and at the same time start electrifying heavy transport and the chemical industry. With more than 100 GW wind energy installed all over the world, Vestas has demonstrated that wind energy can deliver the large amounts of energy necessary to convert other sectors to a sustainable future," added Bo Svoldgaard, senior vice president, innovation & concepts, Vestas.

The SOC4NH3 project plans to make a major contribution to the energy transition. In doing so, it hopes to strengthen Denmark's leading international position in renewables and other green technologies – providing the country with a strong foundation for future growth, export and jobs.

POLAND

Grupa Azoty secure low-cadmium phosphate supply

Poland's Grupa Azoty has gained access to a supply of low-cadmium phosphate rock for the next two years.

A three-partner supply contract was signed in Switzerland in early February – between Grupa Azoty Police, the buyer, Ameropa, the seller, and Somiva, the producer. The contract, which is worth around \$64 million, expires at the end of February 2021.

The development is a sign that Europe's phosphate fertilizer manufacturers are now moving to secure sources of low-cadmium phosphate rock ahead of the planned introduction of the new EU fertilising products regulation. This will initially introduce a cadmium limit of 60 mg/kg cadmium for phosphate rock placed on the European market. The new regulation is due to become mandatory in 2022 under the current EU timetable.

Grupa Azoty Police has been buying phosphate rock from Morocco and Algeria for many years, supplemented by sourcing



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from Senegal, Israel and Egypt. Phosphate rock is used by the company as a raw material in fertilizer production, mainly being consumed in the manufacture of compound fertilizers.

Its new supplier, Senegalese producer Somiva, has been supplying phosphate rock to customers in Europe, Africa, the Middle East, and North and South America since 2011. The company holds a 25-year mining licence for the Ndiendoury-Ouali Diala phosphate deposits in the country's north-eastern Matam region.

"Given its quality and price, this raw material can be used as a standard, fully viable replacement for currently purchased phosphates," Grupa Azoty Police said in a statement.

"Long-term access to low-cadmium phosphate rock is becoming a priority and a strategic decision for any manufacturer of fertilizers targeting the European market," said Wojciech Wardacki, president of Grupa Azoty Police's management board. "This contract guarantees our access to low-cadmium phosphate rock from a stable source of verified quality – which ensures that EU requirements will be met now and in the future."

CANADA

Nutrien embarks on buying spree

Nutrien moved to acquire three new companies in February.

The buying spree began on 5 February with the purchase of Actagro, a leading US manufacturer of sustainable soil and plant health products.

The \$340 million purchase price for Actagro included around \$20 million in working capital. Nutrien expect the business to generate earnings (run-rate EBITDA) of \$55 million within two years of the deal's closure.

Actagro's two US manufacturing sites in California and Arkansas will now become Nutrien-owned assets as a result of the buy-out. Nutrien will also become the owner of Actagro's lucrative commercial product portfolio.

Actagro manufactures and markets a range of around 30 speciality products. These have a proven track-record of improving crop productivity and delivering financial returns for growers. Actagro products are currently distributed to agricultural markets across global via numerous distributors and retailers, including Nutrien's retail outlets.

Valuably, the purchase also brings with it Actagro's strong research and development team. A nearly complete research and development centre in California will also support the future development of soil and plant health technologies.

"The acquisition of Actagro is aligned with Nutrien's strategy to invest in higher-margin proprietary products that provide strong value for growers," said Chuck Magro, Nutrien's president and CEO. "Actagro has a strong track record of developing and manufacturing high-value crop nutrition products and we see a significant opportunity to expand the business by leveraging the global reach of our retail network."

US regulatory approval of the deal is expected in the first half of 2019.

"Nutrien will continue to use its strong balance sheet and cash flow to prudently allocate capital towards growth opportunities that create value for our customers and our shareholders," Magro added.

Magro's statement of intent was followed three weeks later by the purchase of Ruralco Holdings Limited, one of Australia's leading agriservices businesses, for AUD 469 million.

Nutrien entered into a binding agreement on 27 February to acquire all of Ruralco's shares at a price of AUD 4.40 per share.

The purchase of Ruralco complements Nutrien's existing ownership of Landmark, its well-established Australian agricultural retail network.

"The combination of our Landmark operations with Ruralco in Australia is expected to provide significant benefits for all stakeholders including delivering excellent value for both Ruralco and Nutrien shareholders," commented Nutrien's CEO Chuck Magro.

Rob Clayton, the head of Landmark added: "The combined business will further strengthen the service and innovation that Landmark delivers to Australian growers."

The purchase is subject to Ruralco shareholder approval, and additional regulatory approvals by the Australia Competition and Consumer Commission and the Australian Foreign Investment Review Board.

Nutrien ended February by announcing the acquisition of Van Horn, a leading US retailer and agricultural services provider located in central Illinois.

Van Horn is the 42nd largest agricultural retailer in the US. The 80-year old company currently operates eleven retail outlets serving over 5,000 customers in 18 counties.

"Van Horn has built a strong ag retail business, with a track record of providing high value products and service for growers in Illinois," said Mike Frank, Nutrien's executive vice president and retail CEO. "This acquisition is an attractive addition to Nutrien Ag Solutions' retail network."

Frank added: "We are seeing an acceleration of consolidation within the ag retail industry and this acquisition aligns with our strategy to grow our retail business through acquisitions."

"We are very excited to join Nutrien Ag Solutions and look forward to fully utilizing the expanded platform of products, services and technologies that this transaction will provide," said Dan Mogged, Van Horn's president and CEO.

HUNGARY

Second nitric acid plant at Kazincbarcika

Casale has secured a contract with Borsodchem to supply a new 660 t/d nitric acid plant for its Kazincbarcika site in Hungary.

Nitrogen producer Borsodchem is a subsidiary of China's Wahua Chemical Group.

The new plant is based on Casale's NA2000 dual-pressure process and will produce 68 percent strength acid. An identical unit has been in operation at the Kazincbarcika site since 2012. Casale will supply the technology license and basic engineering, review detail engineering and provide site assistance.

"We are very pleased by the continued trust placed by Borsodchem in us and our nitric acid technology... for their second plant. Casale is strongly committed to deliver the same level of high quality, superior performances and long-term reliability as the first one which [has been] in operation since 2012," said Mr F Zardi, Casale's CEO.

The NA2000 dual-pressure nitric acid process was originally developed by GPN. Casale acquired the technology in 2014, as part of its purchase of the Borealis nitrates and phosphates fertilizer technology portfolio.

UNITED STATES

PolyNatura secures polyhalite offtake agreement

PolyNatura Corp secured a 'take-or-pay' offtake agreement with Nitron Group in January.

PolyNatura is developing the Ochoa polyhalite project in Lea County, New Mexico.

Ochoa is the only naturally-occurring large-scale deposit of polyhalite in the Americas.

Under the terms of the agreement, Nitron will purchase 75 percent of PolyNatura's future polyhalite output – 1.5 million t/a at peak production – over a five-year period from the start of production.

"We are excited to partner with one of the most respected names in the global fertilizer industry," commented Graham Wheelock, PolyNatura's managing director. "Financial strength, geographic reach, and deep industry knowledge make Nitron the ideal partner to distribute our organic fertilizer globally, enabling farmers around the world to improve crop yields and quality."

Nitron President Javier Urrutia added: "Our mission at Nitron is to provide high-quality products to meet the growing demands of our clients around the world. This offtake agreement with PolyNatura will enable us to distribute an important organic fertilizer throughout the Americas and other key markets."

Polyhalite is a naturally occurring mineral that can be applied directly as an organic fertilizer with only minimal processing. Raymond Hoyum, an affiliate professor at Auburn University's College of Agriculture, said: "Polyhalite is totally water-soluble and contains potassium, magnesium, calcium and sulphur, so providing balanced crop nutrition. As growers continue to strive for high yields and improved crop quality, polyhalite should be an essential part of their total fertility programme."

Polyhalite is approved for organic use by the UK's Soil Association and Organic Farmers & Growers, and similar organisations globally.

MOROCCO

OCP and Fertinagro announce JV

Spain's Fertinagro Biotech and OCP Group are to jointly manufacture a range of speciality products in Morocco. These will be produced by OCP-Fertinagro Advanced Solutions, a new 50/50 joint venture (JV) company established in January.

The new JV company will be based at OCP's Jorf Lasfar production complex. It will manufacture granular, high-analysis NPKs for the international market, as well as fertilizers enhanced with urease inhibitors, bio-stimulants and micronutrients.

The JV company is aiming to establish a new production unit for speciality NPK fertilizers by 2020. This will have an initial capacity of 250,000 t/a, with the poten-

tial to eventually expand annual production capacity to one million tonnes. The company also intends to set up advisory services for farmers.

"This Joint Venture [will]... address the growing demand in enhanced... fertilizers, and expand... offerings to farmers worldwide, in terms of customized products and services. It is in direct line with OCP's farmer centricity strategy", said Marouane Ameziane, executive vice-president strategy & corporate development at OCP Group.

"Through OCP-Fertinagro Advanced Solutions we shall combine industrial flexibility and competitiveness with innovation and agronomic services for farmers. In line with this, we are going to develop new industries, products and solutions in agriculture with a global joint vision to achieve a more sustainable world," said José Luis Moya, Fertinagro's general manager.

The launch of the JV follows the completion of a larger strategic investment by OCP Group in Fertinagro in October last year.

New Morocco-UK agricultural partnership

Morocco's Mohammed VI Polytechnic University (UM6P) has launched an international academic partnership with two of the UK's leading agricultural research institutes, Rothamsted Research and Cranfield University.

The announcement, made in March, strengthens existing collaborations between the UK and Morocco in the fields of education, research and innovation. Up to 20 early-career agricultural researchers in Morocco and the UK will be supported through the partnership – which is also backed by phosphates giant OCP Group.

Mohammed VI Polytechnic University is fast becoming a hub for education, research, innovation and entrepreneurship, building links between Morocco, Africa and the world. Rothamsted Research is a world-leading, non-profit research centre with a distinguished scientific heritage stretching back 175 years. Its strategic focus on agricultural science has benefited farmers worldwide. Cranfield University was awarded its fifth Queen's Anniversary Prize in 2017. The award recognised the global impact on sustainable resource use of Cranfield's soil and environmental data holdings. Cranfield University registered its first Moroccan agricultural student way back in 1966.

The initial phase of the partnership will focus on the delivery of seven agricultural research projects. The creation of a Centre



Mostafa Terrab, OCP Group chairman, at the signing ceremony.

for Doctoral Training will also support the development of the next generation of Moroccan scientists and engineers.

During the signature ceremony, Hicham El Habti, secretary general of Mohammed VI Polytechnic University, said: "OCP, through its R&D programme and in close co-operation with the Mohamed VI Polytechnic University, is developing fertilizers that are specific to the needs of African soils and crops, as well as... service models [so] African farmers [can] have reliable, affordable access to these inputs and related products. This vital partnership with Rothamsted and Cranfield University will support the acceleration of this strategy to help African farmers become not only more productive, but also more prosperous."

Professor Leon Terry, Cranfield University's director of environment and agrifood, said: "This partnership brings together the very best in UK plant and soil science with the Mohammed VI Polytechnic University, an institution with the very highest of entrepreneurial and scientific ambitions for Morocco and wider Africa. As a university that prides itself on our international outlook, we are delighted to be bringing Cranfield's globally-recognised expertise to support the development of African agricultural research."

Professor Achim Dobermann, Rothamsted Research's chief executive, said: "The development of sustainable agriculture across Morocco, and Africa as a whole, is vital to the continent's food security and economic growth."

He concluded: "The challenges are immense, but by nurturing the talent and enthusiasm of young scientists. I am confident that there can be bright future both for Africa's farmers and its environment. By combining the cutting-edge expertise of Rothamsted and Cranfield, with the drive and vision of UM6P, we can play a major role in delivering this and we are excited about contributing our unique expertise." ■

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BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Petter Ostbo will become EuroChem Group's CEO at the start of June. He will take over from **Kuzma Marchuk**, EuroChem's chief financial officer (CFO), who has been EuroChem's acting CEO since September last year.

"The board is delighted that Petter Ostbo is joining the team," said Alexander Landia, the Group's chairman. "He is highly regarded in our industry and brings broad experience to the position. Petter's appointment demonstrates EuroChem's commitment to bringing in the best talent to take the company into the next chapter of its growth story. I would like to thank Kuzma for his continuing service as acting CEO of EuroChem until Petter takes over."

"I am happy to be able to join EuroChem at this exciting time in the company's development," Mr Ostbo said. "The new potash and ammonia production present great opportunities for EuroChem, and I look forward to working with the board and the management team to accelerate the next phase of growth."

Mr Ostbo was executive vice president (EVP) and CFO at Yara International immediately prior to his appointment. He was also Yara's EVP for production previously, with responsibility for 28 production sites and four mines in 16 countries. Before joining Yara, Mr Ostbo worked at McKinsey & Co from 2003-2010. He holds an MBA from the Norwegian School of Economics (NHH).

Darron Page has been appointed senior vice president (SVP) at JR Simplot. He will

take command of the company's 'Global Solutions' arm. This crucial part of Simplot's business covers four main areas: sustainability, procurement, enterprise services and facilities/wheels/aviation. Darron will report directly to JR Simplot's president and CEO Garrett Lofto. He will also represent Global Solutions within the company as part of the Simplot Leadership Team. Darron takes over Global Solutions from **Sue Richardson** following her appointment as SVP of Global Business Transformation.

"Darron has been a valuable partner and leader within our Company for many years," said Lofto. "His varied experience and innovative mindset will continue to serve the Company well."

"I'm honored for this opportunity and look forward to working with the Global Solutions team and partners across the company," Page said. "Together we will continue to identify and provide the most efficient and sustainable solutions in our quest to help the JR Simplot Company be the best organization we can be."

Darron has enjoyed a 26-year career with Simplot. He worked as Simplot's vice president (VP) of business development in the Company's AgriBusiness Group for two years before his latest appointment. He notably served as Simplot's procurement VP from 2014-2017 and supply chain VP from 2012-2014. Darron has an MBA from Boise State University.

Evgeni Sozinov is the new CEO of North-Western Phosphorous Company (NWPC),

an Acron Group subsidiary located in Russia's Murmansk region. His appointment follows the resignation of the previous CEO, **Vadim Ryazantsev**. Mr Sozinov was executive director of Dorogobuzh, another Acron Group company, immediately prior to the appointment.

Evgeni has served Acron Group in a number of roles over the years. He was appointed Dorogobuzh's executive director in 2017, and acted as deputy to Dorogobuzh's executive director for capital construction and transportation for two years before that. He also held a number of senior roles at NWPC between 2012 and 2015. Mr Sozinov holds an honours degree from the Siberian Automobile and Road Construction Academy.

In coordinated management changes at Dorogobuzh, **Oleg Tikhonov**, the company's chief technology officer (CTO) since April 2009, has become the Dorogobuzh's executive director. MrTikhonov has been with Dorogobuzh since 1995, serving the company in a number of engineering, production and technology roles. He is a graduate of Bauman Moscow State Technical University.

Oleg's replacement as Dorogobuzh's CTO is his former deputy, **Roman Dmitriev**. Mr Dmitriev joined Acron in 2005. During his career with the company, he has served as head of NPK production, deputy to the head of mineral fertiliser production and deputy to the CTO. Roman graduated from Saint Petersburg State Institute of Technology and holds a chemical technology degree. ■

Calendar 2019

MARCH 2019

25-27

Phosphates 2019 Conference,
ORLANDO, Florida, USA
Contact: CRU Events

Chancery House,
53-64 Chancery Lane,
London, WC2A 1QS, UK
Tel: +44 (0)20 7903 2444
Email: conferences@crugroup.com

25-27

Argus Middle East Fertilizer 2019,
MUSCAT, Oman
Contact: Argus Media
Email: fertconferences@argusmedia.com
Tel: +44 (0)20 7780 4340

APRIL

8-11

IFA Global Technical Symposium,
NEW ORLEANS, Louisiana, USA
Contact: IFA Conference Service
Tel: +33 1 53 93 05 00
Email: ifa@fertilizer.org

JUNE

7-8

43rd AIChE Annual Clearwater Conference
2017, CLEARWATER, Florida, USA
Contact: Perry Alonso,
AIChE Central Florida Section
Email: vice-chair@aiCHE-cf.org

11-13

IFA 87th Annual Conference,
MONTREAL, Canada
Contact: IFA Conference Service
Tel: +33 1 53 93 05 00
Email: ifa@fertilizer.org

SEPTEMBER

22-24

TFI World Fertilizer Conference,
CHICAGO, Illinois, USA
Contact: Valerie Sutton
Fax: +1 202 962 0577
Email: vsutton@tfi.org

OCTOBER

1-3

Africa Fertilizer Agribusiness Conference
2019, CAPE TOWN, South Africa
Contact: CRU Events
Tel: +44 (0)20 7903 2444
Email: conferences@crugroup

22-24

IFA Crossroads Asia Pacific,
SYDNEY, Australia
Contact: IFA Conference Service
Tel: +33 1 53 93 05 00
Email: ifa@fertilizer.org



50
YEARS

Our team congratulates Fertilizer International on their 50th anniversary and their contribution to the fertilizer industry. Like Fertilizer International, ArrMaz has been serving the needs of the fertilizer industry for more than 50 years, and we are proud to be a longtime patron of this esteemed publication.

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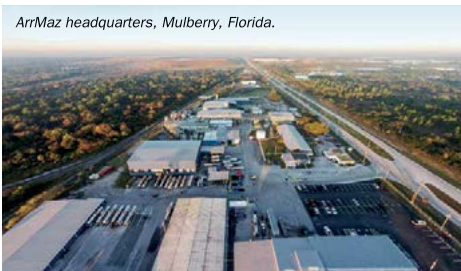
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Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
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THEN&NOW ArrMaz

Fertilizer International is 50 this year. The continuing success of the magazine is built on mutually beneficial partnerships forged over five decades. So, in celebrating our 50th anniversary this year, we will also be profiling a much-appreciated commercial supporter in each issue. This month it is the turn of Florida-headquartered ArrMaz, a valued long-term advertiser. The company is even older than *Fertilizer International*, having celebrated its 50th anniversary in 2017.

ArrMaz headquarters, Mulberry, Florida.



Company profile

ArrMaz is a global leader in the production of specialty chemicals. Headquartered in Mulberry, Florida, and with multiple locations across North and South America, Europe, Asia, Africa and the Middle East, the company serves customers across the globe. ArrMaz has been manufacturing chemical process aids and additives since 1967 – and is a long-standing supplier to the mining, fertilizer, industrial ammonium nitrate, asphalt, and oil and gas industries. The formulations offered by ArrMaz are proven to optimise process performance, enhance product quality and improve customer profitability.

ArrMaz has been a trusted partner to fertilizer manufacturers and distributors worldwide for more than 50 years, treating millions of tonnes of fertilizer for some of the world's largest producers. The company provides a wide range of fertilizer process aids, additives, coatings and engineering services which enable customers to optimise their process performance, maximize production efficiency and produce superior fertilizer products.

In the fertilizer industry, every process and product is unique – making a tailored, bespoke approach essential. To achieve this, ArrMaz works closely with its customers on developing specific process and product goals – delivering the best possible solutions for each and every application.

Latest innovation

In response to industry needs, ArrMaz recently rolled out its newest coating technology, GALORYL® moisture-resistant anti-caking coatings. These coatings – in addition to having anti-caking control properties – reduce deliquescence when high-analysis dry granular fertilizers are bulk blended together. The new GALORYL®-based coating technology delays the onset of deliquescence and reduces a fertilizer blend's propensity for moisture uptake, extending the time available from blending to field application. These innovative new coatings are also compatible with many traditional coating application systems.

1967

- Custom Chemicals founded to provide defoamers for phosphoric acid production

1976

- ArrMaz founded to provide process aids to the phosphate fertilizer market

1978

- ArrMaz pioneered the development of coating agents for phosphate fertilizers
- Custom Chemicals supplied first surfactant-enhanced collectors

1991

- ArrMaz acquired Sherex defoamer and amine flotation reagent business
- ArrMaz opened Convent, Louisiana plant

1992

- ArrMaz opened Vanceboro, North Carolina plant

1995

- ArrMaz acquired Tomah's asphalt additive product line

1996

- ArrMaz opened Soda Springs, Idaho manufacturing plant

1999

- Custom Chemicals acquired Nottingham Chemical's phosphate reagent business

2002

- ArrMaz opened SuperPave Laboratory, achieved American Association of State Highway Transportation Officials (AASHTO) Accreditation

2003

- ArrMaz and Custom Chemicals merged
- Formed ArrMaz do Brasil in Rio de Janeiro, Brazil

2004

- Acquired GALORYL® product line from Nufarm

2007

- Opened ArrMaz Chemicals Yunnan in Kunming, China

2008

- Formed ArrMaz Gulf Chemicals in Saudi Arabia

2011

- Acquired Road Science, LLC

2015

- Launched oil and gas business unit
- Opened Al Jalamid, Saudi Arabia plant
- Opened Uberlandia, Brazil plant

2016

- Started construction of Morocco plant

2017

- Celebrated 50 years of innovation, service and success
- Acquired MaxChem LLC
- Opened ArrMaz Innovation Center, Florida
- Opened Africa Technical Center, Morocco
- Opened Jorf Lasfar, Morocco plant

EuroChem Group is gearing-up for the launch of its state-of-the-art Kingisepp ammonia plant on Russia's Baltic coast. **David Nowak**, the Group's deputy head of communications, profiles what will be Europe's single largest ammonia plant as it approaches completion.

Kingisepp: Europe's new ammonia giant

PHOTO: EUROCHEM

The Kingisepp ammonia plant.

Europe's ammonia market is about to welcome a giant, highly-efficient and low-cost new entrant – thanks to a major investment in production capacity by EuroChem Group.

The Swiss-based fertilizer producer will formally open its \$1 billion greenfield ammonia plant at Kingisepp, southwest of St Petersburg, towards the end of the second-quarter.

The new state-of-the-art one million t/a capacity plant is to be named EuroChem Northwest. Its completion marks the culmination of an ammonia self-sufficiency drive by EuroChem. The new plant will also offer international customers a more cost-effective ammonia supply source.

EuroChem Northwest is located at Kingisepp near the banks of the Luga River – just 50 kilometres upstream of the Baltic port of Ust-Luga – in the same complex as the Phosphorit fertilizer plant. Close proximity to the Group's existing rail and shipping facilities will allow ammonia to be easily transported to EuroChem's other

EuroChem Northwest in numbers

- \$1 billion investment
- One million t/a production capacity
- Nearly 5,000 construction jobs
- 300 permanent jobs
- 12,000 tonnes of steel used in construction
- 64 kilometres of piling

fertilizer production plants in Europe and beyond.

The Kingisepp plant is the largest single-train unit in Europe, with an ammonia production capacity of 2,890 tonnes per day. It took two years to build under the supervision of project manager and engineering, procurement and construction (EPC) contractor Maire Tecnimont Group, working alongside general contractor Velesstroy.

The new plant features a wide range of production, storage and shipment facilities – including an ammonia synthesis unit, liquid ammonia storage capacity, gas pipe-

lines, and other logistics infrastructure. Nearly 5,000 people were employed during the construction phase, and the completed plant will employ 300 permanent staff, once operational.

Kuzma Marchuk, EuroChem's acting CEO, said the new Kingisepp plant was a long-awaited boost to the Group's in-house production capacity: "The project, based on the very best available technology, will add much-needed new ammonia capacity and help EuroChem move towards its goal of becoming a top three global fertilizer producer."

US contractor KBR provided operator training and reliability-based maintenance services to the plant. The plant also uses KBR's latest *Purifier Ammonia* processing technology. Advantageously, this confers much lower energy consumption and offers reduced operating costs. The plant's two on-site isothermal liquid ammonia storage tanks have a total load capacity of 60,000 tonnes.

The Kingisepp plant has its own dedicated gas supply via a nine kilometre-long offshoot of Gazprom's Kohtla-Järve-Leningrad gas pipeline.

EuroChem will consume about 75 per cent of the plant's annual ammonia output for in-house fertilizer production, with the remaining balance being sold to third parties. The new Kingisepp plant will supply the adjacent Phosphorit complex, as well as two other EuroChem plants in Antwerp, Belgium, and Kėdainiai, Lithuania. Ammonia product will be shipped from EuroChem's port facilities at Sillamäe, Estonia, located 45 kilometres from Kingisepp.

Because it will no longer need to deliver ammonia to Phosphorit from further afield, EuroChem anticipates significant efficiency savings from the operation of the new ammonia plant, including reduced fertilizer logistics costs, per tonne of final product.

EuroChem is proud of the plant's high environmental standards. Built on a brown-field industrial site, its development took account of environmental considerations from the very start. These included the installation of turbine generators to capture heat generated during the production process.

EuroChem also collaborated with the John Nurminen Foundation, a Finnish non-governmental organisation, to minimise the environmental footprint of the new plant, including the upgrading of water treatment facilities. The result is a closed water-circulation system that reduces overall water consumption by recirculating wastewater back into the production cycle.

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BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England

Tel: +44 (0)20 7793 2567

Fax: +44 (0)20 7793 2577

Web: www.bcinsight.com
www.bcinsightsearch.com

A new report from trade body Fertilizers Europe explains how industry can supply enough crop nutrients to feed a growing population, while also becoming ever more energy- and environmentally-efficient. Fertilizer producers can also help address other challenges, such as the growing demand for cleaner energy and better resource use, as **Jacob Hansen**, the director general of Fertilizers Europe, explains.



PHOTO: FRANCISREPORTER / ISTOCKPHOTO.COM

At the nutrition and energy crossroads

We live in fascinating times, with technology evolving at an ever-increasing pace, spurring major shifts in many sectors. This is certainly true of the fertilizer industry.

As we look ahead, the future of agriculture in Europe faces two major challenges: how to shift to sustainable food production; and help deliver EU commitments on decarbonisation and a more circular economy. The European mineral fertilizer industry, in our view, will have a vital and important role to play – being at the crossroads where these two challenges meet.

The new vision document from Fertilizers Europe, *Feeding Life 2030*, highlights how the fertilizer sector can contribute, both by addressing these challenges and being part of their solution.

More knowledge per hectare

Meeting future food needs remains a key and vital global challenge.

Today, fertilizers help feed almost 50 percent of the world's population, while some 10 percent of people across the planet remain precariously undernourished. The United Nations, meanwhile, estimates that the global population will continue to grow, up from 7.6 billion today to reach 8.6 billion by 2030. To put this in context, the growth in population expected over the next decade means world agriculture will have to provide for another country the size of Germany, each and every year.

In Europe, while undernourishment is not a major concern, sustainable food production certainly is. As an industry, we know that the supply of high-quality plant nutrients plays a vital and necessary role in providing European consumers with the diverse range of good quality, nutritious and sustainably-produced food they have come to expect.

The principal question for our industry therefore becomes: how can we supply crops with the nutrients needed to feed an ever-growing global population, but in a more

energy- and environmentally-efficient way?

Well, in our view, 'applying more knowledge per hectare' needs to become the mantra for European farming in the future. It's a message that paves the way for better fertilizer products, more precisely targeted to specific crops.

Applying knowledge in this way will help to improve crop quality and deliver higher yields, so providing farmers with higher returns on their investments. It will also have a very positive effect on the environment, as better and more targeted fertilization, by delivering more nutrients to the crop for growth, diminishes losses to the environment.

We predict in *Feeding Life 2030* that commercial farmers and growers will become much more knowledgeable and demanding in future about how fertilizers are applied and the plant nutrient inputs they will use. We expect farmers in 2030 to be increasingly aware of nutrient use efficiency, for example. This will allow them to produce crops more sustainably and profitably by optimising

nutrient applications to maximise their yields. To do this, farmers will have plan ahead more and rely on in-depth professional advice. They will also need to adopt new fertilizer tools and technologies – to tell them exactly where and when and precisely how much nutrients are required, throughout the growing season.

Ammonia – carbon-free energy carrier?

Leading the global battle against climate change is one of the EU's main policy ambitions.

Hydrogen generation from renewable electricity using wind and solar sources will become more common as Europe makes progress towards decarbonising its energy supply. The best way of storing and transporting hydrogen will be an ever more pressing question, as its adoption as a fuel becomes increasingly widespread.

Ammonia has huge potential as a carrier and storage medium for hydrogen as it has a high energy content and is also easy to transport. In our view, ammonia is the potential missing link that can make decarbonisation a reality. In *Feeding Life 2030*, we explain how the nitrogen fertilizer industry holds the key to unlocking the potential of clean energy by producing ammonia as a carbon-free energy carrier on a large-scale.

Additionally, Europe's fertilizer producers will continue to play an important role in the promotion and adoption of the circular economy, resource efficiency and industrial symbiosis in the EU.

From vision to reality

The *Feeding Life 2030* report sets out a forward-looking and ambitious vision of the future for Europe's fertilizer industry. It's also an evolving and outward-looking vision. One of its main aims is to start a wide-ranging discussion between all the different players that have a stake in the industry and its future.

Importantly, the report aligns the European fertilizer industry's goals and commitments with those of the EU – while also calling for a policy framework which will allow this vision to be turned into a reality.

European mineral fertilizer producers operate in a global market and trade large amounts of fertilizers between continents and across borders. That makes ensuring a level playing field for the industry the first and overriding priority.

As plans to decarbonise the EU economy move ahead, it is essential that the European Commission puts forward cost-effective policy solutions. Support for research and pilot projects, and establishing energy infrastructure and transportation standards, will be vital, if ammonia is to play a full role in decarbonisation efforts.

The fertilizer industry is already recycling a wide range of by-products, as well as using surplus energy and raw materials derived from other production processes. Yet the full potential of the circular economy and industrial symbiosis is far from being reached. Promoting circular thinking – with more efficient resource use and closed material loops to minimise environmental impacts – will also require new policies and R&D programmes at EU level.

To conclude, *Feeding Life 2030* sets out a very ambitious future for the European mineral fertilizer industry. The report shows how the industry can help address several major societal challenges in future, while at the same time retaining its economic viability globally. Ensuring that the production of fertilizers in Europe remains closely-aligned with the EU's policy ambitions will require commitment and resolve from industry leaders, member states and policymakers in Brussels and Strasbourg.



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- Free of chlorine, sodium and other harmful elements

For contact details: gea.com/contact or meet us at **Phosphates** in Florida, USA from 25-27 March 2019.

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Nitrogen market rallies – but will it last?

Nitrogen prices outperformed expectations in 2018, following a year of widespread disruption and uncertainty, reports **Laura Cross**, CRU's head of nitrogen analysis.

Urea prices, against expectations, were buoyant in 2018. Supply management policies in China and the re-imposition of US sanctions on Iran helped offset the adverse impact of new urea capacity additions. Collectively, such factors contributed to a \$31/t average increase in urea prices in 2018 compared to the previous year.

Similarly, prices in the ammonia market were also stronger for much of 2018, on the back of strong demand from China and plant commissioning delays. Ammonia and urea prices both lost momentum going into 2019, however, as supply improved and some major import buyers failed to materialise.

Eventual tightening

Urea prices began to soften in early 2019, as prospects for seasonal exports from China increased. The emergence of volumes out of China has more than offset the absence of Iranian urea in the last two Indian import tenders by MMTC. Price declines are expected to continue through the second-quarter of 2019, before stabilising for the remainder of the year.

The urea market should eventually come into balance in 2019, as capacity closures in Brazil and China help offset near-term capacity additions. Prices and utilisation rates are then forecast to increase while the market enters a period of sustained tightness between 2019 and 2022. The projected tightening of the market over the medium-term is linked to stronger trade growth prospects in key urea import markets such as Brazil, coupled to lower urea exports from China (due to an escalating price floor) and Iran (due to geopolitical barriers).

We take a deep-dive into the main issues affecting the 2019 nitrogen market below.

Chinese export volatility

CRU has singled-out Chinese export volumes as the biggest seasonal uncertainty looming over the urea market in 2019. All the evidence suggests that volumes out of China will be volatile this year, being largely dependent on raw material prices. These, in turn, are underpinned by Chinese government environmental policies.

Winter closures, along with a tighter than expected domestic supply balance, saw China's annual urea exports decline to a 12-year low in 2018. China exported 1.4 million tonnes of urea during January-October 2018, down 63 percent from the 3.7 million tonnes exported during the same period in 2017. China subsequently exported an additional million tonnes, approximately, in the last two months of the year, with volumes boosted by lower coal prices and seasonally weak domestic demand.

However, the return of the winter heating season – from November 2018 through to March 2019 – is likely to force a decline in urea plant utilisation rates to 62 percent. The resulting fall in production output will act to limit Chinese exports in 2019's first-half.

Chinese urea exports are also likely to become severely limited during the second-quarter of 2019. Stock building by Chinese urea distributors and NPK buyers for the spring application season looks set to prevent China's participation in the urea export market, from mid-March through to the end of July 2019.

India provides an upside

Political developments in India could provide an upside for global urea demand this year. 2019 is an election year for India, with the government unveiling a seven

percent hike in the fertilizer subsidy in its pre-election interim budget in February. To justify the subsidy hike, the government cited the depreciation of the rupee against the US dollar, the rise in the price of imported fertilizers and an increase in costs of production as the key drivers. But there are also clear political motivations behind the increase in subsidy support.

India's total fertilizer subsidy will increase from INR 700.8 billion in 2018/19 to INR 749.9 billion (\$10.51 billion) for 2019/20. As part of this, the urea subsidy will rise by seven percent year-on-year. The subsidy for imported urea was increased by two percent to INR 136 billion, while the subsidy for domestically produced urea increased 15 percent to INR 365 billion.

Recent pricing developments have highlighted the critical role Indian import tenders play in the global urea market. The ongoing role of US sanctions on Iran will also be a key theme for the urea market in 2019.

Recent Chinese exports to India have included both domestically produced urea and some volumes re-exported from Iran. Working on the assumption that continued sanctions will prevent Iranian urea exports from reaching India over the next few years, other low-cost exporters in the Middle East, and price-setting tonnages from China, are likely to fill the void.

Ammonia price declines

The rapid deterioration in ammonia prices in 2018's fourth-quarter (Figure 1) was attributed to the poor fall season ammonia fertilizer applications in the US. Some states are said to have consumed only 35-50 percent of typical fall ammonia volumes.

Significantly improved supply from exporters East of Suez was another contributory factor. Indonesia's PAU Sulawesi



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London SE1 7SJ, England

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China: winter closures, shutdowns & new capacity

Urea producers in China have been hit hard by stringent environmental standards. Many urea plants across the country have permanently closed due to high raw material costs, poor domestic demand, and environmental and safety concerns.

Plant closures

The formal shutdown of seven urea plants identified by CRU removed 2.56 million tonnes of Chinese capacity in 2018 (see map). But these closures were mostly offset by the addition of an estimated 2.6 million tonnes of new urea capacity in China during the year. The closure of older plants and the shift to modern environmental-friendly urea production is being driven by Chinese government incentives.

Tighter regulation

China's air quality has certainly improved as a direct result of the winter production cuts first introduced in November 2017. Fresh environmental policy changes announced by China's government in October last year will have further – but mixed – consequences for Chinese urea production and costs.

The initial impact of these new policy changes appeared to be less severe than in 2017, as increased coal production enabled anthracite coal- and bituminous coal-based urea plants to remain open. But anthracite coal-based

urea producers employing fixed-bed intermittent gasifiers will be subject to greater regulation in future. This harsher regulatory regime is likely to force some temporary shutdowns during the winter heating period, as well as more permanent urea plant closures over the medium-term.

New capacity

CRU is forecasting that 10.6 million tonnes of new and more energy-efficient urea capacity will be built in China over the medium-term. The emergence of new Chinese capacity at this scale could be detrimental to the global supply, if the resulting production was destined for export. However, in CRU's view, this capacity is likely to be more than offset by the shutdown of older, inefficient and high-cost plants.

Looking ahead, of the urea capacity that is most likely to be permanently shut down between 2018 and 2023, some 40 percent will result from tighter environmental regulation. Enforcement action will require the closure and relocation of plants located close to residential areas and the Yangtse river. The remaining plant closures are attributed to declining economic viability caused by high costs and limited refinancing options. Over 80 percent of the permanent urea capacity closures in China will be plants based on anthracite coal. ■



Chinese urea plant closures, Jan-Nov 2018.

Source: CRU

plant has operated uninterrupted since August, and Yara's Pilbara plant in Australia and Ma'aden's Wa'ad Al Shamal plant in Saudi Arabia also restarted. The slow ramp-up of ammoniated phosphates production at Wa'ad Al Shamal has also contributed to increased ammonia spot availability.

The direct application of ammonia during the US spring application season will remain a key driver of ammonia prices in the first-quarter of 2019. Considerable volumes of ammonia are reported to be available, following a poor fall direct application season, with producers considering exporting surplus ammonia from the US Gulf in the first-quarter. Forward offers were well over \$500/st f.o.b. in the Midwest in December 2018, a pricing level that is likely to prompt some demand substitution of urea and UAN for ammonia in the spring.

Following a poor fall season, there are a range of possible outcomes for the seasonal application of ammonia in the US this spring. Typically 55 percent of annual ammonia volumes are applied in the fall and 45 percent in the spring season, if weather conditions are favourable.

However, making up for lost fall volumes in the spring can be difficult. CRU estimates that as little as 700,000 tonnes or as much as two million tonnes of ammonia could be applied during this year's US spring season, depending on how favourable conditions are.

Previous precedents should be a useful guide. For example, after an abysmal 2009 fall application, more than 90 percent of the lost ammonia volumes were subsequently applied in spring 2010. On that basis, at least 1.5 million tonnes of ammonia could be applied in the US this spring.

Near-term ammonia oversupply

The ammonia market will remain oversupplied in 2019. EuroChem's Kingsepp merchant ammonia plant is due to come on-stream. Other capacity additions commissioned in 2018 will also ramp-up their output. Some relief is expected, however, after 2020. A gradual increase in downstream demand, together with a slowdown in capacity additions, should bring the market back into balance once the new decade begins.

In CRU's view, the absence of any significant merchant ammonia capacity



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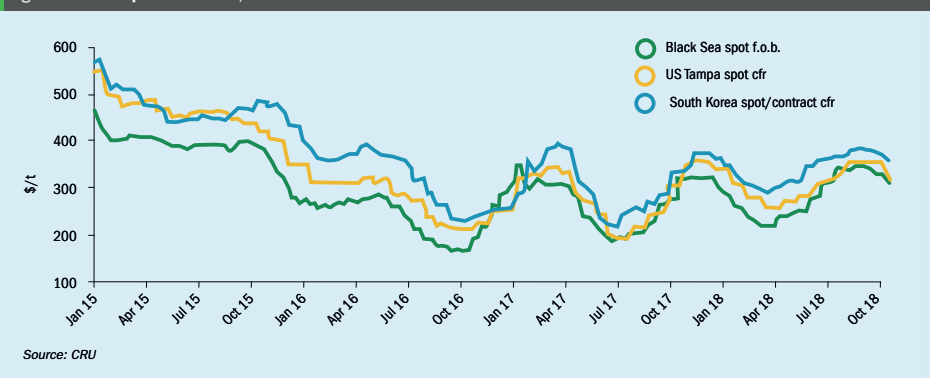
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Fig. 1: Ammonia price evolution, 2015-2018



additions in the period 2019-2022 should prompt an increase in operating rates and support a recovery in ammonia prices. Beyond this timeframe, Ma'aden's commissioning of a significant export-oriented plant in Saudi Arabia is likely to flatten operating rates and limit price growth in 2023.

Ma'aden signed an EPC contract for the construction of a third ammonia plant

at Ras Al-Khair on Saudi Arabia's Gulf coast in October 2018. The commissioning of the new plant, expected in 2023, will initially displace ammonia exports from higher-cost producers East of Suez, in CRU's view. This will take place for an interim period of 18-24 months until Ma'aden commissions the downstream phosphates capacity associated with its new Saudi mega project.

Three projects trigger a commissioning wave

Garabogaz, Turkmenistan

Additional capacity: ammonia 660,000 t/a, urea 1,155,000 t/a.

Turkmenistan's latest nitrogen plant, Garabogaz, was officially commissioned at the end of September last year. It ramped-up gradually in the last few months of 2018, with urea exports commencing in December. Garabogaz is located on the Caspian Sea and is expected to fully ramp-up during 2019. Exports are likely to be targeted at Europe, Brazil, and India.

Chambal Gadepan III, India

Additional capacity: ammonia 726,000 t/a, urea 1,320,000 t/a.

Chambal's brownfield Gadepan III expansion began commercial production at the start of January, earlier than previously anticipated. Gadepan III will reduce India's import requirement this year. It completed a one-month pilot production phase at the end of 2018 and is now making domestic sales.

SOCAR Sumgait, Azerbaijan

Additional capacity: ammonia 396,000 t/a, urea 660,000 t/a.

Azeri state oil company, SOCAR, commissioned its Sumgait urea project in January. This is Azerbaijan's first nitrogen plant. The majority of its output, over 70 percent, will target the export market. The plant will also meet the country's entire nitrogen fertilizer requirements, displacing existing import volumes. CRU assumes that SOCAR will export urea from the plant via neighbouring Georgia, most likely through the Black Sea port of Batumi.

The \$800 million plant was constructed by Samsung Engineering. The South Korean contractor also selected the process technologies for the plant and was responsible for pre-commissioning. The Sumgait project was originally due to commission in February last year. But significant last-stage delays saw this postponed to the end of 2018.

2019 nitrogen capacity additions

A steady stream of nitrogen project updates have emerged in recent months. CRU is currently forecasting 4.3 million tonnes of pro-rated urea capacity coming on-stream in 2019, against global demand growth of 2.8 percent. Projects commissioned this year will contribute 2.8 million tonnes to this total, while project commissioned last year will contribute a further 1.5 million tonnes of 'carryover' capacity during 2019.

Following three recent commissioning announcements, there are now only two urea expansions outside of China expected to commission in 2019.

In the ammonia market, the impending commissioning of EuroChem's Kingisepp plant will be a key milestone – although, beyond this, there is little other net ammonia capacity being installed in 2019.

Projects commissioning in 2019

CRU is forecasting the commissioning of six ammonia projects outside of China over the next 12 months (Figure 2). Of these, only two plants in the forecast will have a measurable impact on the merchant ammonia market. The Mazidagi plant in Turkey is expected to commission its ammonia train (100,000 t/a) – to support the phosphate unit commissioned in late 2018 – in the first-quarter of 2019. EuroChem's major merchant ammonia expansion (891,000 t/a) at Kingisepp, Russia, is the most significant near-term ammonia capacity addition. It is due to be commissioned in April.

Fig. 2: Ammonia capacity expansions (ex China), 2019

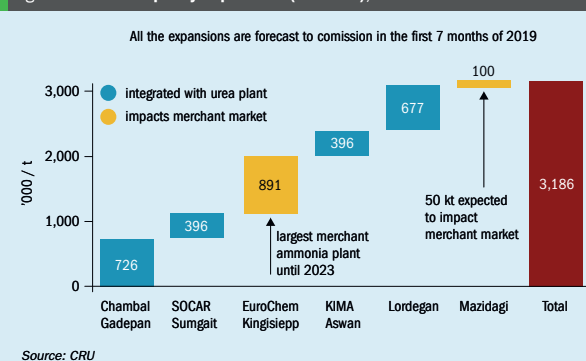
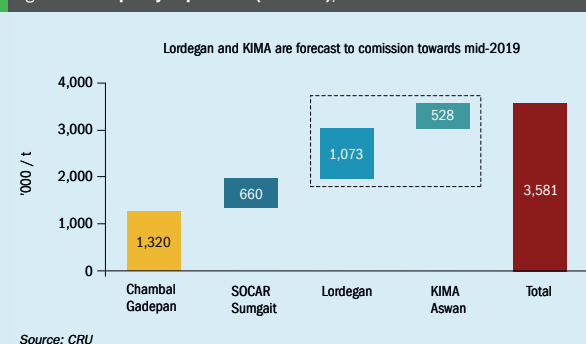


Fig. 3: Urea capacity expansions (ex China), 2019



The urea supply market is set for a relatively quiet year with only four capacity additions forecast (Figure 3). Two of these, Chambal Gadepan III and SOCAR Sumgait, have been commissioned already (see box).

The Egyptian Chemical Industries Company (KIMA) is due to finish expanding its Aswan plant with new ammonia (396,000 t/a) and urea (528,000 t/a) trains around mid-year. Commercial sales from these new trains should then follow in the year's second-half.

The Lordegan greenfield urea complex (1.32 million t/a capacity) in Iran was expected to commission this year, but remains at risk – as highlighted in CRU's December urea market outlook. Sanctions should not, however, slowdown Lordegan's progress as much as some other Iranian nitrogen projects. Fortunately for Lordegan, most of the equipment required for construction and commissioning was already on-site prior to the recent re-introduction of US sanctions.

The urea supply market is set for a relatively quiet year with only four capacity additions forecast.

struction and commissioning was already on-site prior to the recent re-introduction of US sanctions.

In the technical ammonium nitrate (AN) market, manufacturer Austin Powder is forecast to commission 2019's only ammonium nitrate expansion (750,000 t/a) at El Galpon, Argentina, in July. The plant is close to completion but has faced major public resistance due to pollution concerns.

In the fertilizer AN market, a new nitric acid train (150,000 t/a) is currently under construction at Phosagro's Cherepovets

complex in Russia. By increasing nitrate production output at Cherepovets, the new train should allow Phosagro to target more AN at the domestic market.

OPZ and Petrobras struggle on

Ukrainian producer Odessa Port Plant (OPZ) owns and operates two 450,000 t/a capacity ammonia lines and two 330,000 t/a capacity urea lines at its Black Sea nitrogen plant. However, OPZ was forced to shut down and mothball the plant last November after its gas tolling deal with Energy Resources of Ukraine (ERU) ended. OPZ's hopes of a substitute deal with EFTX Group of Oman were also dashed late last year, after clearance from the Kiev government failed to emerge.

The plant ran for a few days in early February after talks with supplier All Ukrainian Energy Company progressed. However these did not result in stable or lengthy production. The plant was then handed another possible lifeline by gas provider Energy Equivalent which offered a tolling agreement to restart the plant. OPZ received payment from this new gas tolling partner in late February. However, gas supply to the plant had not resumed at the end of February, with a March start date also looking unlikely.

In Brazil, state-run oil firm Petrobras was also due to mothball two of its nitrogen plants by the end of January, namely Laranjeiras (Fafen-SE) in the state of Sergipe and Camaçari (Fafen-BA) in the state of Bahia. Collectively, the 657,000 tonne capacity Sergipe urea plant and the 474,000 t/a Bahia urea plant are reported to have operated at a loss of BRL 800 million in 2017. The Sergipe plant also has the capacity to produce 303,000 t/a of ammonium sulphate.

The government announced a new rescue plan to lease both plants in January. The possible reprieve follows Brazil's recent presidential election. Petrobras says it will now evaluate bids from parties interested in leasing the Sergipe and Bahia plants, as well as its fertilizer port terminals in the Port of Aratu.

It is currently unclear whether or when Petrobras will formally close Sergipe and Bahia. The decision to keep both plants running is largely down to social and political reasons, particularly the pressure to secure jobs. Their continued operation goes against the poor economic performance of all four Petrobras nitrogen plants in Brazil, which remain largely uncompetitive.

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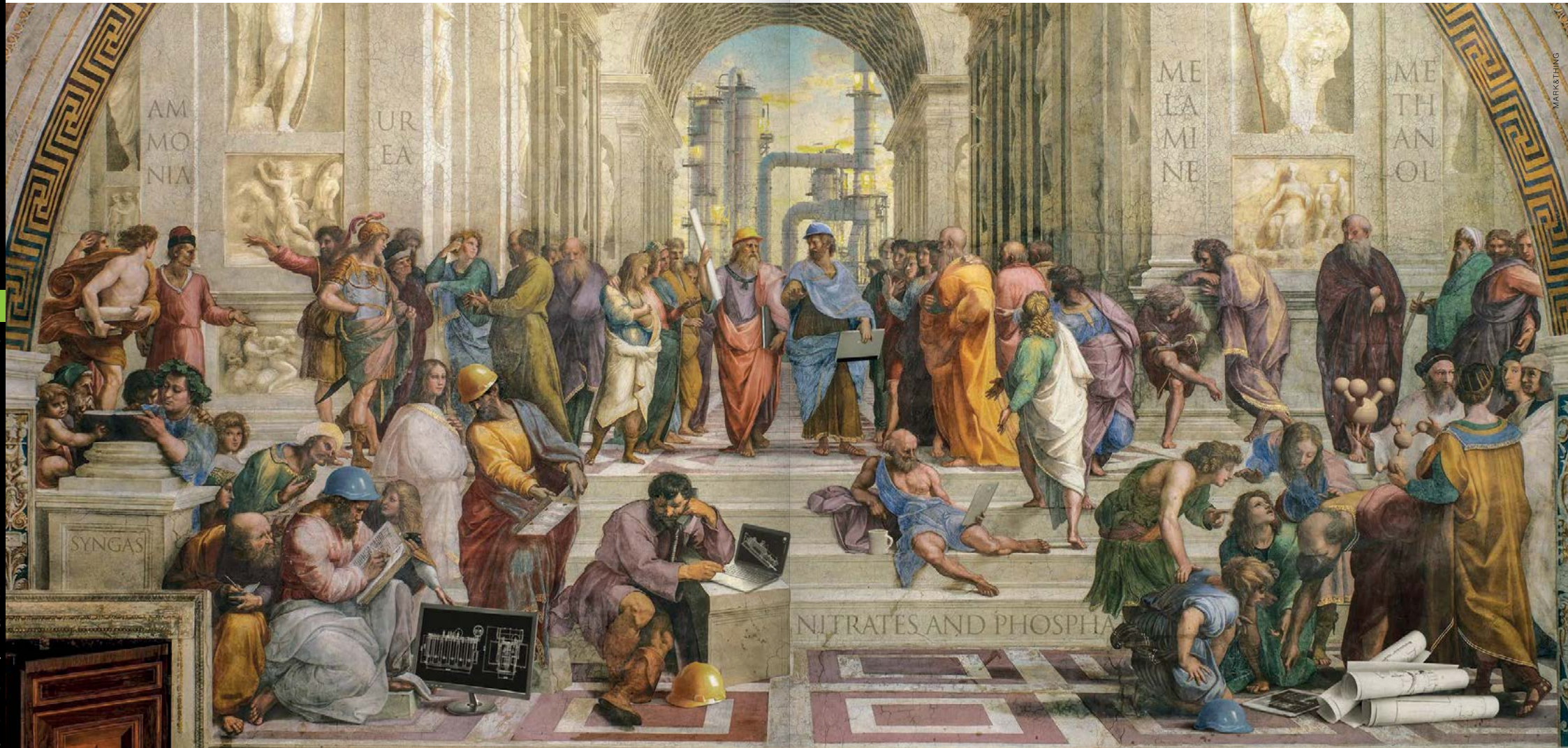
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The International Fertilizer Association (IFA) is helping to fully develop the career potential of younger employees through its Young Professionals initiative. This is providing a new generation of industry professionals with access to mentoring and career development advice. It also gives individuals a chance to network with their peers, as well as subsidising attendance and participation at international conferences.

To support IFA's new initiative, *Fertilizer International* magazine is running a series of profiles featuring industry young professionals. These highlight the wide range of attractive and rewarding career options available to young people in the fertilizer sector. In this issue, Alice Charlton of Sirius Minerals talks to us about her career.

Alice Charlton, 28, corporate development analyst

How did your career in the industry start?

Pure chance, really! I graduated from The University of Birmingham in the UK with a first-class degree in biochemistry in 2012. To be honest, as a fresh graduate, I didn't know the industry existed. But I jumped at the chance to join CRU Group's fertilizer team, specialising in the phosphates sector, as I wanted a career in London. I loved the opportunities CRU gave me. After working there for two and a half years, I joined the consulting team at Argus Media in 2014. The variety of work and market insights you gain while working at a consultancy is amazing. Ultimately, though, I was keen to move into the industry and develop my skills set further. When an opening with Sirius Minerals arose in 2017 it was too good an opportunity to turn down.

What achievement are you most proud of?

I've had some truly great experiences working in the fertilizer industry – from visiting mining operations in Morocco to climbing to the top of a phosphate plant next to a Goan beach! Probably my proudest moment, though, was presenting at the Fertilizer Association of India (FAI) conference in 2015. As one of a handful of female speakers at a meeting with over a thousand delegates, I admit I was a little nervous!

What do you find most rewarding about your job?

During my six years in the industry, I've met some incredibly inspiring people and had such great opportunities – such as presenting at the FAI and China Nitrogen Fertilizer Industry Association conferences. That's what stands out. Now I'm at Sirius, I really enjoy working for such a dynamic and unique project, and the challenges which that presents.

What hurdles have you had to overcome?

I knew nothing about the market when I started in the industry. So I had to learn quickly – and continue to do so! I thrive on being able to learn continually and advance my skills set. I recently completed a 'Mining for Bankers' course at Imperial College London to develop my understanding of the mining industry from a finance perspective.

How do you get the best from yourself and your colleagues?

Being professionally active and accepting new challenges is what keeps me motivated. That includes taking the initiative and stepping up to do things when others don't – such as speaking at conferences. I'm also an active committee member of Women in Mining. I'm passionate about that and in March I'll be chairing a panel discussion on 'why is the fertilizer industry so vital' in front of a mining industry audience in London – which is exciting.

Young professionals

Has mentoring been important to you?

Absolutely! I've been very fortunate to have received guidance from highly experienced people, both within and outside of the industry. My first boss at CRU, Juan von Gernet, supported me during my time there, teaching me about how the dynamics of the market work. That's certainly proved to be a great stepping stone for my career and helped me in future roles. Being a member of two mining groups in London – Young Mining Professionals and Women in Mining – means I get to network a lot with my industry peers. That's been supportive, and has also helped me raise the profile of the fertilizer industry too.

Will your job and the industry change in future?

We're undoubtedly going to see a shift towards more sustainable fertilizer use. That's part of a general need to adopt more sustainable farming practices globally. We need to boost crop yields – if we're going to feed the planet's growing population – while also using less land and reducing environmental impacts. Working for Sirius Minerals, which will be producing POLY4, a naturally-occurring, low-chloride, multi-nutrient fertilizer certified for organic use, we're going to be at the forefront of this trend.

Would you recommend a career in the sector to others?

Yes. Seize every opportunity, take every chance to learn, always network. And do not be risk-averse!

PHOTO: IFA

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Phosphates 2019 welcomes you to Orlando, Florida

CRU Events will convene this year's Phosphates Conference at the Omni Orlando Resort, Florida, between 25-27 March 2019.

Orlando, Florida is the setting for Phosphates 2019, the annual international meeting for the global phosphates industry. The event is a must-attend phosphates sector gathering and is celebrating its twelfth anniversary this year.

Last year's conference attracted more than 500 delegates from over 40 countries. This year's three-day event promises an equally wide-ranging and topical mix of subjects. How to respond to changing demand – especially the impact of new products and the phosphate industry's ever evolving relationship with its customer – will be a key focus for 2019.

Leading international phosphates producers, traders and engineering, technology and equipment providers are all expected to attend.

Uniquely, CRU Phosphates combines a commercial agenda with a technical agenda in one single event. This enables

the conference to cover the entire value chain of the phosphate industry – including the fertilizer, feed and industrial segments – from both an operational and market perspective.

Phosphates 2019 features a typically strong commercial programme. This will offer up key insights and in-depth market information on phosphate raw materials, intermediates and finished products. Programme highlights include:

- The global market outlook
- The future of farming
- Global production perspectives
- North American fertilizer distribution
- Phosphate fertilizer cost dynamics
- The future of phosphate fertilizers
- Diverse phosphate consumption trends
- Phosphate mining project showcase

The event also offers a separate but equally strong technical programme (see overleaf).

Phosphate 2019's keynote speakers include **Bruce Bodine**, Senior Vice President, Phosphates, at The Mosaic Company. Mosaic is a phosphates industry leader with an increasingly globally-integrated supply chain. Bruce's presentation is sure to offer some fascinating insights into the latest developments at Mosaic and its future strategy.

Dr Robert Mullen, Nutrien's Director of Agronomy, will also explore the future of farming in his keynote presentation. Strategies such as vertical integration can help the global phosphates supply chain become more ag-centric, in Robert's view, and prepare the sector as the relationship between fertilizer producers and consumers enters a whole new realm.

These industry leaders will be joined by high-level speakers from other major phosphate producers, such as OCP, JR Simplot and Itafos, over the course of the presentation programme.

Phosphates market overview

Chris Lawson, CRU's head of fertilizer analysis, sets the scene for Phosphates 2019 with this personal take on the state of the industry: "Phosphate markets were remarkably stable throughout 2018 – a surprise given the ramping-up of new low-cost capacity in Morocco and Saudi Arabia.

"Indeed, this new capacity was much slower to enter the market than many had expected. Slower ramp-ups combined with continued uncertainty over supply in China and the shuttering of Mosaic's Plant City facility in Florida to help keep diammonium phosphate (DAP) prices above \$400/t throughout the year. These prices helped to boost phosphate producer margins after a difficult few years.

"Prices softened somewhat at the beginning of 2019, owing to slow demand in some markets and an imbalance of supply. Demand has been very slow in China, where producers remain uncertain over the severity of environmental reforms set to be implemented this year. At the same time, production costs in China continue to hike, owing to closures and consolidation in key phosphate rock mining areas. China remains the largest exporter of phosphate fertilizer globally, and the country's cost structure will be key to how prices perform in the future.

"The Ma'aden Wa'ad Al Shamal phosphate project will continue to ramp-up through 2019. Meanwhile, OCP will also be ramping up its fourth Jorf Lasfar hub, which also commissioned last year. As well as this, OCP is commissioning another phosphoric acid line at Jorf Lasfar this year, along with other efficiency and debottlenecking measures.

"Other projects also started in 2018, including the NCIC Ain Sokhna plant in Egypt and Eti Bakir's Mazidagi site in Turkey. Both sites have the capacity to produce just over 200,000 t/a of phosphoric acid. Their emergence in the market could be critical, given they will both be run by unestablished producers. In 2019, Yara will also begin production at its Serra do Salitre plant in Brazil, another facility of similar size. Nutrien's closure of US and Canadian capacity, meanwhile, will prompt ample import interest in the North American market.

"All these supply-side structural changes are altering the industry's trade flows. Furthermore, the trend for product diversification is also having an impact. NPK and NP/NPS products, in particular, are in-vogue with consumers and producers alike, further altering the structure of the industry.

"There remain plenty of opportunities to grow and evolve in the phosphate market – but understanding the numerous changes occurring will be critical in navigating the market going forward."

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Web: www.bcinsight.com
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Technical programme highlights

A selection of presentations from Phosphates 2019's technical programme.

Farim phosphate project

The Farim phosphate project is located in northern Guinea-Bissau in Western Africa. The project has the potential to be the first active mining operation in the country. Project developer Itafos recently completed a project definitive feasibility study (DFS). This revealed mineral reserves of 44 million tonnes (at 30.0% P_2O_5). An additional phosphate bearing unit, below the current resources and reserves, also offers potential for mine expansion. An overview of the project geology, resource evaluation and mine design is presented.

New froth flotation collectors

With high-quality phosphate deposits in decline, more advanced beneficiation technologies are becoming necessary to process complex deposits. Nouryon has recently developed several new tailor-made collectors for the phosphate industry. They include a synthetic anionic collector for direct apatite flotation from igneous ores. Studies have shown this to be more selective than natural fatty acids. It also has a better froth profile and is effective at lower dosages. Nouryon has also investigated the removal of silicates and carbonates from sedimentary phosphate ores with two other synthetic collectors, *Atrac 50N* and *MD 20925*. Both collectors exhibited good selectivity towards silica-bearing minerals and improved both P_2O_5 recovery (around five percent higher) and enrichment compared to traditional collectors.

The decadmiation challenge

Pending EU regulations on cadmium levels are driving the need for effective heavy metal removal from phosphate fertilizers. These regulations may well spur other countries to implement their own tight guidelines. Consequently, an opportunity for innovation in decadmiation removal has emerged – due to the combination of increasing regulation, shrinking margins on fertilizer products and the high decadmiation costs of traditional methods. This presentation highlights available decadmiation technologies and discusses why heavy metal removal is an urgent need for the industry. It also provides an update on Solvay's *ACCO-PHOS®* reagents for cadmium and arsenic removal from phosphoric acid.

Energy recovery from sulphuric acid plants

Extracting more of the energy released during the production of sulphuric acid is increasingly important to create additional revenue for sulphuric acid plant operators. Production of superheated high-pressure steam for power generation is standard – but only allows up to 70 percent of the available energy to be recovered. To achieve energy recoveries of up to 100 percent, Chemetics has developed a family of process add-on systems for sulphuric acid plants. These recover additional energy without causing a reduction in plant availability. Chemetics gives an overview of the process systems it offers – and shows how each of these are designed to operate independently.

The Umm Wu'al phosphoric acid plants: a success story

Three phosphoric acid plants constructed as a part of the Umm Wu'al Chemical Complex in Saudi Arabia are currently in operation. The complex is a joint venture between Ma'aden, Mosaic and Sabic. Jacobs provided the technology for all three phosphoric acid plants and performed basic engineering for the project. A joint team of Jacobs, Mosaic and Ma'aden participated in the detailed engineering phase of the project with Hanwha, the project's EPC contractor. Project execution – from basic engineering through construction and culminating with process performance test results – are described in this joint presentation from Jacobs and Mosaic.

WAPHCO: a novel Egyptian project

WAPHCO is currently developing a new phosphoric acid plant complex adjacent to the existing Abu Tartour mine in Egypt. This will export merchant grade phosphoric acid (MGA) to the international marketplace. The background to this new phosphoric acid project and the novel technologies involved are outlined in this joint K-Tech and WAPHCO presentation.

The complex will include: a new 5,000 t/d sulphuric acid/co-generation plant; a dual train 500,000 t/a phosphoric acid plant, licensed and designed by Prayon Technologies of Belgium; and a continuous ion exchange (CIX) system licensed and designed by K-Technologies, Inc (K-Tech) of the United States. The CIX system will

reduce iron, aluminium, and magnesium impurities to acceptable levels. The complex is expected to start-up in 2021.

K-Tech's patented CIX purification process will reduce the minor element ratio (MER) below the internationally recognized value of 0.08, while at the same time reducing the Fe_2O_3 content of the MGA below 1.8 percent.

Optimising granulator bed design

Granulators are almost ubiquitous in modern fertilizer plants. The current spreadsheet approach to the design and placement of granulator internals has evolved empirically over time. While largely successful, Hatch has developed a proprietary 1D bed profile model to improve this method. This mathematically determines the bed height along the length of the granulator. Unlike empirical residence time calculations, the bed profile model is also dependent on the flow rate of solids, solids density, dynamic angle of repose and dam configurations.

Hatch specialises in modeling rotating equipment such as granulators. Software options such as Discrete Element Modelling (DEM) can be used to verify existing industry assumptions on bed behaviour, and optimise the design and placement of granulator internals – such as the ammonia sparger and slurry sprays. The resulting optimisation can deliver a number of benefits in fertilizer granulation, including better product quality and lower OPEX (power, ammonia feed and maintenance costs).

Novel fertilizer coatings for dust control applications

Dust formation, cake formation and moisture uptake problems are particularly challenging storage and handling issues in the fertilizer industry. Coatings are typically applied to the surface of granules to prevent dust generation, reduce caking tendencies and reduce the uptake of moisture. High viscosity coatings normally need heating to an elevated temperature to spread properly and achieve optimal coating efficiency.

This presentation from ArrMaz focuses on the application of a novel coating technology. This can be applied at ambient temperature yet still achieve high performance dust control, anti-caking and moisture resistance properties. ■

Florida: centre of excellence

Florida's phosphate industry is supported by a cluster of world-class companies. Our US correspondent, **Mark Evans**, profiles the sunshine state's innovative and outward-looking phosphate sector and reveals its recipe for global success.

Florida's pre-eminence as a phosphate-producing region dates back to the industry's earliest days. Phosphate rock deposits near Hawthorne in Alachua County were the first to be mined in 1883.

The discovery of exceptionally large phosphate reserves in Florida during the late 19th century came at a time when agriculture was also of increasing importance to the state's burgeoning economy. Although phosphate mining was a primitive affair in those pioneering times, early Florida settlers were quick to recognise the agronomic benefits of phosphate, which were readily-apparent when applied to the citrus trees they were planting in ever larger numbers.

Florida leads, others follow

Indeed, the presence of abundant citrus groves on their doorstep provided Florida's nascent phosphate industry with a ready-made market for their product. Furthermore, a near-perfect match of supply and demand in Florida created ideal conditions for a number of crucial and landmark mining and production innovations. In the 1920s and 1930s, a growing market, and the drive for greater efficiency and lower costs, provided all the incentives necessary for the introduction of draglines and the development of flotation and other beneficiation technologies.

As process engineering improved, and agricultural knowledge also grew,

Florida's phosphate producers introduced new downstream processes, pioneered by the Tennessee Valley Authority (TVA) in the 1960s, to manufacture more concentrated phosphate fertilizers. The new high-analysis products – monoammonium phosphate (MAP) and diammonium phosphate (DAP) – were able to deliver more phosphate to farmers at a lower cost. As a consequence, ammoniated phosphates ended up displacing superphosphate as Florida's primary fertilizer commodity. This development ultimately transformed what had been largely a mining industry in Florida into a chemicals business.

As the 20th Century progressed, Florida's state of the art phosphate production processes offered a mining and manufacturing template which others could learn from and follow. The landmark developments pioneered in the state became standard phosphate industry practice, setting an operational benchmark for the other phosphate-producing countries which have emerged around the world subsequently.

Eclipsed by China

For decades during the post-war period, Florida enjoyed a commanding position globally as a supplier of phosphate rock and finished phosphate products. But since the 1990s the state's global hegemony has been increasingly challenged by the rise of other centres of phosphate production – in China, Morocco, India, Saudi Arabia, Russia, Brazil and elsewhere. Hav-

ing once been a major phosphate import market, China has transformed itself through a crash programme of industrialisation into the world's largest producer of finished phosphates, and a net phosphate exporter.

Although eclipsed by China's phosphate fertilizer (DAP/MAP/TSP) production might – a mammoth 38.1 million t/a of capacity – the US still ranks as the second largest global production centre with a greater finished phosphates capacity (13.2 million t/a) than its nearest rival Morocco (11.9 million t/a).

The eventual end of phosphate mining in Florida has also been long predicted. US phosphate rock production peaked at 54.4 million tonnes in 1980, accounting for 37 percent of world production that year. Production has slid inexorably since then to 7.7 million tonnes in 2017, just 12 percent of global production. That figure is less than one-third of China's 24.6 million tonne phosphate rock production volume, and is also eclipsed by the 10.2 million tonnes produced by Morocco in 2017.

Yet the Florida phosphate industry has shown remarkable resilience, ingenuity and longevity in the face of these challenges.

US phosphate reserves are estimated at one billion tonnes currently, sufficient for a further 30-40 years of mining at current extraction rates. In Florida, abundant unexploited reserves still exist south of the state's historic mining area, centred on Polk, Manatee and Hillsborough Counties. Despite fierce local opposition to new mines, The Mosaic Company was recently granted the last permit for its Ona phosphate mine project in Hardee County, securing an additional 160 million tons of phosphate rock for future mining.

Economic worth

For the US as a whole, phosphate rock is mined by five companies from 11 mines in four states. This ore is beneficiated into 27.7 million tons of phosphate rock concentrate with a market worth of around \$2.1 billion f.o.b. Florida and North Carolina combined account for more than 75 percent of total US output, with Idaho and Utah responsible for the remainder.

More than 95 percent of the phosphate rock mined in the United States is consumed in the production of phosphoric acid, an intermediate in the manufacture of phosphate fertilizers, both granular and

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liquid, and feed phosphates. About 50 percent of the wet-process phosphoric acid produced is subsequently exported in the form of diammonium (DAP) and monoammonium phosphate (MAP) and merchant-grade acid (MGA).

The economic worth of the phosphate industry in the Central Florida and Tampa Bay regions remains enormous. Fertilizers are one of the state's leading export commodities, with a 2016 value totalling \$1.7 billion, according to Enterprise Florida. The Port of Tampa also calculates that phosphate fertilizers create around 46,000 regional jobs, generating close to \$3.1 billion in personal income for the local economy. The industry generated \$501.9 million for the Port in 2016, plus \$10.7 million in related output, resulting in over \$12.2 billion in total economic value to the region. Jobs created by the phosphate industry accounted for over 50 percent of the Port's direct, indirect and related jobs, as well as around 70 percent of Port Tampa's annual economic activity.

Seamless reinvention

To its credit, North America's phosphate industry has neither stood still or been left behind. Instead, it has parlayed its world-class expertise and track record as a trailblazer to become the purveyor of process engineering, technology, products and services to the global phosphate industry. North American phosphate producers such as The Mosaic Company have also acted, with acumen and foresight, to secure their competitive position and continued market access – via a programme of global acquisitions and investments, and by forging strategic partnerships internationally.

Taking production figures at face value, some commentator will argue that the US phosphate industry is locked into a slow but inevitable decline, compounded by underlying factors such as depleted resources, increasingly stringent environmental regulation and international competition. But that is not the whole story. The US industry's depth and breadth of expertise – and reputation for engineering excellence and technological innovation – still gives it a competitive edge globally.

The following profiles help explain why the US phosphate sector still punches above its weight – and continues to capture new markets for its products and services. ■

The Mosaic Company

Through a series of mergers and acquisitions, The Mosaic Company has not only emerged as the predominant regional producer, it also remains the largest integrated phosphate producer in the world. Impressively, the Company is responsible for nearly 65 percent of the granular phosphate fertilizers supplied to US farmers. Its output of finished phosphate products is also equivalent to some 12 percent of overall global supply.

As a Fortune Top 500 Company, Mosaic generated much local media excitement when it announced that it would relocate its global headquarters from Minnesota to Hillsborough County (which embraces Tampa), with effect from 2019. Mosaic's own economic impact in Florida is a powerful one. Its outlays within the state approached one billion dollars in 2017, comprising:

- \$465 million payroll
- \$307 million capex
- \$41 million for land reclamation
- \$28 million in county and real estate taxes
- \$40 million state severance and sales taxes
- \$1.1 million to the Florida United Living organisation.

Importantly, Mosaic says the move to Hillsborough will place it closer to and benefit communications with its newly-acquired operations in Brazil. However, the move is also a vote of confidence by Mosaic in the future of Florida, both as a centre of phosphate production and the company's own operations in the state. The successful completion recently of a project to convert a dual-train production plant at the New Wales complex to *MicroEssentials* production is another clear sign of Mosaic's belief in Florida's long-term future. This was Mosaic's largest phosphate project to date and the largest US granular fertilizer plant expansion in over 30 years (*Fertilizer International* 484, p56).

Mosaic has meanwhile welcomed Port Tampa's \$63 million project to deepen the Big Bend Channel. Mosaic is one of Port Tampa's principal tenants and makes extensive use of the Big Bend Channel for both shipments of finished fertilizers and for the discharge of key inputs such as sulphur. To permit entry to port of much larger vessels, the Channel's is being widened from 200 feet to 250 feet and its depth increased from 34 feet to 43 feet. The project is due for completion in April. ■

Hatch

Engineering giant Hatch employs 9,000 staff worldwide in over 60 offices, providing operations support, technologies, process design and project and construction management in the metals, energy and infrastructure sectors. The company maintains close ties with the Florida and global phosphate industry via its 'Phosphate Center of Excellence' office in Tampa.

In 2016, Hatch's Tampa office provided engineering, procurement, construction management (EPCM) and commissioning services for Mosaic's 'DAP2' conversion project. This successfully converted a dual-train diammonium phosphate (DAP) production plant at the company's New Wales site to *MicroEssentials*, Mosaic's market-leading premium phosphate product (*Fertilizer International* 484, p56). The \$200 million capital project included:

- Complete re-engineering of the dual-train plant for granular monoammonium phosphate (GMAP) and *MicroEssentials* production
- Installation of new dust collection systems
- Increase in plant recycle rate for improved product quality
- The installation of new closed-circuit scrubbing systems
- New ammonia vaporisers
- A new 65,000 ton product warehouse with an automatic reclaimers
- A new sulphur pit with molten sulphur transfer systems
- An unloading, storage and pneumatic conveying system for the micronutrients used in *MicroEssentials* production such as zinc.

Hatch was able to fulfil the EPCM project 10 percent below the \$200 million budget. ■



Laboratory froth flotation.

ArrMaz

ArrMaz is a global leader in the production of speciality chemicals for the mining, fertilizer, oil and gas and other industrial sectors worldwide. The company is based in Mulberry in the historic heartland of Florida's phosphate industry and celebrated its 50th anniversary in 2017. ArrMaz has formulated chemical process aids and additives able to optimise process performances and product quality since the late 1960s. ArrMaz serves customers in more than 70 countries via a network of regional offices in North and South America, Europe, Asia, Africa and the Middle East.

In the phosphate mining industry, ArrMaz is an acknowledged global leader in developing process chemicals, custom reagent schemes and flowsheet designs, all tailored for customer-specific ores. Froth flotation expertise is a key strength. Access to state-of-the-art flotation laboratories at various locations worldwide enables ArrMaz to develop the best reagent for each phosphate ore type encountered. In-house laboratory expertise also enables ArrMaz to decide on the optimal application system, monitor reagent performance and adjust formulations, as necessary, over time. These expert laboratory capabilities allows ArrMaz to design flotation flowsheets for customers that maximise phosphate product grade and ore recovery.

For downstream production, ArrMaz recognises the challenges phosphate manufacturers face in terms of environmental compliance, chemical efficiency, plant productivity and product improvement. The company has responded by developing a broad range of chemical technologies to help producers overcome these challenges, both efficiently and cost-effectively.

The custom-formulated defoamers developed by ArrMaz are one example. These enable phosphoric acid producers, who are under constant pressure to eliminate all visual emissions from their processes, to maintain strict environmental control of exhaust gases from scrubber systems and avoid recycling contaminated waste water. ArrMaz defoamers have the ability

to lower reactor levels, reducing the foam that can carry over into exhaust gas scrubbers and preventing reactor overflows.

Every phosphoric acid plant has its own operating challenges. In many cases, the primary factor that limits production rates is the volume of phosphoric acid that passes through the calcium sulphate cake on the plant filter under vacuum. ArrMaz provides filtration aids that increase the rate of filtration, boosting overall efficiency.

The level of impurities in phosphoric acid must be kept low to prevent these becoming concentrated in the fertilizers produced downstream. ArrMaz clarification aids improve quality by greatly increasing settling and the removal rate of impurities in phosphoric acid.

Various process aids, including defoamers, flocculants and corrosion inhibitors, can be harnessed during the production of finished fertilizers, although these generally need to be removed from the final product. ArrMaz works in partnership with fertilizer producers, distributors and users to help them improve operational efficiencies and product quality. The correct products for each specific application, and the right application systems, are identified and developed as part of these collaborations.

ArrMaz has drawn on its leadership in dolomite and silica flotation for recent projects. The company's collaboration with the Brazilian phosphate industry to address the issue of lower-quality deposits is one noteworthy example. Notably, ArrMaz is also extending the boundaries and capabilities of froth flotation by developing collectors that allow the use of sea water in phosphate beneficiation. Mining and processing operations have generally used ground and surface waters. But these traditional water sources are proving to be insufficient to meet the increasing demands of the industry as it deals with lower quality ores. In response, ArrMaz is currently developing a collector that allows for the flotation of phosphate in sea water, while still meeting the required grade (>27.5% P₂O₅) grade and recovery (>80%) criteria. ■

Florida is the purveyor of process engineering, technology, products and services to the global phosphate industry.

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KEMWorks

Florida's KEMWorks Technology, Inc specialises in phosphate project development services. The Lakeland-based company offers bankable feasibility studies for phosphate projects as well as pilot plant testing for both beneficiation and phosphoric acid production. KEMWorks also works with technology suppliers and large international contractors.

Since its foundation in 1995, KEMWorks has completed more than 500 projects for more than 100 companies. Its client list includes most of the major phosphate producers and leading phosphate project developers.

The company uses the 'Hollywood Model' when it comes to staffing. Modern film studios do not permanently employ actors, directors and crew. Similarly, KEMWorks prides itself on being able to assemble project-specific teams of highly experienced and skilled professionals tailored to meet the client's exact requirements.

The company does, however, retain a full-time complement of project managers and experts in pilot plant operation, beneficiation, phosphoric acid, fertilizers and animal feed ingredients. In-house staff expertise is supplemented by drawing on external experts in disciplines such as mechanical, civil and structural, electrical and instrument engineering. One of the benefits of being based in Lakeland is that many of these skillsets are available from Central Florida's local talent pool.

KEMWorks' know-how encompasses the complete range of process technologies for the phosphate industry. Its process expertise includes the production of phosphoric acid, granular fertilizers, and animal feed additives. Defluorination, fluoride recovery and uranium extraction from phosphoric acid are also covered.

KEMWorks has supplied know-how and basic engineering to several projects in South Africa, and similar projects in Morocco,



KEMWorks laboratory services.

Senegal, Australia and Canada. The company's phosphate industry track record includes the following projects:

- Farim project in Guinea Bissau for Itafos: KEMWorks initially carried out beneficiation test work, developing a simplified flow sheet that eliminated flotation entirely to produce a high grade (34% P_2O_5) concentrate. KEMWorks also produced the project's bankable feasibility study in partnership with Canada's Lycopodium. The Farim project is an advanced stage and will be at the lower end of the cost curve.
- World-scale merchant-grade phosphoric acid (MGA) plant project for the WAPCO consortium in Egypt: KEMWorks teamed up with Lakeland-based K-Technologies, which has developed a continuous ion exchange process to remove impurities from MGA. Using low-grade Abu Tartour phosphate rock as a feedstock, the objective is to manufacture phosphoric acid of sufficient quality for the downstream production of high-analysis phosphate fertilizers, such as DAP.

As most of its projects are overseas, KEMWorks is an exporter of services that generates income for Florida's economy. ■

PegasusTSI

Tampa-based PegasusTSI, Inc specialises in providing EPCM services to the phosphate and nitrogen fertilizer industries worldwide, as well as the oil refining, chemical and consumer and municipal sectors.

PegasusTSI's project involvement begins at the conceptual engineering phase, starting with:

- Feasibility studies
- Technology evaluations
- Budget cost estimates
- New and revamped process plant facilities
- Definitive process design and cost estimates
- Technology transfer
- Preparation of front end process design packages
- Plant test runs and performance evaluations
- Capital budget expenditure planning.

PegasusTSI's expertise also includes front-end engineering design (FEED).

PegasusTSI has made significant contributions to the development of Morocco's world-scale phosphate industry. In 2012, for example, the company notably led the study phase for Daoui wash/flotation plant project for JESA, the engineering group jointly owned by Morocco's OCP Group and Jacobs Engineering.

To improve the performance of the existing washing plant at

Khouribga, PegasusTSI was tasked with providing a cost-effective means of recovering additional P_2O_5 from phosphate tailings. The study was needed to ensure that any design for the proposed modification was workable, operable and met industry best standards. PegasusTSI was able to leverage decades of industry experience, especially in upgrading existing phosphate fertilizer plants, to ensure that the basic engineering package for the project was both comprehensive and accurate.

PegasusTSI also played a leading role in converting the phosphate rock feed system in the Pakistan Maroc Phosphore (PMP) phosphoric acid complex in Jorf Lasfar. The previous feed system needed to be converted from dry rock to slurry to accept feed transported along OCP's new 192-kilometre Khouribga-Jorf Lasfar slurry pipeline.

Having previously provided project scoping and basic engineering work, PegasusTSI provided EPCM services for the PMP slurry project. The slurry emerging from the pipeline (50% solids concentration) needed to be thickened (to 65% concentration) to allow the phosphoric acid plants to operate efficiently. To achieve this, PegasusTSI designed and installed two deep cone thickeners and associated pumps and tanks. The two thickeners performed as required, achieving an operating rate of 140 t/h in performance tests completed in mid-2015. ■

Kimre

Florida's Kimre, Inc is a world leader in innovative clean air technologies. Founded in 1973, the company offers a comprehensive range of mist eliminators, scrubbers and filters. These are designed to reduce or eliminate process and gas stream emissions.

Kimre's main North American manufacturing site is located at Homestead, Florida, south of Miami. The company's clean air technology has been installed throughout the phosphate industry, dealing with the off-gases and particulate matter generated at every stage of the production process. Phosphate production generates fluorides (HF and SiF_4), ammonia, NO_x , SO_x , ammonium phosphate and dust contaminants – all of which need to be scrubbed to prevent air pollution.

For over 40 years, gas cleaning systems supplied by Kimre have consistently achieved the lowest emission levels in the industry. Kimre notably manufactures the high performance SXF^{SM} semi-cross flow scrubber. Dirty gas flows horizontally through the scrubber after exposure to pre-conditioning sprays. The scrubber incorporates a series of proprietary $KON-TANE^{\circ}$ scrubber and tower packing stages and a final $B-GON^{\circ}$ mist eliminator stage. Using stage-wise separation, the SXF^{SM} scrubber removes contaminant gases and particulate matter to meet emission limits, while also recovering valuable products to return to the process.

The number of Kimre installations at phosphate plants worldwide exceeds 100. They include installations at every level of the fertilizer manufacturing process, including:



Emissions reduction and elimination.

- Rock drying
- Fume scrubbers
- Fluosilicic acid (FSA) scrubbers
- Ammonium phosphate, single and triple superphosphate scrubbers.
- Vacuum scrubbers



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Above: Phosphogypsum stack. Below: Closure and aftercare.



Ardaman & Associates

Florida's Ardaman and Associates, Inc provides geotechnical consulting and environmental engineering services to the public and private sectors. The Orlando-based company has made numerous contributions to the development of the phosphate industry worldwide. Resource management services offered by Ardaman cover:

- Industrial solid waste and phosphogypsum management
- Dams, levees and earthen structures
- Mining
- Water resources
- Contamination remediation
- Laboratory testing.

Ardaman also offers the following infrastructure and other services:

- Geotechnical and foundation engineering
- Construction materials inspection and testing
- Environmental assessments and remediation
- Sinkhole investigations and evaluations
- Subsurface investigations.

Ardaman has worked on over 75 phosphogypsum disposal sites worldwide. Impressively, its project to close the Polk County stack, one of the largest phosphogypsum stack system closures in the world, was selected for an award by the Florida Institute of Consulting Engineers. This unlined stack, which had been used to store phosphogypsum waste for over 30 years, had reached a height of 140 feet and extended over 900 acres by the end of its working life. A closure plan was necessary to ensure proper aftercare and prevent the stack becoming a potential source of surface and groundwater contaminants in future.

Ardaman & Associates designed the stack's closure plan, and assisted with the permitting process and the water management plan. Pondered process water (1.9 billion gallons) at the site, and almost 80 percent water of the gypsum pore water (about 900 million gallons) in the stack, were removed as a result of the closure. Pollutant discharges also fell dramatically as the stack's closure proceeded. ■

Florida Industrial & Phosphate Research Institute (FIPR)

Florida's phosphate industry has long benefitted from the support of the Florida Industrial & Phosphate Research Institute (FIPR). The Institute was created as a state agency in 1978 – under its original guise, the Florida Institute for Phosphate Research – with a remit to study phosphate industry issues affecting Florida's citizens, economy and environment. This remit was broadened in 2010 to encompass energy research and the mining and processing of other minerals. FIPR eventually became part of Florida Polytechnic University in 2012.

FIPR's main mission is to improve phosphate mining and processing efficiency, promote industry best practice, and protect and improve the environment and public health. Scientists and engineers from around the world are able to apply for grants and participate in FIPR's original phosphate research programme. FIPR staff collaborate externally and also conduct their own in-house research.

FIPR is an acknowledged global centre for research and knowledge on phosphate mining and production. The Institute's four main areas of research cover:

- Mining and beneficiation
- Chemical processing

- Land reclamation
- Public and environmental health.

FIPR's parent body, Lakeland-based Florida Polytechnic University (FPU) is the state's newest university, being established in 2012 to provide STEM (science, technology, engineering and mathematics) education. Since then, the university has formed partnerships with more than 100 external organisations in the corporate, non-governmental and public sectors. The Mosaic Company is one of FPU's leading industry partners.

A new five-year strategy for the university, unveiled last October, aims to cement FPU's status as a centre of technological excellence and help drive economic growth in Central Florida. The strategy includes plans for a new research park adjacent to the existing FPU campus.

"This research park will be the catalyst for bringing financial and facility capital to this area," said Dr Randy Avent, Florida Polytechnic University's president. "It will be where private companies and academic researchers come together to commercialise innovation and where an entire community of people, who are not even here yet, come together to live, work, and play." ■



JDCPhosphate

JDCPhosphate, Inc is working to commercialise the Improved Hard Process (IHP) route for phosphoric acid production. The process involves combining phosphate rock with green petroleum coke, sand (silica) and clay together to form a kiln feed. This mixture is granulated, fed to a rotary kiln and heated to generate P_4O_{10} gas from phosphorus via endothermic reduction and exothermic oxidation. Clean concentrated phosphoric acid (70%) is obtained as an end-product by cooling and absorbing the gas in water using an acid hydrator. Heat integration within the kiln recovers over 90 percent of the electricity consumed in the furnace acid process.

With a minimum requirement of 15 percent P_2O_5 , the IHP can produce phosphoric acid using much lower-grade phosphate rock than is possible by the conventional wet acid process. IHP also has less stringent criteria for impurities. Consequently, IHP, promises to unlock billions of tonnes of low-grade phosphate rock by transforming these into usable reserves, if and when it is fully commercialised.

IHP also has a lower environmental footprint compared to the wet acid process. The process avoids the production of phospho-

gypsum waste, reduces carbon emissions, and should also eliminate wastewater discharges.

JDCPhosphate concluded an equity financing deal with Stonecutter Phosphate Investors in July 2017 to help accelerate IHP's commercialisation. The company is currently upgrading its IHP demonstration plant at Fort Meade in Central Florida (above) to allow the plant to be operated over sustained periods and on-demand. The upgrade, due to be completed in mid-2019, will allow potential licensees to validate the IHP for their phosphate ore and silica sources. As a next step, JDCPhosphate will focus on completing the process design engineering needed to fully commercialise the technology.

JDCPhosphate board member Chris Fountas said: "JDC's IHP technology will be key to extending the life of the phosphate industry in Florida and globally. The phosphate industry is an important driver in Florida that has seen operations curtailed due to diminishing local phosphate reserves and competitive pressures from producers around the world." ■

Additional reporting by Simon Inglethorpe.



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Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
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Phosphates project listing 2019

Fertilizer International presents a round-up of phosphate rock, phosphoric acid and finished phosphates projects.

Finished phosphates, phosphoric acid and integrated phosphate rock projects

Plant/project*	Company	Location	Product	capacity ('000 t)	Status	Start-up date
ALGERIA						
Bled Al-Hedba	Asmidal/Manal Group/Indorama	Oued El Kebrit, Hadjar Soud	Phosphate rock	5,000	PL	2020
Bled Al-Hedba	Asmidal/Manal Group/Indorama	Oued El Kebrit, Hadjar Soud	Phosphoric acid (P ₂ O ₅)	1,600	PL	2020
Bled Al-Hedba	Asmidal/Manal Group/Indorama	Oued El Kebrit, Hadjar Soud	DAP/MAP	3,900	PL	2020
BRAZIL						
Serra do Salitre	Yara	Patrocinio, Minas Gerais	Phosphate rock	1,200	UC	2018
Serra do Salitre	Yara	Patrocinio, Minas Gerais	Phosphoric acid (P ₂ O ₅)	250	UC	2019
Serra do Salitre	Yara	Patrocinio, Minas Gerais	SSP	650	UC	2019
Serra do Salitre	Yara	Patrocinio, Minas Gerais	DAP/MAP	350	UC	2019
Santa Quitéria	Galvani	Itatiaia	Phosphate rock	800	PL	post-2022
Santa Quitéria	Galvani	Itatiaia	Phosphoric acid (P ₂ O ₅)	240	PL	post-2022
Santa Quitéria	Galvani	Itatiaia	MAP/NPK	290	PL	post-2022
Catalão (Ouidor)	Copebras/CMOC	Catalão, Goiás	Phosphate rock	1,200	PL	post-2022
Catalão (Ouidor)	Copebras/CMOC	Catalão, Goiás	Phosphoric acid (P ₂ O ₅)	400	PL	post-2022
Catalão (Ouidor)	Copebras/CMOC	Catalão, Goiás	MAP	520	PL	post-2022
Catalão (Ouidor)	Copebras/CMOC	Catalão, Goiás	TSP	240	PL	post-2022
Salitre Patrocinio	Vale/Mosaic	Salitre Patrocinio, Minas Gerais	Phosphate rock	1,100	PL	2019
Salitre Patrocinio	Vale/Mosaic	Salitre Patrocinio, Minas Gerais	Phosphoric acid (P ₂ O ₅)	560	PL	post-2022
Salitre Patrocinio	Vale/Mosaic	Salitre Patrocinio, Minas Gerais	MAP	780	PL	post-2022
Salitre Patrocinio	Vale/Mosaic	Salitre Patrocinio, Minas Gerais	TSP	330	PL	post-2022
EGYPT						
Ain Sokhna	NCIC	Suez Ain Sokhna	Phosphoric acid (P ₂ O ₅)	400	C	2019
Ain Sokhna	NCIC	Suez Ain Sokhna	DAP/MAP	850	C	2019
El Wadi	WAPHCO	Abu Tartur	Phosphate rock	3,000	UC	2021
El Wadi	WAPHCO	Abu Tartur	Phosphoric acid (P ₂ O ₅)	500	UC	2021
El Wadi	WAPHCO	Abu Tartur	DAP/MAP	800	UC	2021
El Wadi	WAPHCO	Abu Tartur	TSP	600	UC	2021
INDIA						
Visakhapatnam	Coromandel International	Visakhapatnam	Phosphoric acid (P ₂ O ₅)	100	UC	2019
Sikka expansion	GSFC	Sikka	DAP/NPK (Train 4)	500	UC	2019
Krisnapatham	OCF/Kribhco	Krisnapatham	DAP/NPK	1,200	PL	2021/22
Orissa expansion	Paradeep Phosphates	Orissa	DAP	440	PL	2020
Orissa expansion	Paradeep Phosphates	Orissa	SSP	560	PL	2020
KAZAKHSTAN						
Taraz	Kazphosphate	Taraz	PPA (P ₂ O ₅)	240	UC	2021/22
Taraz	Kazphosphate	Taraz	MAP	460	UC	2021/22
MOROCCO						
JFC IV	OCF/Jorf Fertilizers Company	Jorf Lasfar	Phosphoric acid (P ₂ O ₅)	500	C	2018
JFC IV	OCF/Jorf Fertilizers Company	Jorf Lasfar	Finished phosphates	1,000	C	2018
Maroc Phosphore	OCF	Jorf Lasfar	MAP soluble	120	C	2018
Maroc Phosphore	OCF	Jorf Lasfar	Finished phosphates	900	PL	2019
Emaphos	OCF/Prayon/Bedenheim	Jorf Lasfar	PPA (P ₂ O ₅)	140	PL	n/a
Phosboucraa	OCF	Phosboucraa	Phosphoric acid (P ₂ O ₅)	500	PL	2021/22
Phosboucraa	OCF	Phosboucraa	Finished phosphates	1,000	PL	2021/22
PHILIPPINES						
Leyte	PHILPHOS	Leyte	DAP/NPK	400	UC	2019

Plant/project*	Company	Location	Product	capacity ('000 t)	Status	Start-up date
SAUDI ARABIA						
Wa'ad Al Shamal/Umm Wu'al	MWSPC	Wa'ad Al Shamal	Phosphoric acid (P ₂ O ₅), 3 lines	1,500	C	2018/19
Wa'ad Al Shamal/Umm Wu'al	MWSPC	Ras al Khair	DAP/MAP, 3 lines	3,000	C	2018/19
Second mega project	MWSPC	Ras al Khair	Finished phosphates	3,000	PL	post-2022
TUNISIA						
M'dilla II	GCT	M'dilla	Phosphoric acid (P ₂ O ₅)	180	UC	2019/20
M'dilla II	GCT	M'dilla	TSP	500	UC	2019/20
TURKEY						
Mazidagi	Eti Bakir	Mazidagi	Phosphoric acid (P ₂ O ₅)	200	C	2018
Mazidagi	Eti Bakir	Mazidagi	DAP/NPK	435	C	2018
UGANDA						
Sukulu	Guangzhou Donsong Energy Group	Tororo	Phosphate rock	1,500	C	2018
Sukulu	Guangzhou Donsong Energy Group	Tororo	Phosphoric acid (P ₂ O ₅)	400	C	2018
Sukulu	Guangzhou Donsong Energy Group	Tororo	DAP/MAP	150	C	2018
Sukulu	Guangzhou Donsong Energy Group	Tororo	NPK	150	C	2018
UNITED STATES						
White Springs	Nutrien	Florida	MAP	400	UC	2019

* Excluding China. Notable start-ups in 2018 included OCP's fourth Jorf Lasfar hub in Morocco, Yara's Serra do Salitre project in Brazil, Eti Bakir's Mazidagi plant in Turkey and NCIC's Ain Sokhna plant in Egypt. OCP's output from its latest hub and Ma'aden's Wa'ad Al Shamal project in Saudi Arabia will continue to ramp-up this year, adding considerable new supply to the market. A second Saudi phosphates mega project has also been announced by Ma'aden. In Africa, Guangzhou Donsong Energy Group's Sukulu project in Uganda was also formally opened last October.

Phosphate rock projects

Plant/project**	Company	Location	capacity ('000 t)	Status	Start-up date
BRAZIL					
Goiás expansion	Copebras/CMOC	Goiás	230	UC	2023
CANADA					
Lac-à-Paul	Arianne Phosphate	Quebec	3,000	FS	2020
Sept-Iles	Mine Arnaud	Quebec	1,500	FS	2020
REPUBLIC OF CONGO					
Hinda	Kropz	Hinda	1,200	FS	n.a.
GUINEA-BISSAU					
Farim	Itafos	Guinea-Bissau	1,300	FS	2020
JORDAN					
Eshidiya expansion	JPMC	Eshidiya	1,300	UC	2018/19
KAZAKHSTAN					
Zhanatas expansion	EuroChem	Zhanatas	800	PL	2021
SENEGAL					
Avenira expansion	Avenira	Gadde Bissik	1,000	PL	n.a.
SOUTH AFRICA					
Elandsfontein	Kropz	Elandsfontein	1,500	C	2020

KEY

- FS Feasibility study complete
PL Planned
UC Under construction
C Project completed
DAP Diammonium phosphate
MAP Monoammonium phosphate
PPA Purified phosphoric acid
SSP Single superphosphate
TSP Triple superphosphate

** The number of junior phosphate mining projects globally exceeds fifty. However, only 2018-2022 capacity developments reported by the International Fertilizer Association (IFA), or projects with a feasibility study are listed here. Additionally, expansions by established Russian producers (PhosAgro at Kola, EuroChem at Kovdor, Acron at Oleniy Ruchey) should add 1.8 million tonnes to Russia's phosphate rock capacity by 2022. North Africa is undoubtedly the region with the most potential for phosphate rock expansion – although large uncertainties over individual projects remain. IFA reports that completion of two projects in Algeria (by Somiphos at Djebel Onk and Manal at Bled ElHabda) could expand the country's capacity by seven million tonnes. Tunisia could also expand its capacity by five million tonnes over the longer-term, suggests IFA, with potential new mines at Nefta Tozeur and Oum El Khcham. In Morocco, OCP Group is pressing on with its large-scale phosphate rock capacity expansions. These will take place at Khouribga in the short-term and at Meskala over the longer-term. Consequently, IFA expects Morocco's phosphate rock capacity to rise to 45 million tonnes in 2022, up from a 2017 baseline of 39 million tonnes. No major expansion of phosphate mining or downstream production is expected in China over the short-term. Indeed, IFA currently predicts that Chinese phosphate rock production will decline in future, eventually stabilising at 81 million tonnes after 2020.

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Fax: +44 (0)20 7793 2577
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EcoPhos heads east

EcoPhos and its Chinese joint venture partner Guizhou Chanhen are collaborating on the Chaneco phosphate project in Guangxi province. The aim is build an innovative, high-tech and eco-friendly phosphate production plant, explains **Mohamed Takhim**, the founder and CEO of EcoPhos.

Belgium's EcoPhos S.A. has launched a joint venture (JV) to construct and operate a new phosphates plant in China. The new plant – the first of its kind in China – is being built near Nanning, Guangxi province, and will use innovative and eco-friendly proprietary technology developed by EcoPhos.

Chaneco phosphate project

EcoPhos and China's Guizhou Chanhen established a JV company named Chaneco Co Ltd in March last year. The company is 60 percent owned by Guizhou Chanhen and 40 percent owned by EcoPhos.

Chaneco was set up to build and operate a new phosphates plant in China based on the proprietary EcoPhos production process. The 300,000 t/a capacity (P_2O_5 equivalent) plant will be capable of converting low-grade phosphate rock into high-quality finished phosphate end-products. This plant will also be free of phosphogypsum waste. Instead, it will generate, as a by-product, commercial-grade gypsum plaster suitable for construction use or technical applications.

The Chaneco plant will manufacture the following range of high-purity products for food, technical and feed applications:

- Food-grade purified phosphoric acid (PPA)
- Feed-grade monocalcium Phosphate (MCP)
- α -hemihydrate plaster
- β -hemihydrate plaster
- Compound NPK fertilizer.

The new plant will be constructed at the Fusui China-ASEAN Youth Industrial Park near Nanning, Guangxi province. This location, at the heart of a free trade zone, provides a strong customer base for phosphate and plaster products. It also offers convenient logistics for domestic transport and/or overseas shipments, being located just 160 kilometres from the Vietnamese border.

The Chaneco phosphate project will include three independent 100,000 t/a capacity (P_2O_5) production lines (Figure 1). The front end engineering for the first line was completed in December last year by Belgium-based EcoPhos Industrial Services. Detailed engineering is currently underway with construction due to formally start by the end of this year.

Chaneco project process

The main raw materials for the Chaneco project will be low-grade Chinese phosphate rock from Chanhen's phosphate mine in Guizhou – together with sulphuric acid from a copper smelter, calcium carbonate and hydrochloric acid feedstocks. The EcoPhos-patented process needed to be adjusted for the project, to account for the high magnesium (3.5 to 4.4% MgO) and iron and aluminium content (5.1% $Fe_2O_3 + Al_2O_3$) of the local phosphate rock. The chosen process involves the selective digestion of phosphate rock, and the subsequent capture and isolation of its P_2O_5 content in the form of dicalcium phosphate (DCP), which has a P_2O_5 concentration of about 41 percent.

The plant will include the following *ChemBe* and *TacHem* process steps:

- Module 1A
- Module 1B
- Module Dry DCP
- Module CCP
- Module 3HD
- Module 4

In the first process step, *Module 1A*, phosphate rock is digested at low temperature using dilute hydrochloric acid. The relatively benign and 'soft' process conditions enable the selective digestion of P_2O_5 – with only limited digestion of aluminium, iron, silica and heavy metals. Pre-neutralisation with limestone slurry also allows the removal of fluoride, excess aluminium and iron. Most of the rock impurities are directly eliminated at this stage as a small amount of residue. The chloride present, from the addition of hydrochloric acid, is also converted into calcium chloride ($CaCl_2$) in this step. The insoluble fraction of the rock is removed by filtration, yielding a clear phosphate solution. The remaining rock residue (lean rock) is then sent to the NPK production line for recycling.

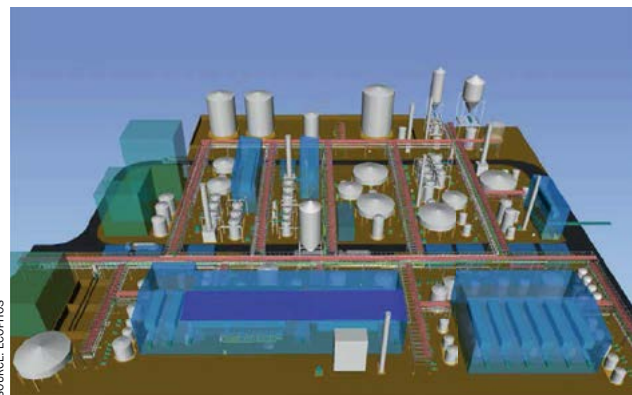


Fig. 1: 3-D model for one of the Chaneco project's three 100,000 t/a capacity (P_2O_5) production lines.

Extending China's reserve base

China's high-grade phosphate rock reserves (>30% P_2O_5) are becoming rapidly depleted, with exhaustion predicted as early as 2030. Phosphate plants running with traditional processing technology may therefore only have a few years' reserves left.

Chinese low-grade rock reserves (20-30% P_2O_5), in contrast, are more extensive and should allow production to continue until 2068, assuming phosphate consumption continues at the today's rate. Reserves should actually last beyond this date, however, given the potential for phosphorus recycling and the wider adoption of more efficient precision farming methods.

Valuably, the Chaneco project's use of innovative EcoPhos process technology means it can consume low-grade Chinese phosphate rock as a feedstock – and convert this into high-quality phosphoric acid suitable for the production of water-soluble fertilizers. The Chaneco project, by improving the longevity of domestic fertilizer supply, should help China guarantee its food production and security – in what is the world most populous country – for many decades to come.

The Chaneco project is also fully aligned with the Chinese government's environmental and pollution prevention policies for air and water. The government embarked on serious enforcement efforts in January 2015 with the revised environmental protection law. This was followed in 2017 by:

- Guidance to enhance the Industry Green Developments in the Yangtze River Economic Belt,
- The Work Programme for Prevention and Control of Air Pollution
- The Taxation law for Environmental protection was later introduced in January 2018.

As a result, some phosphate mines in Northern Sichuan have been closed down to allow a natural park to be created for giant pandas. From 2018 onwards, phosphoric acid plants in Guizhou province will also have to balance the production of phosphates with becoming phosphogypsum-free. This move will make the valorisation of gypsum and the development of end-markets for phosphogypsum waste a priority.

In the next step, *Module 1B*, DCP is crystallised from dissolved P_2O_5 in the phosphate solution by the addition of $CaCO_3$. After filtration, the DCP is dried in the subsequent *Module Dry DCP* step.

In *Module CCP*, the pH of the calcium chloride solution is raised to precipitate magnesium and heavy metals. Calcium chloride is also concentrated in this module to adjust the water balance of the hydrochloric acid loop.

In *Module 3HD*, dry DCP powder can be converted into phosphoric acid and gypsum hemihydrate by reacting with sulphuric acid. Membrane purification is necessary to reach food-grade quality.

In *Module 4*, the purified calcium chloride stream is reacted with sulphuric acid to generate gypsum dihydrate and hydrochloric acid, the latter being recycled to the rock digestion step.

Finally, the feed-grade phosphoric acid (*Module 3HD*) is mixed with dry DCP (*Module Dry DCP*) to produce feed-grade MCP.

Conclusions

China's phosphate producers will need to adopt innovative production technology to ensure the industry's sustainability over the longer-term. Thanks to EcoPhos technology, low-grade Chinese phosphate rock

can now be efficiently valorised and converted into high-quality value-added products. The forthcoming Chaneco production plant will be notable for its:

- High-purity products free of heavy metals
- These include water-soluble fertilizers and highly digestible feed phosphates
- Low production costs and energy consumption
- The production of very high purity gypsum for the construction market
- Zero solid waste generation
- Recycling of the rock residue (lean rock) from acid digestion in NPK production, meaning P_2O_5 recovery is virtually 100 percent.

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North Africa is to the world's phosphate industry what the Middle East is to oil & gas. The region has developed its large share of world phosphate rock reserves to emerge as a globally important production and export hub. We report on the state of the phosphate sector in Algeria, Egypt, Morocco and Tunisia.

North Africa: phosphates powerhouse

The Maghreb countries north of the Sahara, and their close neighbour Egypt, have emerged as a major regional phosphate-producing hub. Their influence on the global phosphate market is increasing, thanks to the vast scale of their phosphate reserves, massive investment in new production capacity, and their relative proximity to strongly-growing markets in Africa and Latin America, and the mature but sizeable European market.

Vast reserves, massive investment

Morocco, in particular, has established itself as a global phosphates powerhouse. Its exemplary success is encouraging North Africa's other major phosphate reserve holders, Tunisia, Algeria and Egypt, to follow suit and invest in their mining capacity and downstream industries. Africa as a continent is responsible for nearly one-quarter of world phosphate rock production, with 90 percent of that total coming from North Africa – Senegal and South Africa being the continent's two others major producing countries (Table 1). North Africa also supplies almost one-half of the international traded market in phosphate rock. The region, through major investments in downstream capacity, is also making an ever-greater contribution to the processed phosphates and phosphoric acid markets, with an 11 percent and 14 percent world share, respectively (Table 1).

Morocco

Morocco's OCP Group occupies a pre-eminent position in the global phosphates industry. The state-owned company enjoys exclusive access to 75 percent of global phosphate rock reserves, and is ranked

as the world's number one phosphates producer/exporter. In 2017, OCP's share of the international phosphate rock, phosphoric acid and phosphate fertilizer market stood at 37 percent, 46 percent and 22 percent, respectively.

Strong performance in international markets helped the Group generate revenues of \$5.0 billion and earnings (EBITDA) of \$ 1.3 billion in 2017. OCP's main revenue earners, in order of importance, are finished phosphate fertilizers (\$2.69 billion), phosphate rock (\$1.06 billion) and phosphoric acid (\$751 million) sales.

In 2017, OCP's phosphate rock exports reached 11.1 million tonnes, up 41 percent year-on-year, and the company's phosphate fertilizer production output reached 8.6 million tonnes. Fertilizer exports for 2017 reached a record 8.1 million tonnes, up from 6.5 million tonnes in 2016, with the company loading as much as 0.9 million tonnes for international delivery in a single month. On an individual product basis, OCP exported:

- 4.6 million tonnes of diammonium phosphate (DAP) and monoammonium phosphate (MAP)
- 1.1 million tonnes of triple superphosphate (TSP) and
- 2.4 million tonnes of NPK/NPS in 2017.

Africa (30%), Latin America (27%) and Europe (20%) and North America (18%) were the main international export destinations. OCP is also a key phosphoric acid supplier globally, exporting 1.9 million tonnes (P₂O₅) in 2017, with much of this volume destined for its Asian joint venture partners (38%), the Asian spot market (35%) and Europe (24%).

OCP mines phosphate rock at three main sites: Khouribga in the north of Morocco, the more central Gantour region (Benguerir and Youssoufia) and Boucraa (Figure 1). OCP also divides its business geographically. The company's three main cash-generating units, known as the Northern Axis (Khouribga–Jorf Lasfar), the Central Axis (Benguerir and Youssoufia–Safi) and the Phosboucraa Axis (Boucraa–Laâyoune), reflect the separate centres of mining and processing in Morocco and their associated downstream chemical assets.

In the Northern Axis, phosphate ore from mines at Khouribga is transported by slurry pipeline to the Jorf Lasfar complex where it is processed into phosphoric acid and finished phosphate fertilizers, particularly DAP and MAP. Fertilizers and phosphate rock are then exported via OCP's Jorf Lasfar port. The complex is also the site of OCP's flagship Jorf Lasfar Phosphate Hub (JPH) project.

In the Central Axis, phosphate ore from mines at Youssoufia and Benguerir is transported by rail to Safi and processed into intermediates and end-products such as phosphoric acid, TSP and feed phosphates (DCP/MDCP). These are exported from OCP's Safi port. Finally, in the Phosboucraa Axis, phosphate rock from Boucraa is transported by conveyor for processing at Laâyoune for export by sea.

OCP has committed \$21 billion to a massive long-term investment programme.

Fig. 1: Major phosphate producing facilities in North Africa



Table 1: North African phosphate production, 2017 (million tonnes)

	Phosphate rock		Phosphate fertilizers*	Phosphoric acid
	Production	Exports	Production	Production
Algeria	1.27	1.05	-	-
Egypt	4.80	3.39	0.17	0.11
Morocco	32.96	11.04	7.16	10.51
Tunisia	4.38	-	0.86	1.66
North Africa total	43.41	15.48	8.19	12.28
Other Africa	4.80	2.21	0.35	1.72
Africa total	48.21	17.69	8.54	14.00
World total	209.74	31.64	71.66	86.04

*MAP/DAP/TSP

Source: IFA

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The largest fertilizer complex in the world, Jorf Lasfar (Arabic for "Yellow Cliffs"), is completely energy self-sufficient.

This is aiming to double the Group's mining capacity and triple its fertilizer production capacity between 2008 and 2025. Completion of the first phase of this investment programme in 2018 delivered the following landmark capacity improvements (since 2007):

- 14 million tonne increase in **phosphate rock mining capacity** to 44 million t/a – with up to 26 million tonnes of this capacity dedicated to downstream processing leaving 18 million tonnes of export capacity
- Combined **phosphate rock transportation capacity** of 64 million tonnes, 38 million tonnes by slurry pipeline and a further 26 million tonnes by rail
- Tripling of **fertilizer production capacity** (DAP equivalent) from four million tonnes to 12 million tonnes
- 20 million tonne boost in **port shipment capacity** to 50 million tonnes.

OCF's investment priorities in 2017 included:

- Expanding the capacity of the Merah El Ahrach (MEA) washing plant at Khouribga by three million t/a
- Completing of the new 5.5 million t/a Béni Amir phosphate mine
- Revamping/adaptation of the phosphoric acid lines Maroc Phosphore (MP) III & IV at Jorf Lasfar to accept phosphate pulp from the Khouribga slurry pipeline, and the construction of a new unit (1,400 t/d P_2O_5) to meet the production gap while the this work was being carried out

Jorf Lasfar is the largest fertilizer complex in the world. Investment in 'JFC' production units at the site – each one with a capacity of one million tonnes – has been instrumental in OCP driving up its production capacity from nine million tonnes in 2016 to 12 million tonnes last year. Each fully-integrated and standalone JFC unit includes a:

- Sulphuric acid line (1.4 million t/a capacity)
- Thermal power station (62 MW capacity)
- Phosphoric acid line (450,000 t/a capacity, P_2O_5)
- Phosphate fertilizer line (one million t/a capacity, DAP equivalent)
- Storage warehouse (200,000 tonnes)

OCF has completed four JFC units in the last three years:

- The MAD 5.3 billion Africa Fertilizer Complex (AFC) was commissioned in the third-quarter of 2015 and officially inaugurated in February 2016
- JFC II followed, starting up in July 2016
- JFC III became operational in March 2017
- The latest JFC IV unit entered production in April 2018.

All four JFC units were constructed by JESA, a joint venture between OCP and Jacobs Engineering.

OCF has also built two massive drying plants at Jorf Lasfar to dry-out slurry concentrates arriving via the Khouribga pipeline prior to ship loading. The completion of these plants provides the company with the capacity to export 10 million t/a of

phosphate rock via Jorf Lasfar. First shipments of plant-dried rock were made in February 2018. Extra to this, upgrades to the two fertilizer berths at the Port of Jorf Lasfar now allow OCP to load six fertilizer vessels simultaneously. The company has added four additional piers and four shiploaders (2,000 t/h) at the port as part of recent upgrades.

OCF is set to grow further and increase its market dominance – to the extent that the Group is now aiming to supply half of the total growth in phosphate product demand (26 million tonnes) expected to emerge globally over the next decade. The company says it will achieve this by ultimately adding another 13 million tonnes of fertilizer production capacity between 2017 and 2027. The company expects to add five million tonnes of this extra capacity by 2021, with the timing of remaining eight million tonnes adjusted to meet demand growth.

However, a hiatus looks likely with no major capacity expansions expected from OCP over the next two to three years. Although the construction of up to six further JFC units at Jorf Lasfar remains integral to OCP's future plans, analysts CRU do not expect the next wave of hubs to begin until 2022, with OCP concentrating on operational efficiency gains in the interim.

In the short-term, the International Fertilizer Association (IFA) includes the commissioning of 120,000 tonne capacity soluble MAP unit and 900,000 tonne granulation unit at Maroc Phosphore in its 2018-19 capacity developments. These additions should bring OCP's total product granulation

capacity close to 12.6 million tonnes by the end of this year, according to IFA.

Expanding its higher-margin speciality product range is another key pillar of OCP's strategy. The company has added 40 new speciality product formulations in the last six years, including feed phosphates (DCP, MDCP), water-soluble products (MAP), and sulphur- and micro-nutrient-enriched fertilizers (NP, NPK and MAP). Sales of these value-added products have grown exponentially over the last decade, from just 140,000 tonnes in 2011 to an estimated 2.6 million tonnes in 2017. OCP was planning to further expand its speciality portfolio by introducing a new line of sulphur-enhanced fertilizers in 2018.

Algeria

Algeria, Morocco's eastern neighbour, has the world's third largest phosphate rock reserves, after Morocco and China, estimated at 2.2 billion tonnes. Phosphate mining in the country is controlled by state-owned Ferphos (Entreprise Nationale du Fer et du Phosphate) through its Somiphos (Société des Mines de Phosphates) subsidiary. Almost all of Algeria's phosphate rock production is exported, with only small volumes consumed domestically.

Algeria's reserves are part of the westward extension of Tunisia's Gafsa basin, with several prominent deposits running along the Tunisian border (Figure 1). Deposits at Djebel-Onk, the country's key phosphate mining region in Tébessa province, contain reserves estimated at 2.8 billion tonnes (25-28% P_2O_5). Phosphate rock from two main mines at Djebel Onk supplies a two million t/a capacity beneficiation plant which produces rock concentrate for onward export through the Mediterranean port of Annaba.

Algeria is seeking to revitalise and expand its mining sector. The OPEC member wants to diversify the country's economy, moving away from oil and gas after a sharp fall in energy sector earnings. The government acted to encourage mineral exploration and production by introducing a new law exempting value-added tax and customs duty on mining equipment and services in 2014.

The government's long-standing ambitions for the phosphate sector include the expansion of Djebel Onk, the launch of a major new phosphate mine at Bled El Hedba – also in Tébessa province – and the construction of large-scale phosphate processing facilities at Oued El Keberit in neighbouring Soukh Akhras province.

In a sign of progress, Indonesia's Indorama signed an agreement to work with state-owned companies Asmdal and Manal on several Algerian phosphate and fertilizer joint ventures in a deal worth \$4.5 billion. The deal included:

- The development of a six million t/a phosphate mine at Bled El Hedba in Tébessa province near the border with Tunisia
- The construction of a 1.45 million t/a phosphoric acid plant and three million t/a diammonium phosphate (DAP) plant at Oued El Keberit
- The additional construction of an 800,000 t/a capacity calcium ammonium nitrate (CAN) and 200,000 capacity technical ammonium nitrate (AN) plant at Hadjar Soud in Skikda province.

Algeria already produces ammonia and should have sufficient in-country supply for domestic DAP manufacture.

The above projects were originally targeting start-up dates as early as this year. But Oxford Business Group reported in late 2017 that little progress has been made

towards their finalisation. It is also unclear whether a subsequent \$15 billion agreement between Manal and Asmdal and Saudi Arabia's Radyolla Group signed in February 2017 – for a fertilizer project using phosphate rock sourced from the Djebel Onk mine – supersedes or supplements the earlier

Indorama deal.

In a move suggesting the agreements with Radyolla and Indorama are both now dormant, Algeria unveiled fresh plans to revitalise the phosphate sector, a \$6 billion mega project, late last year.

In November, state-owned oil and gas giant Sonatrach signed an agreement with China's Citic Group for the construction of an integrated phosphates project at Bled El Hadba. The project is designed to exploit and commercialise the area's phosphate and natural gas deposits. It could

create up to 3,000 jobs and is scheduled to begin production as early as 2022.

The new agreement was unveiled at a signing ceremony attended by Algerian Prime Minister Ahmed Ouyahia. He welcomed it as: "The largest industry project in the last decade in Algeria, marking the beginning of a real partnership between Algeria and China." Abdelmoumen Ould Kaddour, Sonatrach's CEO, and Chen Xiaojia, the chairman of Citic Construction, also attended the ceremony.

The partners behind the joint venture includes Sonatrach, Manal and Asmdal (51%) and the China's state-owned Citic Group (49%).

The project is looking to increase the phosphate rock output of Algeria's Bled El Hadba mine from one million t/a currently to 10 million t/a. The project will also produce 1.2 million t/a of ammonia from natural gas. This will be combined with phosphate rock to produce four million t/a of finished fertilizers, including ammoniated phosphates.

The integrated project will divide its investments and activities between four main sites in Algeria. The Bled El Hadba region will receive \$1.2 billion, the east-most Souk Ahras province \$2.2 billion and the north-eastern province of Skikda \$2.5 billion. A port extension at Annaba will receive an additional investment of \$200 million.

Tunisia

Although Tunisia's phosphate rock reserves are much smaller than those of Algeria, its geographically larger western neighbour, they have been much more extensively developed. The phosphate rock output of this relatively small Maghreb country peaked at 8.1 million tonnes in 2010, making Tunisia the world's fifth largest phosphate rock producer at the time, after China, the US, Morocco and Russia. National output has fallen sharply since, languishing at 4.38 million tonnes in 2017, for example.

In common with its neighbours, Tunisia's phosphate industry is state-owned, operating through two parastatal companies: phosphate mining company CPG (Compagnie des Phosphates de Gafsa) and its downstream customer the processed phosphate producer GCT (Groupe Chimique Tunisien).

On paper, CPG has the capacity to produce around 8.4 million t/a of phosphate

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BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

rock from its five mines in Algeria's Gafsa area (Figure 1). Mined phosphate rock is transported by rail to the port of Sfax – where about one million t/a is exported – and downstream production sites at Gabes, La Skhira, Sfax and M'dhilla, all of them GCT-operated. GCT manufactures triple superphosphate (TSP) at Sfax and M'dhilla, and phosphoric acid (including merchant grade acid) at Skhira and Gabes, the latter also manufacturing diammonium phosphate (DAP).

A new 360,000 t/a capacity phosphoric acid plant came on-stream at Skhira in 2013, developed by the Tunisian-Indian Fertilizers (TIFERT) joint venture (JV). India's Coromandel International Limited and Gujarat State Fertilisers and Chemicals Ltd (GSFC) each hold a 15 percent stake in the JV, while Tunisian partners GCT and CPG each hold an equal 35 percent share in the venture. TIFERT exports its entire acid output to India as part of the JV agreement.

Tunisia has plans for CPG to upgrade its phosphate production, and bring additional downstream capacity on-stream at M'dhilla via an 800,000 t/a triple superphosphate plant. The latter – M'dhilla II – is due to come on-stream this year. It includes 200,000 t/a P_2O_5 of merchant grade phosphoric acid production.

While Tunisia has the second largest processed phosphates capacity in North Africa, production has been hard hit by the civil unrest and strikes that have plagued the country intermittently since the 2011 Arab Spring. Unemployment and wages have become a simmering cause of the discontent in Tunisia, with the phosphate industry – the country's major foreign currency earner – becoming a particular target for protestors.

During the Arab Spring, Tunisia's phosphate output fell off the cliff, from 8.1 million tonnes in 2010 to 2.5 million tonnes in 2011, and national production has rarely exceeded four million t/a since. GPC produced three million tonnes of phosphate rock in 2018, for example, due to strikes in the first-quarter. This volume was half the government's initial forecast, with first-quarter production down 0.9 million tonnes on 2017.

The strike action that hit Tunisia between January and March 2018 illustrates the country's continuing difficulties. GCT was forced to stop DAP production in February 2018 after strikes halted the transport and supply of phos-

phate rock. By drawing down stocks, GCT did still managed to sell 30,000 tonnes of DAP for February shipment – but this left little or no availability for March. Tunisian phosphate rock production for January 2018 fell below 160,000 tonnes, *Tunis Afrique Presse* reported, compared to the 500,000 tonnes mined by GPC the same month last year. The crisis was so serious that government and industry representatives were said to have discussed the possibility of importing phosphate rock.

It is clear that the stability of Tunisia's phosphate industry – and its eventual expansion – ultimately hinges on a solution being found to the country's deep-seated economic problems, and the social discontent that has periodically erupted since 2011. Outside observers can only wish the country and its citizens well.

Egypt

Egypt produced 4.8 million tonnes of phosphate rock in 2017, making the country the eighth largest producer in the world after China, Morocco, the US, Russia, Jordan, Brazil and Saudi Arabia. More than 70 percent of 2017 output was exported, ranking Egypt – after Morocco and Jordan – as the world's third largest phosphate rock exporter.

By global standards, Egyptian phosphate rock is relatively low-quality (c.30% P_2O_5), with much of the country's output currently going to either lower-value superphosphate production or the direct application (DAPR) market. Due to its low production costs, rock exports have remained a viable option for Egypt, despite the recent tough price environment.

Egypt's phosphate resources occupy a wide belt stretching eastwards from the Western Desert through the Nile Valley to the Red Sea. From west to east, the country's three major phosphate-producing districts are:

- Abu Tartour in the New Valley governorate
- Sebaila, sited between Luxor and Aswan
- Safaga near Hurgada on the Red Sea coast.

Egypt's phosphate mining companies are all state-controlled, the two largest operators being government-owned Misr Phosphate Company and the military-owned El Nasr Company.

Misr Phosphate operates mines in all three phosphate producing districts. Its

largest mine is the three million t/a capacity open-pit operation at Abu Tartour. The company extracts phosphate rock (26-31% P_2O_5) from the Abu Tartour reserves (715 million tonnes), trucking these to the Red Sea port of Adabiya at a total f.o.b. cost of just \$15-20/t.

The country's other major phosphate miner El Nasr operates a surface mine at Sabaiya in the Nile Valley. The company extracts around 2.25 million tonnes annually, producing 1.25 million tonnes for export with the remaining million tonnes going to the local market. Additionally, the National Company for Mining & Quarries (El Wataneya) owns a 600,000 t/a capacity mine at Aswan which re-started in 2016.

Egypt produced just 112,000 tonnes of merchant grade phosphoric acid and 172,000 tonnes of triple superphosphate (TSP) in 2017. Nevertheless, Egyptian producers – following the trend seen in Morocco – are attempting to capture more value by investing in new downstream capacity. The country's large phosphate reserves (1.3 billion tonnes) and low cost base should provide a good springboard for investment in, and expansion of, downstream production.

NCIC (El Nasr Company for Intermediate Chemicals, a subsidiary of El Nasr) is pressing ahead with the Ain Sokhna project on the Red Sea coast. Approved by President Abdel Fattah Al-Sisi in 2015, the downstream project includes a sulphuric acid plant, phosphoric acid plant, 400,000 t/a capacity DAP plant and a 250,000 t/a capacity TSP plant. Spain's Intecsa Industrial secured a €15 million (\$347 million) contract to build the sulphuric acid plant, DAP plant and TSP plant at the fertilizer complex in February 2016. In August that year, Italy's Desmet Ballestra were also contracted to build two 600 t/d capacity (P_2O_5) phosphoric acid plants licensed by Prayon Technologies of Belgium. The project is now complete and the complex is operative.

WAPHCO (El Wady for Phosphate Industries and Fertilizers), part-owned by Misr Phosphate, is currently investing in downstream production at Abu Tartour as part of the El Wady project. The under-construction project consists of one 5,000 t/d sulphuric acid plant and two phosphoric acid plants, with a combined capacity of 1,562 t/d, licenced by Prayon and US company K-TECHNologies. Start-up is scheduled for the fourth-quarter of 2021. ■

Tight supply supports bullish producers

Prices look set to increase in the global potash market, with availability scarce and as expected new capacity fails to materialise, reports **Andy Hemphill**, potash and sulphuric acid markets editor at ICIS Fertilizers.

However you look at it, 2019 will be a tough year for potash buyers. Between increasing demand, production discipline, outages, and the delayed ramp-up of new capacity, supplies of this vital fertilizer will remain limited for much of the year.

Market players expect this tightness – which emerged in 2018 amid a year characterised by bullish offers – to push muriate of potash (MOP) and sulphate of potash (SOP) prices higher in 2019, albeit in \$5-10/t increments, as opposed to big jumps.

Buyers will likely have little option but to pay this premium.

Caught short

2018 was characterised by tight potash supply.

In Europe, both granular MOP and SOP buyers felt the bite as availability declined – notably on outages at K+S, alongside reduced availability from Russia's Uralkali, which has repeatedly denied production constraints, and Belarus Potash Company (BPC).

Germany's K+S suffered numerous outages at its three plants on the River Werra, owing to low water levels, and suffered a €10 million hit to its fourth-quarter earnings as a consequence.

Compounding the issues affecting existing (legacy) potash producers, expected production from new market entrants also largely failed to materialise in 2018 – notably from EuroChem's two massive new Russian mines.

Potash supply in Southeast Asia was similarly tight. Importers did pause momentarily in the fourth-quarter of 2018, with weaker palm oil export prices reducing enquiries. Buyers instead shifted their attention to demand requirements for the first-quarter of 2019, approaching produc-

ers in an attempt to secure cargoes early. Many were turned away, however, rebuffed by producers who were unwilling to commit that far ahead.

Legacy producers supplying Southeast Asia also found themselves under threat from cheaper-priced imports out of Laos – although some buyers would not consider purchasing Laos-origin material, even for blending purposes, considering it to be of lower quality.

In fact, the only comforting news for MOP-strapped Southeast Asian buyers was talk of slowing enquiries in Brazil at the tail-end of 2018. Producers had been taking advantage of an astonishing run of strong Brazilian demand for much of the year. This was largely thanks to the attractiveness of Brazilian soybean exports, compared

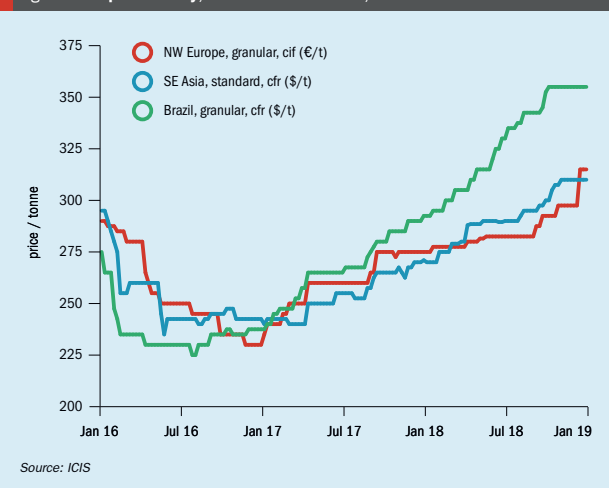
to those offered by US growers, a consequence of the US-China trade war. Despite slowing demand, granular MOP offers to Brazil remained steady into the first-quarter of 2019, suggesting additional bullish offers may lie ahead later this year.

Looking ahead

Although global potash capacity is still in oversupply, at least on paper, market observers say buyers are unlikely to find any relief from prevailing market tightness. This is due to production control/producer discipline and the aforementioned slow ramp-up of new players.

Potash supply to Europe should increase as the region moves into the spring planting and application season –

Fig. 1: MOP price history, selected benchmarks, 2016-2019



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although production constraints at Uralkali in Russia remain a concern. In addition, other major legacy producers have admitted European availability will be tighter than usual, thanks to potentially higher netbacks from other regions globally.

In early January, European granular potash pricing ticked up, after producers secured €15-20/t increases over fourth-quarter offers, pushing granular MOP into the €310-320s/t cif (cost, insurance, freight) range (Figure 1). As the first region to see first-quarter trading increase, price hikes seen in Europe will set a precedent for other world regions going forwards.

The picture is similar in Southeast Asia. The region began 2019 in a seasonal lull, but will no-doubt see demand increase as palm oil plantations race to secure their MOP supplies. Large plantations and conglomerates of buyers, looking for good-quality MOP at an agreeable price, typically flood the market with enquiries in the first-quarter and into the second. However, the prospects for palm oil exports – and its impact on potash demand – will be far more of a concern than usual this year. Plantation owners are particularly worried about a potential downturn in palm oil exports to Europe.

The legislature in Europe is zeroing-in on palm oil sustainability and consumption, as public concerns over this have grown. Whether this will result in a downturn in European palm oil buying – which could in turn prompt a drop in MOP imports

to Southeast Asia – remains unclear, with market opinion divided. One local agent for a legacy potash producer remains optimistic, saying: “There’s plenty of other customers for palm oil, if Europe continues to complain about deforestation.”

SOP market tightness ahead

Chilean former potash major SQM’s future production levels are another topic of debate in 2019. The company freely admits it will “focus on efforts in the Salar de Atacama to increase lithium production” over and above its MOP and SOP output. The Chilean lithium major’s combined MOP/SOP sales volumes declined by 39 percent in 2018’s third-quarter to 249,000 tonnes, with an accompanying 29 percent fall in potash sales revenues to \$80 million over this period.

Indeed, with SQM’s SOP production in decline, and Germany’s K+S still racing to recover from outages in the fourth-quarter of last year, both the European and wider global SOP market will see tightness and bullish pricing in 2019 – much like its far larger MOP sister market.

“[SOP] demand will increase by around 2-2.5 percent next year,” comments a source at one SOP producer. “There are gaps in supply all over, and no one there to fill them yet.”

Indeed, similar supply ‘gaps’ occur across the potash market, affecting MOP, SOP and polyhalite production capacity,

with greenfield project start-ups as diverse as Danakali, Sirius Minerals (see box), and Emmerson, plus Australia’s five SOP potentials, still some way off first production.

Some relief for the SOP market may be on the horizon, however, after China abolished all export fees on fertilizers – a move that possibly presages increased SOP exports from what is East Asia’s powerhouse economy. That said, China’s primary SOP production capacity may well be overstated, according to our European SOP source. In terms of Chinese secondary SOP production capacity, even if the country’s Mannheim furnaces could be ramped up – despite many of these being shut down on pollution concerns – producers would still have to resolve the issue of by-product hydrochloric acid sales and disposal. Nevertheless, any additional Chinese SOP exports are likely to be readily consumed – with the global SOP market set to grow over the next decade – especially if Chinese firms ship to countries willing to accept potentially less pure product.

Different target markets

The application of standard-grade potash is particularly well-suited to rice and other crop staples which are cultivated on a large-scale in Asia and elsewhere. That makes China and India key import markets for potash, due to the scale of their demand and a general lack of large-scale

Potash projects: ones to watch

Danakali’s Colluli SOP project, Eritrea

SOP start-up Danakali is showing strong potential on the global stage. Recent developments include the recent signing of a take-or-pay offtake agreement with industry major EuroChem. This will see Danakali supply the largely Russian-based fertilizer producer with up to 100 percent of the output of its Colluli SOP project over a 10-year term from the start of production. Colluli, located in Eritrea’s Danakil Depression, has ore reserves estimated at 203 million tonnes SOP equivalent. The project plans to extract potash from a single open pit.

Emmerson’s Khemisset MOP project, Morocco

UK-based developer Emmerson’s Khemisset MOP fertilizer project in Morocco promises to quickly deliver a high-return from a relatively low-cost capital investment, according to a company-commissioned study released late last year. Emmerson expects the project to generate a post-tax cashflow of \$184 million per annum, assuming a potash price of \$360/t cfr Brazil. Based on these assumptions, payback on the required \$405 million capital investment would take around 3.5 years. Morocco’s MOP consumption is increasing rapidly, creating a domestic market for Khemisset’s output. The country is also home to incumbent phosphates giant, OCP Group, a fact that has not gone unnoticed by Emmerson.

BHP’s Jansen MOP project, Saskatchewan, Canada

Development of BHP’s massive Jansen project is continuing apace, with two shafts now at the required depth for expansion. In its latest operational review, BHP also announced a \$122 million boost for the project, taking the MOP mine’s budget to

\$2.7 billion. Although the project is still pending shareholder sign-off, BHP appears intent on entering the global potash market in future years to come – although it has yet to reveal a specific timeline.

Unsurprisingly, Canadian potash powerhouse Nutrien, which is sitting on around six million tonnes of potential additional potash capacity of its own, is watching BHP’s progress at Jansen closely. The company has signalled its determination to guard its market position. In an interview with *Reuters* last August, Nutrien CEO Chuck Magro said: “There will be a price in the global market that, once we get there, you will see Nutrien put more tonnes into the market because the demand is there. We will not be shy.”

Crystal Peak’s Sevier Lake SOP project, Utah, USA

SOP start-up Crystal Peak Minerals is aiming to make Utah the “solar salt capital” of the United States. The company’s Sevier Lake project is on track to begin construction in the fourth-quarter of 2019. The project aims to produce SOP by the solar evaporation route, and is targeting the fertilizer market for fruits and vegetables, nuts, tobacco, and other greenhouse crops – just like those grown in the vast farm belts of neighbouring state California.

Crystal Peak combines a solid project plan with the necessary executive-level experience to make the project work, at least on paper, although it still faces challenges ahead. Ultimate success will depend on wooing investors and attracting funding – in what remains a tight financial market for mineral resource projects – and having the ability to place product on the market at a cost commensurate with SOP’s price premium. ■

domestic supply. Consequently, the benchmark potash import price agreed for the two countries is frequently used as a yardstick for subsequent potash price negotiations around the globe.

Because of this, the China and India long-term contract prices for potash will undoubtedly be key talking points for 2019. These were both agreed at \$290/t cfr in 2018, a year-on-year increase of \$50/t for India and – after Chinese buyers’ delaying tactics backfired – an extraordinary \$60/t increase for China. Although further increases are forecast for 2019-2020 potash contracts, how high these hikes will be remains to be seen.

There is also the question of the different strategies adopted by legacy producers towards target markets. Russian major Uralkali, for example, took the bold step of almost completely by-passing Chinese and Indian import business in 2018, opting for higher-returning Brazilian, Southeast Asian, and European enquiries instead.

Market players say this all adds up to just one eventuality: higher prices for buyers – which they will simply have to accept.

Indeed, Dmitry Mazepin, Uralkali’s deputy chairman, said in early December that the company had limited its selling of potash to China to “minor volumes” because the \$290/t cfr contract price was too low. A price of more than \$310/t cfr would be more appropriate for Uralkali in India and China, he added. Commenting on this, a source at a competitor MOP producer told ICIS: “I sort of agree with sub-\$300/t cfr not being attractive. [It will be] interesting [to see] how China may react, especially in view of the limited volume they will obtain at present pricing.”

Mazepin has also confirmed that Uralkali will look further afield when placing its potash volumes in 2019, and is again likely to prioritise Southeast Asia, Brazil, Europe, and possibly Africa, where netbacks to the Baltic are more agreeable for the producer.

BPC, a major rival to Uralkali, has a different market strategy. The Belarus MOP producer frequently acts as the lead negotiator for the long-term Indian MOP supply contract. Because of its pivotal role, BPC has come under pressure from its Indian buyers to meet the country’s shortfall in potash imports in 2018 and into 2019. As a result, Belarusian volumes to other parts of the globe are likely to decline in 2019.

To summarise, manoeuvrings by bullish producers for the best returns will combine with supply tightness and a slower-than-expected ramp-up of new capacity, creating a situation that is continuing to bite. Market players say this all adds up to just one eventuality: higher prices for buyers – which they will simply have to accept. ■

Sirius minerals digs in

Sirius Minerals is currently constructing the Woodsmith mine near Whitby on England’s North Sea coast. This large-scale underground mine will extract polyhalite, a multi-nutrient fertilizer, from a rich seam found at a depth of more than 1,200 metres. The company’s breakneck progress towards first production is continuing.

But that’s not all. “Starting in January 2019, we’re in the fertilizer business,” says JT Starzecki, the company’s marketing chief.

Starzecki was referring to the company’s latest offtake agreement with Brazilian fertilizer distributor Cibra. The new agreement, one of a number of offtake deals the company inked in last year, will see Sirius supply Cibra with up to 2.5 million t/a of its polyhalite product POLY4. Critically, the deal also provides an ownership stake in Cibra, with Sirius acquiring a 30 percent equity share in Cibra in return for providing Cibra with 95 million ordinary shares in Sirius.

As Starzecki’s comments confirm, the Cibra deal provides Sirius with its first real foothold in the industry – through the part-ownership of a major distributor. It also underlines the company’s continuing efforts to prepare beachheads for its product

in key importing regions, especially those where POLY4 can be sold as a constituent of fertilizer blends, rather than as a direct replacement for muriate of potash (MOP).

An aggressive sales and marketing approach has won Sirius peak aggregated take-or-pay offtake deals amounting to 8.2 million t/a. This total including 1.5 million tonnes over seven years with North American giant Archer Daniels Midland (ADM), alongside the two million t/a notably contracted with Chinese buyers.

That said, while offtake agreements are surely encouraging, Sirius has experienced some shareholder jitters in recent months. Last September, shares in the company fell after CEO Chris Frazer announced the need for \$400-600 million of additional project financing to reach completion. As a consequence, its share price dropped by 30 percent at the time to a low of under £24/share.

Despite a small rebound in mid-September, Sirius shares have continued to trend downwards over the last quarter of 2018, hitting a new low of £20/share in December. Company executives do, however, remain resolute in the face of these stock jitters. ■

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London SE1 7SJ, England

Tel: +44 (0)20 7793 2567

Fax: +44 (0)20 7793 2577

Web: www.bcinsight.com
www.bcinsightsearch.com

The water-soluble phosphate market

Demand from horticulture has seen the use of water-soluble phosphates rise globally to almost one million tonnes annually. We assess the market and its growth prospects, identify leading producers and highlight recent product innovations.

Water-soluble fertilizers (WSFs) are a niche group of speciality products that nevertheless occupy a strongly growing segment of the global fertilizer market. Worth more than \$12 billion currently, the world market for WSFs is expanding at around eight percent annually.

Global sales volumes are estimated at 3.24 million tonnes. East Asia and Europe are leading regional consumers of WSFs with a market share of 32 percent and 27 percent, respectively. Latin and North America combined are also responsible for a further 26 percent of world WSF consumption (Figure 1).

Applying fertilizers in soluble form offers a number of clear-cut efficiency gains for commercial growers – whether in terms of input costs, nutrient use efficiency, labour, time

or energy. The adoption of WSFs also comes at a time of agricultural intensification – the drive to get more crop per drop and yield per acre – a trend that is in turn linked to constraints on water and land availability.

The market for water-soluble fertilizers is largely split between fertigation, with a two-thirds share of consumption, and foliar applications which account for most of the remaining one-third of usage.

The rise of fertigation – the delivery of water-soluble fertilizers via irrigation systems – has been a particular strong driver of market growth. Over fourteen million hectares of land are now watered via drip irrigation worldwide, with just 15 countries responsible for more than 95 percent of this drip irrigated area. Adoption is particularly high in China, India, Spain and the US (Figure 2).

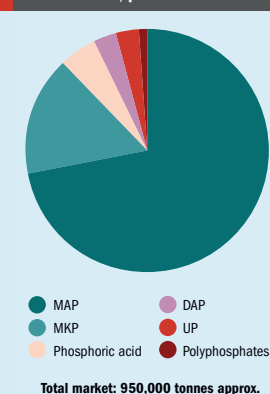
India, for example, although a small WSF market currently (150,000 t/a), has huge growth potential due to the country's great potential for fertigation. Although irrigation is a relatively widespread practice, only 20 percent of India's irrigation systems currently incorporate fertigation, compared to global averages of up to 50 percent.

Water-soluble phosphates

The consumption of water-soluble phosphates has grown into a sizeable global market of almost one million tonnes – a sales volume that is roughly equivalent to 30 percent of the total world market for WSFs. Main products include:

- Monoammonium phosphate (MAP, 12-61-0)

Fig. 3: World water-soluble phosphate market, product basis



Source: De Rijke (2018)

- Monopotassium phosphate (MKP, 0-52-34)
- Phosphoric acid (PA, 0-61-0)
- Diammonium phosphate (DAP, 18-46-0)
- Urea phosphate (UP, 18-44-0)
- Polyphosphates (PP, 0-48-47)

MAP and MKP combined account for almost 90 percent of world consumption. MAP is the dominant product in the global marketplace, with an unassailable market share of more than 70 percent (Figure 3).

Monoammonium phosphate (MAP)

MAP is by far the most widely produced and consumed type of water-soluble phosphate globally. World consumption is around 680,000-690,000 t/a, with China alone accounting for almost six-tenths of the global market. The EU, Latin America

– particularly Brazil and Mexico – and Mediterranean countries such as Turkey also represent sizable regional markets for water-soluble MAP (Figure 4).

Average global growth in water-soluble MAP (4-5% p.a.) masks distinct regional variations. Much strong growth prospects in Asia (14% p.a.) contrast with the more stagnant growth rates (1-2% p.a.) seen in the mature markets of North America and the EU.

Global water-soluble MAP production capacity is circa 695,000-745,000 t/a, with the majority of this capacity (400,000-450,000 t/a) being located in China. Major global producers include:

- Prayon: 70,000 t/a capacity
- Israel's ICL Specialty Fertilizers and Haifa Group: combined 75,000 t/a capacity (including MKP)
- Russia's Uralchem, GMZ and EuroChem: 70,000 t/a capacity combined
- North America's Innophos: 50,000 t/a capacity
- China's Kingenta: 30,000-40,000 t/a capacity

Prayon has been manufacturing horticultural phosphates in Europe for over 40 years. The Belgian company markets a comprehensive range of water-soluble fertilisers. These were consolidated under the single *Hortipray*® brand in 2011. The *Hortipray*® range of fertilizer products are designed for application to fruits, vegetables, flowers and plants by fertigation. All these products are recognised for their purity and high solubility. They include:

- Monoammonium phosphate (MAP)
- Monopotassium phosphate (MKP)
- Potassium nitrate (NOP)
- *micronutri Fe*
- *Pbooster*

Notably, Prayon also markets the *Hortipray*® *anticalc* range of water-soluble fertilizers

for fertigation. The Belgium-based producer offers anticalc versions of both of its standard *Hortipray*® MAP and *Hortipray*® MKP fertigation products:

- *Hortipray*® MKP *anticalc* contains 52 percent phosphorus (P_2O_5) and 34 percent potassium (K_2O) and has a solubility of 230g/L at 20°C
- *Hortipray*® MAP *anticalc* contains 61 percent phosphorus (P_2O_5) and 12 percent nitrogen (as NH_4) and has a solubility of 384 g/L at 20°C.

Both *Hortipray*® *anticalc* products are designed to ensure continuous and uniform irrigation and avoid the unnecessary loss of water and nutrients. Their *anticalc* properties prevent the build-up of lime-scale and phosphates on irrigation pipes and the growth of bacteria. This reduces the risk of blockages and uneven irrigation. It also extends the life of irrigation pipes.

Monopotassium phosphate (MKP)

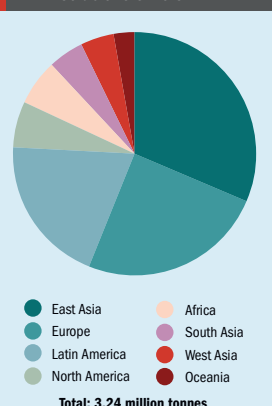
MKP is sold commercially as fertilizer, food additive and fungicide.

Fertilizer-grade MKP is a high-analysis product (0-52-34) that provides plants with a concentrated supply of both potassium and phosphorus. To justify its premium, MKP is primarily marketed as a speciality fertilizers for use on high-value crops. Its high purity and water solubility make it an ideal fertilizer for fertigation – hydroponics in particular – and foliar application.

MKP is a highly-concentrated source of both P and K with a total nutrient content of 86 percent. Applications help to increase the sugar content of fruit crops and improve their quality. Its use is especially valuable in situations where nitrogen fertilization needs to be limited.

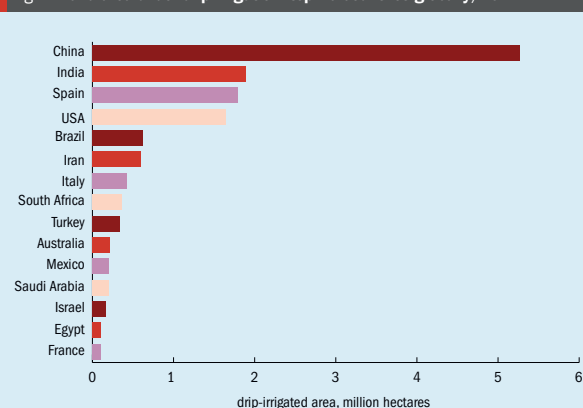
MKP is fully water-soluble with a low salt index and is free of chloride, sodium

Fig. 1: World consumption of water-soluble fertilizers



Source: Rams & Co for IFA, 2017

Fig. 2: Land area under drip irrigation: top 15 countries globally, 2017



Source: International Commission on Irrigation and Drainage (ICID), 2018

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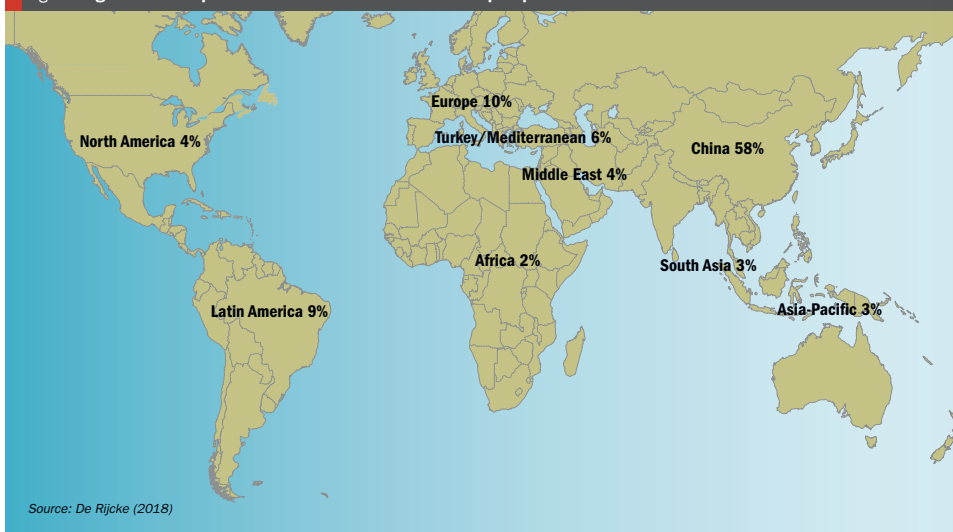
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Fig. 4: Regional consumption of water-soluble monoammonium phosphate



and other deleterious constituents. It can be used as a buffering agent in fertigation solutions due to its moderately low pH. MKP helps to optimise the plant absorption of nutrients by maintaining pH at 4.5.

MKP is said to be the most expensive type of water-soluble product on the market (average cost of \$1,700/t in 2017). Total world production is in the region of 160,000 t/a with China responsible for roughly one-third (50,000-60,000 t/a) of global production volumes. Major import markets include the US, Netherlands, Thailand, Italy and Belgium (Figure 5).

Outside of China, leading MKP suppliers Israel's ICL Specialty Fertilizers (*Nova PeaK*) and Haifa Group (*Haifa MKP*) both have the capacity to produce around 35,000 tonnes of MKP annually, with Belgium's Prayon (*Hortipray MKP*) producing a further 20,000 tonnes each year. Yara International (*YaraTera Krista MKP*) is another notable producer.

ICL claims to be the largest manufacturer of MKP fertilizers worldwide. Its *Nova PeaK* (0-52-34) MKP product offers the following benefits:

- The highest concentration phosphorus fertilizer
- Very low salt index
- Very safe for fertigation applications (drip irrigation, hydroponics, sprinklers, pivots) or foliar spraying, being free of

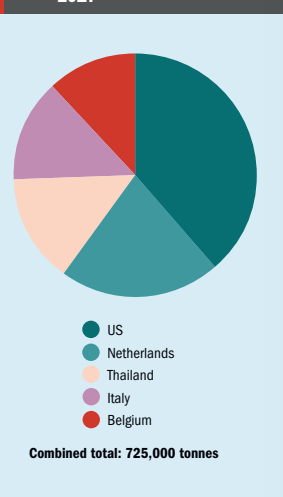
chlorine, sodium and impurities, without the risk of phytotoxicity or leaf burn

- Buffering effect stabilises the pH of nutrient solutions
- The absence of nitrogen permits nutrient application at the optimum P:K ratio for growth stages – such as rooting, flowering, fruit set, ripening and harvest – where lower nitrogen levels are required.

ICL also markets the PK fertilizer *Nova PeKacid* (0-60-20) for hydroponic growing and open-field horticulture. This fully soluble and strongly acidifying crystalline powder is ideal for fertigation on calcareous soils and/or hard irrigation water. It can be mixed in the same tank as other water-soluble fertilizers containing calcium and magnesium. *Nova PeKacid* also has valuable anti-clogging properties and can boost nutrient uptake due to its acidic nature.

Yara's *Krista MKP* is a free-flowing, finely-crystalline water soluble fertilizer that can be applied to a wide range of horticultural crops. It makes an ideal source of phosphorus and potassium during late applications to fruiting plants, when nitrogen applications need to be controlled. The product dissolves quickly in water, making it suitable for both foliar application and fertigation use, including hydroponics, drip systems, low throw sprinklers, centre pivots and spray units.

Fig. 5: Top five MPK import markets, 2017



YaraTera Krista MKP can be used in combination with nitrogen fertilizers such as calcium nitrate (in a separate stock tank), potassium nitrate, ammonium nitrate and urea. Its buffering behaviour stabilises the pH of fertigation solutions (pH 4.5) and increases the effectiveness of pesticide

sprays. Foliar applications can help suppress leaf diseases such as powdery mildew.

Urea phosphate (UP)

Urea phosphate (UP) is highly-acidic soluble NP fertilizer produced by reacting urea with phosphoric acid. It is essentially a crystalline and nitrogen-containing form of phos acid. Its high acidity is both an advantage and a disadvantage. In hard water regions, the 'anticalc' characteristics of UP solutions are useful for preventing blockages in pipes and nozzles in drip irrigation systems. Conversely, the corrosive nature of UP solutions is potentially damaging unless drip irrigation systems are properly protected with resistant materials.

Due to these characteristics, the global market for UP is niche and relatively small, just 28,000-29,000 t/a according to some estimates. Dubai-based SQM Vitas (*Ultrazol Magnum P44*) operates 30,000 t/a of production capacity. Manaseer Group also runs a 25,000 t/a UP production plant in Jordan.

EuroChem subsidiary AB Lifosa opened a new €14 million UP plant at Kedainiai, Lithuania, towards the end of last year. The 25,000 t/a capacity plant will produce crystalline UP, adding to existing production of water-soluble DAP and MAP at the site.

Innovation

Prayon has been a notable innovator in the water-soluble phosphate market, developing and introducing new products such as anticalc MAP and MKP.

These products harness the properties of polyphosphates. These polymerised compounds sequester calcium and magnesium, reducing precipitation at high pH, and help keep irrigation systems clean. By improving phosphorus uptake, polyphosphates also allow phosphate to be applied more efficiently, according to Prayon.

Pbooster (0-48-47), for example, is a water-soluble fertiliser developed by Prayon for crops grown without soil in hydroponic environments. *Pbooster* is designed to completely substitute for standard hydroponic products such as MKP and phosphoric acid. The product's combination of polyphosphates and orthophosphates, prevents phosphate from precipitating with calcium, magnesium and trace elements. Polyphosphates are also more stable at higher pH than orthophosphates, acting to prevent the formation of insoluble precipitates above pH 6-6.5. Overall, *Pbooster* guarantees phosphate availability, ensuring healthier plant roots, as the polymerised phosphate present:

- Does not precipitate
- Does not react with other nutrients
- Is always available, even at high pH.

Polyphosphates are also incorporated in Prayon's *micronutriFe* product. This innovative micronutrient-enriched WSP has proved to be a highly effective iron fertilizer compared to standard chelated products. Two years of trials have demonstrated the efficiency of *micronutriFe* in growing tomato, cucumber, strawberry crops hydroponically.

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Editor:
SIMON INGLETHORPE
simon.inglethorpe@bcinsight.com

Publishing Director:
TINA FIRMAN
tina.firman@bcinsight.com

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