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ISSUE 494
JANUARY-FEBRUARY 2020

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Careful custodians

> **Guaranteeing the fertilizer industry's social license to operate arguably hinges on good global stewardship, as IFA seems to recognise.**

Anyone who lives in or visits England's green and pleasant land is probably familiar with the Countryside Code. This benign if paternalistic piece of government advice dates back to the 1930s. Yet its simple, clear and sensible message still holds true today:

"We all have a responsibility to protect the countryside now and for future generations, so make sure you don't harm animals, birds, plants or trees and try to leave no trace of your visit."

The code calls on all citizens to be stewards of our natural environment: to respect it, protect it, enjoy it. Its advice to "leave no trace" has wider resonances too.

That's because stewardship, as a concept, equally applies to the responsible management of resources – and all the economic activities that ultimately depend on the environment and nature.

For manufacturers – the industries that make things, as fertilizer producers do – the real spotlight is on product stewardship. This requires those who design, produce and sell things to take full responsibility for all stages of a product's life cycle. That includes the environmental impact of 'stuff' and its final destination after use.

For manufacturers of fast-moving consumer goods and gadgets, these are legally-binding obligations in some regions. Under EU extended producer responsibility (EPR) regulations, for example, producers of electrical and electronic equipment have to finance the waste collection, recycling and end-of-life disposal of the products they make and sell.

Product stewardship is also a familiar theme to many in our industry. The International Fertilizer Association (IFA), in particular, has worked long and hard to embed product stewardship within the industry's safety, health and environmental (SHE) culture.

IFA has done this by establishing 12 SHE principles. These require the association's members to: "Establish and improve their safety, security, health and environmental performance through annual objectives, targets or key performance indicators."

IFA has also offered its member companies a practical and accessible product stewardship certification scheme for some years now. Called 'Protect & Sustain', the scheme is open to fertilizer producers and non-producers such as fertilizer distributors, traders and transporters.

Take-up has been highly encouraging. Some 52 fertilizer companies operating across 57 countries globally have become Protect & Sustain certified, as of November 2018.

But IFA is now going further – and placing industry sustainability centre-stage – by launching a Global Stewardship Conference for the first time this year. This completely new event has the backing of three influential IFA committees – agriculture, communications & public affairs, and technical safety, health & environment.

The eclectic and ground-breaking new conference is being held over five days in early February at the Lotte New York Palace Hotel, Madison Avenue. It includes sessions on the world food system, business sustainability, innovative fertilizers, product stewardship, nutrient stewardship, green production technology and climate change.

Impressively, IFA has secured executives from the industry's top flight to moderate these sessions, including Dmitry Konyaev, Uralchem's chairman, Tip O'Neill the CEO of IRM, and Prayon's CEO Yves Caprara. IFA chairman Mostafa Terrab, the CEO and chair of OCP, is also lending his heavyweight support to the event.

Fertilizer International is proud to be IFA's official media partner for its new Global Stewardship Conference. To coincide with the event, the current issue of the magazine carries several features with a strong stewardship theme. These includes a deep dive into 'green' production technology (p27), and a look at the production of NPK fertilizers (p34) and liquid fertilizers (p37) using nutrients recovered from bio-wastes.

Guaranteeing the fertilizer industry's social license to operate arguably hinges on good global stewardship, as IFA seems to recognise. That makes it incumbent on all of us to be careful custodians of our planet – at home, at leisure and, most crucially, at work.

S. Inglethorpe

Simon Inglethorpe, Editor

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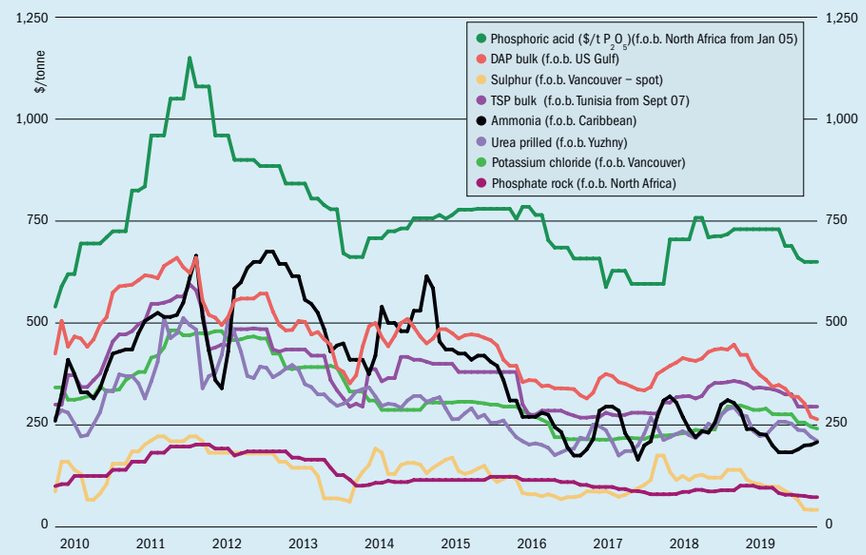
Market Insight

Historical price trends $/tonne



Source: BCInsight

Market Insight courtesy of Argus Media

PRICE TRENDS

Urea: A mostly bearish market characterised by a general lack of demand prevailed during the fourth-quarter. European buyers stayed out of the market. Dry weather and low crop prices in Australia and Asia also hindered demand. Prices in Brazil have fallen by $50/t since September, due to delays to the *safrinha* corn planting season, although they did eventually bottom out at around $230/t cfr. India held several significant tenders in the fourth-quarter. These helped stabilise the market after three months of decline, even prompting small price rises in China and Egypt. US prices, meanwhile, have continued to trade at a discount for much of the last quarter. Supply into the US was boosted by a two million tonne increase in Chinese export shipments, compared to 2018, while Black Sea urea shipments into the country also rose by around 100,000 tonnes/month.

Phosphates: Prices fell throughout the fourth-quarter, linked to oversupply and a lack of demand. Production cuts at Mosaic's Faustina plant in the US had little to no effect, with Nola DAP prices falling as low as $236/st f.o.b. in December. The Nola price falls had the added effect of dragging down Brazilian MAP prices as well. These bottomed out at around $277/t cfr – some $60/t lower than in September. Mosaic responded at the end of December by announcing further production cuts for the first-quarter of this year.

Falling DAP prices in China prompted the announcement of a collective cut in production at the end of December by the '6+2' group of producers. Buying activity in India and Pakistan also died down as 2019 ended.

Australia has experienced weaker than usual demand because of extremely dry weather and wildfires. Unusually, this meant the country continued to export phosphates during the fourth-quarter, a time of the year when it normally becomes a net importer to satisfy domestic demand.

Potash: Prices have now been in retreat since November 2018. While high inventories have led to oversupply, production cuts to counter this were only implemented at the end of third-quarter. At the same time, demand has fallen due to a combination of low crop prices, relatively high potash prices and adverse weather. Demand in five of the top six buying-countries has been negatively affected by additional factors such as the poor US spring season and the US-China trade war. African swine fever has also hit hog herds in China, reducing both soybean demand and potash sales.

Sulphur: The sulphur market was very bearish during the fourth-quarter, the result of both market oversupply and a particularly weak downstream phosphates market. Consequently, prices hit record lows in both the spot and contract markets. Chinese port stocks remained at their highest levels for six years, exceeding 1.5 million tonnes at one point, allowing buyers

Market price summary $/tonne – Early January 2020

Nitrogen	Ammonia	Urea	Ammonium Sulphate	Phosphates	DAP	TSP	Phos Acid
f.o.b. Caribbean	200-215	-	f.o.b. E. Europe 112-126	f.o.b. US Gulf	267-294	-	-
f.o.b. Yuzhny	210-225	203-220	-	f.o.b. N. Africa	275-300	275-315	560-675
f.o.b. Middle East	220-235	238-250**	-	cfr India	292-305	-	590*
Potash	KCl Standard	K_2SO_4	**Sulphuric Acid**		**Sulphur**		
f.o.b. Vancouver	236-250	-	cfr US Gulf	70-80	f.o.b. Vancouver	38-45	-
f.o.b. Middle East	250-280	-	-	-	f.o.b. Arab Gulf	38-50	-
f.o.b. Western Europe	-	470-507	-	-	cfr N. Africa	55-70	-
f.o.b. Baltic	213-280	-	-	-	cfr India	55-70+	-

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

to stay out of the cfr import market. The weak phosphates market has lowered production in northern China, hurting sulphur demand. Sulphur suppliers attempted to sell December product early. But lack of availability pushed prices back up in the Mediterranean region and almost completely halted business in India. First-quarter contract negotiations have now started with significant quarter-on-quarter price drops looking likely. Traders secured tonnages from Adnoc in the high-$30s/t f.o.b., for example, down $13/t on the last quarter. OCP, meanwhile, settled with Adnoc below $60/t cfr, following no agreement in the fourth-quarter. Fundamentals are better in Western Europe's molten market, though, where tighter supply suggests a flat-to-firm outlook.

MARKET OUTLOOK

Urea: The Asian market is turning bearish, now that volumes are in place to cover awards to India, with traders starting to sell short again. With the outlook looking flat to bearish, low Asian demand is likely to drag down Middle East urea prices. The market west of Suez is firmer but likely to come under pressure too. Any price recovery in the US looks vulnerable to incoming cargoes.

Phosphates: With most major producers announcing production cuts at the end of last year, the phosphate market enters 2020 slightly more balanced than it was in 2019. But demand in most key destination markets is still weak, and stocks in India and Pakistan remain high, resulting in a soft outlook for the first-half of 2020.

Potash: Argus expects potash prices to begin to flatten out at some point in the second-quarter, once production cuts have been given time to take effect and supply rebalances with demand. Prices should then stabilise in the second-half of 2020, buoyed by a need to restock after purchasing cuts in 2019. Fundamentals are also showing positive signs, in terms of both crop prices and long-term potash demand growth. Potash prices are, however, unlikely to rise while affected by adverse weather conditions and with economic slowdowns hampering demand. New muriate of potash (MOP) entrants face the challenge of capturing market share in a fundamentally oversupplied market.

Sulphur: Prices are holding steady with most cfr spot levels above $60/t. Because larger sulphur consumers are mainly covered, aside from pockets of demand in Indonesia, Bangladesh, Jordan and Argentina, the impact of fertilizer production cuts will weigh on prices. In China, high port stocks and cuts in phosphate production will keep buyers out of the market, while production cuts in North Africa will also mean lower levels of demand. Middle East producers kept their monthly prices flat as the year began. Concerns about freight rate increases also persist due to the new IMO 2020 regulations and geopolitical tensions. Black and Baltic Sea ports may face freight rises if ice restrictions are implemented there.

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UNITED KINGDOM

Anglo in possible £386m Sirius rescue bid

Sirius Minerals is in talks with Anglo American about a £386 million cash offer for its UK-based polyhalite mine project.

Anglo is potentially offering to buy-out Sirius Minerals at a price of 5.50 pence per share. This would provide shareholders with a 34 percent premium on the company's 7th January share price, the level shares were trading at before the takeover talks were announced.

Sirius shares were valued as high as 37 pence, going back to August 2018, but were trading at just over four pence a share before Anglo's approach was revealed. The proposed buy-out price "could provide certainty to Sirius' shareholders", Anglo said in a statement.

Sirius Minerals confirmed on 8th January that its board was in "advanced discussions" with Anglo American. Under UK takeover rules, Anglo now has until 5th February to make a formal offer for the business. Sirius has told Anglo that it expects to recommend the takeover to its shareholders, if a firm offer is made at the currently proposed share price.

Sirius has successfully raised $1.2 billion (£920 million) of 'stage 1' finance for its under-construction Woodsmith mine in North Yorkshire, near Whitby, close to England's North Sea coast. But the junior mining company was seeking $3.8 billion to fully develop the project and become the world's biggest polyhalite producer.

However, Sirius was forced to abandon its 'stage 2' financing plan in September last year, citing adverse bond market conditions (*Fertilizer International* 493, p12). Instead, it announced a slowdown of construction at the Woodsmith mine and launched a comprehensive six-month project review. This root-and-branch review is examining financing options, project optimisation and cost reductions, as well as possible strategic partnerships.

Sirius subsequently issued a revised two-stage development plan in November 2019 in an update on the progress of its strategic review.

Anglo American's current offer is provisional and the company is not obliged to proceed to a firm offer. The massive multinational mining company has also reserved the right to reduce or vary its offer. Specifically, Anglo could make an offer on less favourable terms:

- With the agreement of Sirius' board
- Or if another party makes a lower offer for Sirius
- Or if Sirius announces a 'whitewash transaction'.

In a statement, Anglo confirmed it had been potentially interested in the Woodsmith mine project for some time. This was due to "the quality of the underlying asset in terms of scale, resource life, operating cost profile and the nature and quality of its product".

The polyhalite resource beneath the Woodsmith mine "has the scale, thickness and quality to be mined efficiently using bulk mining methods through a relatively simple, low-energy, non-chemical production process", commented Anglo. The long-term profitability of the project, specifically its potential to operate at an earnings (EBITDA) margin well above 50 percent, was another attractive feature.

Anglo said the potential Sirius takeover was in keeping with its strategy of focusing on world-class assets and shifting its portfolio to "products that support a fast-growing global population and a cleaner, greener, more sustainable world".

If the current discussions proceed to a formal offer, Anglo says it will commit to providing the necessary financial, technical and marketing resources needed to successfully deliver the project – adding that this was in the interests of both Sirius' employees and its customers.

Anglo has signalled that it would broadly keep to the latest development plan for the Woodsmith mine published in November, if the takeover proceeds. However, it will "update the timeline, optimise mine design and ensure appropriate integration with its own operating standards and practices".

The takeover, if confirmed, would mark Anglo American's re-entry into the fertilizer market, having previously divested its Brazilian phosphate assets to China Molybdenum for $1.5 billion four years ago. This divestment was part of a major restructuring and debt reduction exercise carried out in 2016. ■

Sirius Minerals team at the tunnel boring machine launch on Teesside in 2019.

Sulphur in agriculture conference

ICL UK held its first conference dedicated to sulphur as a crop nutrient in December. The one-day UK-based event was attended by over 75 delegates

According to the company, the conference had two clear aims: firstly, to raise awareness of the role of sulphur in crop nutrition and rising soil sulphur deficiency; and, secondly, to demonstrate the benefits of a precise and balanced crop nutrition strategy.

Soils requiring fertilizer application to replenish their sulphur content are increasingly widespread, explained professor Steve McGrath of Rothamsted Research. While at one time adequate supplies came from atmospheric deposition, today's cleaner air means sulphur needs to be applied to maximise crop yields and quality. In 1970, it was estimated that eight million t/a of sulphate were deposited onto UK soils from industrial emissions. Today, the figure is less than 500,000 t/a. Yet fertiliser application on UK farms only adds an additional 220,000 t/a of sulphate, leading to substantial and widespread sulphur deficits. Sulphur also has a vital role to play in nitrogen uptake by crops. "Where sulphur is deficient, expensive nitrogen is wasted," said professor McGrath.

It is important to check for essential soil macro- and micro-nutrients, said Jonathan Telfer of Lancrop Laboratories. There are three key stages where sulphur measurements need to be taken in his view: firstly, a pre-season soil check for the crop nutrition plan; secondly, in-season leaf and tissue analysis to check whether nutrients are deficient; and, finally, post-season grain analysis to evaluate the efficiency of nutrient use and content. Sulphur deficiency in all UK soils has increased from 60 percent in 1995 to 97 percent in 2017, according to Lancrop's data.

Sulphur can play an important part in wheat and potato quality. Dr Tanya Curtis of Curtis Analytics outlined how food processing and retail industries are increasingly concerned about the acrylamide content of crops, something that sulphur can help control. An inadequate sulphur supply can lead to the accumulation of the amino acid asparagine and sugars in crops. These are precursors of acrylamide, a neurotoxin that can form at high temperatures in baking, roasting and frying.

ICL's Boulby mine in northern England produces a range of polyhalite-based fertilizer products. These are marketed and sold under the *Polysulphate* brand name. Conference delegates were presented with ICL's latest research findings and independent UK trial results. These demonstrated the agronomic benefits of *Polysulphate* products – particularly as a source of sulphur.

Peter Scott, UK and Ireland technical director for Origin Fertilisers, unveiled positive findings for *Polysulphate* use on maize, grassland and alfalfa. Tom Land, Agrii UK's fertiliser manager, also described the consistently good results obtained when using *Polysulphate* on wheat, oilseed rape and pulses.

Andrew Stillwell, technical sales manager for Bartholomews Agri Food, presented the results of spring barley fertilization trials carried out in collaboration with the International Potash Institute (IPI). These compared fertilization with ICL's *FertilizerpluS* and *PotashpluS* products to a conventional fertilization programme using potassium chloride (MOP). The use of *PotashpluS* was found to improve barley yield at all nitrogen application rates and splits. For malting barley, it also helped to improve final grain nitrogen content, and other quality parameters, providing better returns to the grower.

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TURKEY

Veolia supplies technology to Alkim

Veolia Water Technologies is to supply Istanbul-based Alkim Alkali Kimya with production technology for a new sulphate of potash (SOP) plant.

Alkim, one of the world's largest sodium sulphate producers, is investing in a 50,000 t/a capacity water-soluble SOP unit at its Koralkim production complex in Turkey. This will enable the company to produce, market and sell premium potash fertilizer for the first time.

Veolia will equip the plant with the processing technologies required for high-quality SOP production. The company's proprietary *HPD*® crystallisation systems will be an integral part of the new production unit. The technology package offered to Alkim will also include multiple-effect crystallisers. These will be used to synthesise around 35,000 tonnes of food-grade sodium chloride annually, a by-product of the process.

The project's capital costs will be kept low by using surplus cogeneration capacity at the Koralkim site to help power the new SOP unit. Opex (operational expenditure) will also be controlled by recovering the clean condensate and residual heat used for dissolving and heating incoming potassium chloride solution.

Veolia recently announced it was supplying crystallisation technology for Alkimia Group's new 25,000 t/a capacity water-soluble monoammonium phosphate (MAP) plant in Gabes, Tunisia (*Fertilizer International* 493, p11)

UNITED STATES

Mosaic cuts production further

The Mosaic Company announced fresh phosphate production cuts in December in response to market conditions.

Phosphate production at its Central Florida operations will be reduced by 150,000 tonnes per month, the company confirmed in a statement.

The latest phosphate production cutback comes on top of the already announced 500,000 tonne reduction in Mosaic's 2019 second-half output, primarily in Louisiana. The company is also operating its Canadian potash mines at lower rates currently (*Fertilizer International* 493, p8).

Although temporary, the production cuts are extended and indefinite. "Production in both phosphates and potash will return to full rates when required to meet customer needs," Mosaic said in a statement.

The potash and phosphates producer linked the latest production cut to a number of market factors. "A third consecutive disappointing application season in North America has led to continuing high inventories and price weakness. Mosaic will not produce at high rates when we are unable to realize reasonable prices," said Joc O'Rourke, Mosaic's president and CEO.

He added: "We believe our extended production curtailments will contribute to balancing the global supply-and-demand picture as we move into 2020. With fertilizer-depleted soils and rising agricultural commodity prices, we continue to expect robust demand and strong business conditions in the year ahead."

Mosaic now expects its fourth-quarter potash and phosphates shipments to be "modestly below" its previous guidance. It also expects its profitability for phosphates production (gross margin per ton) to fall "significantly below" previous guidance – as a direct consequence of the low sales volumes and low prices now being realised for phosphates.

Wilbur-Ellis buys Nachurs Alpine Solutions

Wilbur-Ellis has announced its purchase of Nachurs Alpine Solutions (NAS), the pioneering North American precision agriculture firm and leading speciality chemicals manufacturer.

The purchase of NAS will add to Wilbur-Ellis' existing assets portfolio. The company is already a leading international distributor of agricultural products, animal nutrients and speciality chemicals.

NAS has pioneered the precision-placed liquid fertilizer market in the US and Canada over many decades, since its formation in 1946. The company currently employs 200 highly-skilled staff and owns seven strategically-located and highly-automated manufacturing plants, together with 85-plus distribution terminals across North America.

NAS formulates its liquid fertilizer products to meet a wide range of crop nutrition needs and different growing conditions. Notably, it was one of the first fertilizer producers in North America to adopt 4Rs Nutrient Stewardship. The company has also diversified in the past 20 years. It now provides de-icing and freeze prevention solutions for the transportation and mining industries, as well as fluids for the energy sector.

Following the buy-out, NAS will become a new business division of Wilbur-Ellis, operating alongside the company's other core businesses – namely Agribusiness, Nutrition and Connell. NAS products will continue to be sold in the US and Canada under the signature *NACHURS*® and *ALPINE*® liquid fertilizers brands.

The new division will be led by current NAS president and CEO Jeff Barnes. He will report directly to John Buckley, the president and CEO of Wilbur-Ellis.

"NAS is a great strategic fit for Wilbur-Ellis," said John Buckley. "It has also demonstrated an extraordinary ability to innovate. Over the past five years, the company has launched over 50 new products, which has provided greater stability in changing markets and contributed significantly to their product portfolio."

"At NAS, our business is built on quality, integrity and innovation," said Jeff Barnes. "So, we're proud to be joining Wilbur-Ellis, a company that supports those values, has an unwavering commitment to safety, and is dedicated to serving customers."

Van Iperen expands in the US

Van Iperen International is fully up and running in the US market.

The leading Dutch speciality fertilizer producer is now operating in the United States through subsidiary company Van Iperen America, based in Miami, Florida. This provides Van Iperen with the ability to directly supply US distributors and growers, and provide better support to its customers in Central and South America.

Van Iperen offers a wide range of speciality fertilizers and biostimulant products for fertigation and foliar application. The company already operates in more than 100 countries world-wide.

"Our roots go deep in the fertilizer business and we are thrilled to provide our world-wide crop experience and top-quality specialty fertilizers to the US and Latin American markets," said Erik van den Bergh, managing director, Van Iperen International.

Van Iperen also has a strong partnership with Milliken, exclusively offering Milliken's non-staining *Liquitint Agro* colourants in its high-quality NPK formulations.

"We… offer a broad range of *Liquitint Agro* coloured formulations that provide distributors with a great opportunity to differentiate themselves in a competitive marketplace, with tailor-made colours for tailor-made NPK formulas."

PHOTO: MILLIKEN

Fertilizer coloured with Liquitint Agro.

Van Iperen says there is a growing recognition from both manufacturers and farmers that colour can play a significant and highly beneficial role in fertilizer formulations, seed treatment and crop protection.

"*Liquitint Agro* colourants make it possible to blend thousands of colours from across the spectrum on demand from only three liquid primary colourants held in inventory," said Steven Spanhove, senior sales director, Milliken Europe. "We are seeing a trend that deeper and brighter colours represent quality, as well as a preference towards natural and earthy reds, blues and greens."

NETHERLANDS

Tecnimont and Stamicarbon celebrate 10th anniversary

Maire Tecnimont Group and its urea licensing subsidiary Stamicarbon celebrated a decade in business together in December.

Italian-headquartered Maire Tecnimont purchased Dutch company Stamicarbon from DSM in 2009. The 10th anniversary of the buy-out was jointly celebrated on 11th December with an event at Limbricht Castle in the Netherlands. This was attended by Stamicarbon staff and the management of both companies.

The anniversary provided both companies with an opportunity to reflect on the joint achievements of the last ten years, and look ahead to future shared opportunities.

From Maire Tecnimont's point of view, the purchase of Stamicarbon has enabled it to become a leading technology provider for urea production. More than 250 urea plants worldwide use Stamicarbon's technology currently. The purchase has also strengthened Tecnimont's profile in the fertilizer industry, as both a technology licensor and EPC contractor. Stamicarbon, in turn, has been able to broaden its commercial offering to customers, and expand its international footprint by taking full advantage of Maire Tecnimont's global network.

Speaking at the 10th anniversary event, Fabrizio Di Amato, the chairman and founder of Maire Tecnimont Group, praised "the technological attitude and innovation DNA of Stamicarbon". He added: "The group currently owns more than 1,400 patents and has more than four R & D centres. The next step to further foster innovation was the establishment of NextChem."

Pierroberto Folgiero, Maire Tecnimont's CEO, said: "Innovation is the result of vision and investment. But to take off it needs

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know-how and human capital, two qualifications that Stamicarbon has always had."

Folgiero added: "The future driver for innovation and transformation of the group will be digitalisation, where we were able to make a step forward by acquiring the company Protomation. The acquisition also brought growth to Stamicarbon, as we were able to expand our portfolio of products."

Pejman Djavdan, Stamicarbon's CEO, said. "In order to keep feeding a growing population we will focus, together with the group, on sustainable intensification of agriculture with fertilizers. This means that production of fertilizers needs to be optimised to have less impact on the environment and to be based on renewable energy sources. But also new technologies have to be developed to make fertilizers more efficient and effective. A challenge that we and Maire Tecnimont will work on."

Koolen Industries invests €4m in Proton Ventures

Clean energy conglomerate Koolen Industries has invested four million euros in the ammonia production and storage company Proton Ventures.

Proton Ventures is at the forefront of 'green' ammonia production technology. The Dutch company designs and builds pressurised and cooled ammonia storage plants, as well as small-scale ammonia production plants known as *NFUEL* units.

"Proton Ventures' unique and patented technologies enable the production of ammonia using clean energy sources. Ammonia is an ideal storage solution for solar power plants and wind farms as it is particularly well suited to store and transport large amounts of energy in efficient ways. This makes it a perfect fit for Koolen Industries as we continue to push the global transition to clean energy," said Kees Koolen, the CEO of Netherlands-based Koolen Industries.

Proton Ventures is currently involved in a number of renewable energy ventures, including large-scale ammonia storage projects in Estonia and Bulgaria, The investment by Koolen will help Proton speed-up the global roll-out of its *NFUEL* ammonia production units.

"This creates great opportunities for ongoing cooperation and opens doors for us to bigger projects," said Hans Vrijenhoef, the CEO of Proton Ventures.

"Alongside our lithium and flow battery capabilities, ammonia adds value to our portfolio, especially with regards to clean energy storage at large scale. This form of energy is relatively cheap, and it is easy to transport and import into the Netherlands or indeed into other markets," said Gerben Hilboldt, Koolen's chief technology officer.

ERITREA

AFC invests $50m in Danakali

The Africa Finance Corporation (AFC) is to make a $50 million strategic investment in Australian potash project developer Danakali.

This will be delivered through a subscription agreement for the placement of ordinary shares. The investment will provide AFC with a 32 percent equity stake in Danakali.

The latest agreement with AFC, announced in early December, forms part of a wider funding package to develop and construct the Colluli sulphate of potash (SOP) project in the Danakil region of Eritrea, East Africa.

The newly-announced $50 million equity stake takes AFC's total participation in the project to $150 million. It adds to AFC's $100 million credit approval for the Colluli Mining Share Company (CMSC) previously announced last August (*Fertilizer International* 492, p10).

AFC will be granted the right to nominate up to two directors to Danakali's board as part of its new equity investment.

Colluli is a well-advanced, fully-permitted and construction-ready potash project. Danakali says it is now ready to begin project execution, putting Colluli on-track for production as early as 2022.

CMSC finally issued a notice to proceed to DRA Global, the Colluli project's preferred EPCM contractor, at the end of December. This allows DRA to begin the EPCM process, according to Danakali.

DRA's contract with CMSC covers:

- All aspects of Colluli project design, project management, procurement, construction management and supervision
- Commissioning of the complete process plant and associated infrastructure
- Awarding and overseeing major contracts for early works, earthworks, structural, mechanical, piping, electrical and instrumentation works, and the laboratory and permanent camp.

Initial EPCM activities include: a review and update of front end engineering design (FEED) by DRA, geotechnical test work, and the purchase of critical items including reverse osmosis equipment.

Tony Harrington, Colluli project director, said: "I am very pleased we will be formalising our partnership with DRA. With the majority of project funding committed, the CMSC team is ready and eager to collaborate with DRA and commence work immediately. This is the moment our personnel and other stakeholders in Eritrea have been waiting for."

INDIA

KBR to supply technology to Talcher project

KBR is to supply ammonia synthesis technology for the Talcher ammonia-urea project in India.

It secured the Talcher contract from Wuhuan Engineering, the project's EPC contractor. KBR will provide the technology license, basic engineering design, catalyst, and proprietary process equipment for the project.

Talcher is a flagship coal-to-urea project for India. It is a central part of government efforts to reduce the country's import reliance by increasing domestic urea capacity. The project is owned by Talcher Fertilizer Limited (TFL), a joint venture between a number of Indian public sector companies.

The Talcher project is a particularly pioneering venture as no other operational urea plants in India are based on coal gasification technology at present.

"We are proud to be part of this significant project in India," said Doug Kelly, KBR president, technology solutions. "KBR's ammonia synthesis process will deliver flexibility, reliability, and cost competitiveness to Talcher for years to come."

Ramagundam aims for March start-up

The Ramagundam urea plant is expected to complete commissioning and begin commercial urea production by the end of March, according to its owners Ramagundam Fertilizers and Chemicals Ltd (RFCL).

The plant's gas supply pipeline from Kakinada is now operational and its flare stack was also recently commissioned.

The plant will be the first of the previously closed state-owned fertilizer plants In India to be brought back on-line. A number of plants are being revamped and upgraded as part of Indian government ambitions for self-sufficiency in urea production.

RFCL was formed as a joint venture between six partners in 2015. National Fertilizers Ltd (NFL) and Engineers India Ltd both have a 26 percent stake. Other partners include the Gas Association of India Ltd (14.3%), HTAS Consortium (11.7%), the Fertilizer Corporation of India Ltd (11%) and the government of Telangana (11%).

The new plant's foundation stone was laid by India's prime minister Narendra Modi in August 2016.

TOGO

Dangote backs phosphate fertilizer project

Dangote Industries Limited has signed a project agreement with the government of Togo to develop the country's phosphate resources.

The $2 billion project to build a one million tonne capacity phosphate fertilizer production plant forms part of Togo's National Development Plan. This proposed plant will consume locally-supplied phosphate rock, with initial mine development work due to start before the end of 2019.

Togo, with over two billion tonnes of phosphate reserves, is one of the Africa's leading phosphate producers.

Under the terms of the agreement, Dangote will supply ammonia as a raw material for phosphate fertilizer production, while the Togolese government will provide access to the country's phosphate rock resources. Dangote, said to be Africa's biggest industrial group, is expected to become Africa's largest ammonia producer on the completion of its large-scale petrochemicals and fertilizer complex near Lagos, Nigeria.

Dangote also unveiled plans to construct a 1.5 million t/a capacity cement manufacturing plant in Lomé, Togo's capital. This plant will satisfy domestic and regional cement demand and use clinker from both Togo and Nigeria.

Aliko Dangote, Dangote Group's president and CEO, said: "This partnership is in line with our agenda in creating prosperity and enhancing economic development not only in Togo but also in Africa. In addition, Dangote Group is determined to support the Government of Togo in its industrialisation strategy… making Togo an attractive investment destination."

Faure Gnassingbé, Togolese President, said: "By processing our phosphate… we will be able to provide our farmers with good quality fertilizers at an affordable cost. Having an industrial investor like Dangote shows that our efforts to improve the business climate are paying off."

SAUDI ARABIA

Aramco sell-off raises almost $26bn

The Saudi Arabian government's sell-off of 1.5 percent of its shares in Saudi Aramco in early December has become the world's biggest ever initial public offering (IPO).

The share sale raised $25.6 billion for the Saudi state. This still fell some way short of the valuation hoped for by Saudi crown prince Mohammed bin Salman, however. Although the sell-off notionally values Aramco at $1.7 trillion, bin Salman had reportedly been looking to raise $100 billion from the sale.

Although the original aim of the flotation was to attract international institutional investors to the Saudi market, in the end it was only offered to local and regional investors.

The proceeds of the IPO will be used to diversify the oil-dependent Saudi economy. They will be invested into strategic projects via the country's Public Investment Fund.

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People

Gordon (Gord) McKenzie became the new president and CEO of Canpotex in mid-January. His appointment is the culmination of a 25-year fertilizer industry career in a variety of senior sales and marketing roles. Gord most recently served as Mosaic's vice president for global sales.

"Gord is an outstanding leader with a proven ability to deliver strong operating and financial performance in an internationally-focused organization," said Joc O'Rourke, chair of Canpotex's board of directors, and Mosaic's president and CEO. "The Board believes that Gord is the right choice to lead Canpotex."

"Canpotex is a great Canadian company with an outstanding team that has served overseas potash customers with excellence for almost 50 years. With Gord's appointment, Canpotex is well-positioned to continue to compete, and to succeed, in highly competitive overseas potash markets," said Ken Seitz, who sits on Canpotex's board of directors and is also executive vice president and CEO for potash at Nutrien.

Raed Soub was appointed Secretary General of the Cairo-based Arab Fertilizer Association (AFA) at the start of January. He replaces **Mohamed Zain**. Mr Soub is a highly experienced international manager and was formerly the advisor to the chairman of the Arab Potash Company (APC). He has served with more than 20 international companies since 1989, occupying the positions of chair, director or general manager. Raed is a chartered engineer and holds a bachelor's degree in chemical engineering from the University of Jordan.

Samir Brikho took up the role of chairman of EuroChem Group in December. He has served on EuroChem's board since 2018. Mr Brikho was notably CEO of Amec Foster Wheeler from 2006 to 2016. Samir's long and high-level business career has also included stints as CEO of Alstom Kraftwerke and CEO of ABB Lummus Global.

"I am proud to be taking over as chairman at such an exciting point in EuroChem's history," Samir Brikho said. "I see enormous potential for the business and am looking forward to helping the company become the most successful player in the fertilizer sector."

Mr Brikho replaces **Alexander Landia** who has left EuroChem's board after more than six years. He will now take up an unspecified new role within AIM Capital, EuroChem's holding company. "It has been a pleasure to serve as chairman for EuroChem Group, and I would like to wish Samir all the best in his new role," Alexander Landia said.

OCP Group has received the Industry Stewardship Gold Medal for the second year in a row. The International Fertilizer Association (IFA) prize was awarded to **Hanane Mourchid**, OCP's senior vice president for sustainability, at IFA's Strategic Forum in Versailles on 20th November. The award, which was personally presented by IFA president Mostafa Terrab, recognises OCP's strong commitment to health, safety and environment (HSE) and its leadership on sustainable development.

OCP has demonstrated its commitment to HSE through the company-wide 'Zero Incidents' programme. This was set up with the help of DuPont OCP Operations Consulting (DOOC), a joint venture between OCP and DuPont. The programme covers both employees and external subcontractors. It makes each individual responsible for the safety of colleagues as well as their own safety in the workplace. OCP has also now implemented 18 health and environmental safety standards across all its industrial sites. Thanks to these efforts, the group's accident frequency rate has dropped by 60 percent in the last five years.

Alexander Gilgenberg was appointed as general director of the PhosAgro subsidiary company Apatit in November. Alexander was appointed to the role from his previous position as deputy general director. He has worked for PhosAgro since 1999. **Vladimir Davydenko**, who previous headed Apatit, will now take on a high-level technical development role at PhosAgro.

PhosAgro CEO Andrey Guryev said: "These changes in the management structure of our production assets will enable the company to take on the challenges we face. PhosAgro's recently-announced 'Strategy to 2025' calls for a large-scale investment programme of $3 billion. This requires direct personal control over investment activities – which will be carried out by Vladimir Davydenko with his enormous professional experience in this area."

PhosAgro plans to increase its production capacity for fertilizers and feed phosphates to 11.7 million tonnes by 2025, a 25 percent increase on its 2018 capacity. The strategy also involves an expansion in the number of fertilizer grades produced by PhosAgro. These are set to increase from 39 grades in 2018 to 50 fertilizer grades by 2025. The company's expanded product range will include new high-performance products which incorporate bio-additives.

Calendar 2020

FEBRUARY

4-7
IFA Global Stewardship Conference,
NEW YORK, United States
Contact: IFA Conference Service
Tel: +33 1 53 93 05 00
Email: ifa@fertilizer.org

11-13
26th AFA Annual Forum & Exhibition,
CAIRO, Egypt
Contact: Arab Fertilizer Association
Tel: +20 2 23054464
Email: afa@arabfertilizer.org

17-19
CRU Nitrogen+Syngas 2020,
THE HAGUE, Netherlands
Contact: CRU Events
Tel: +44 (0) 20 7903 2444
Email: conferences@crugroup.com

MARCH

3-5
IFA Market Intelligence Conference,
DUBAI, UAE
Contact: IFA Conference Service
Tel: +33 1 53 93 05 00
Email: ifa@fertilizer.org

8-10
CRU Phosphates 2020, PARIS, France
Contact: CRU Events
Tel: +44 (0) 20 7903 2444
Email: conferences@crugroup.com

APRIL

20-22
88th IFA Annual Conference,
NEW DELHI, India
Contact: IFA Conference Service
Tel: +33 1 53 93 05 00
Email: ifa@fertilizer.org

JUNE

12-13
44th Annual AIChE Clearwater
Conference, CLEARWATER, Florida
Contact: Miguel Bravo,
AIChE Central Florida Section
Email: vicechair@aiche-cf.org

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THEN&NOW

PHOTO: KIMRE

Above: The Kimre team, Homestead, Florida.

Kimre

Fertilizer International reached its 50th anniversary in 2019. The magazine's continuing success is built on mutually beneficial partnerships forged over five decades. This year, we are continuing to show our appreciation by profiling a much-valued commercial supporter in every issue. This month it's the turn of renowned clean air technology company **Kimre**, a stalwart long-term advertiser. Founded in Florida by MIT graduate George C Pedersen in 1973, this leading global business is still headquartered in Homestead, Florida, within easy driving distance of both Miami and Key Largo. Marketing manager Christine McAniff offers her personal take on Kimre's success story…

Company profile

As we embark on another successful year, we would like to take the opportunity to recognise and thank our loyal clients. Without them, our longstanding success in the industry would not be possible. For more than 45 years, Kimre engineers and application specialists have been solving process and gas stream emission problems in chemical and fertilizer plants around the globe. This invaluable experience provides us with a superior understanding of gas and vapour stream separation and mass heat transfer. At Kimre, we pride ourselves on our trusted relationship with clients – and on developing and maintaining these.

Our main office and manufacturing facility is based out of Homestead, Florida. Being a global business, we are ably supported by our Pennsylvania factory, our Chinese partner and our worldwide network of distributors and representatives. Process engineers, environmental engineers and production managers all recognise Kimre as a valuable and trusted resource. We are responsive and committed to boosting production and efficiency in the chemical process industry.

Kimre offers several services, from top of the line filtration to customised turnkey air pollution control systems. We design, engineer and manufacture our monofilament products – from raw materials to the finished item. Our fibre bed filter division ensures that each filter is tested on-site. We staff a brilliant team of highly qualified engineers who are experts in various applications, such as ammonium nitrate, chrome nitric acid, phosphates, sulphuric acid, urea granulation and oil mist.

Our latest development

Using our own *SXF™ Semi-Cross Flow Horizontal Scrubber* with *AEROSEP® MULTI-STAGE AEROSOL SEPARATION SYSTEM* and *B-GON®* mist eliminator media, Kimre is able to determine removal efficiencies of chrome particulates, at both our own manufacturing plant and on-site for customers. Currently, we are in the process of using our pilot unit to capture highly carcinogenic chromate dust particle emissions to prove the removal efficiencies of our products. The chromate pilot unit testing is being performed at a customer site in a highly populated residential downtown area. It is Kimre's objective to ensure the residents are not exposed to plant emissions and that local air quality standards are maintained. As air emission standards are extremely difficult to achieve economically, accurate testing will prove the ability of Kimre's *AEROSEP®* to achieve the lowest emission levels in such an important application. ■

1970s

- **1973** ● Kimre was founded by George C Pedersen, a Florida native and MIT graduate.
- **1974** ● First commercial sale of a product.
- **1979** ● Kimre successfully retrofitted Borden Chemical Company phosphate operations at Piney Point, avoiding a plant shutdown due to excess emissions.

1980s

- **1983** ● Established *LIQUI-NOMIX®* Technology for oil/water separation systems installed in a majority of OWS applications.
- **1985** ● Kimre is recognised as the first nitrobenzene retrofit for equipment.
- ● First major *AEROSEP® Multistage Aerosol Separation System* operating, GK Mannheim, Germany.
- **1989** ● Cooling tower installation at SASOL LTD, Secunda, South Africa: a 100 metre diameter *Drift Eliminator* installation.

1990s

- **1995** ● Kimre's Europe office opens.
- ● Kimre technology identified as MACT by the EPA for chrome plating operations.

2000s

- **2008** ● Designed and supplied first full-scale scrubber for phosphate fertilizer plants.

2010s

- **2012** ● Fibre Bed Filters added to product line.
- **2014** ● Kimre designed and supplied four turnkey urea granulation plants in 2014.
- **2016** ● Opened Kimre China offices.
- ● Opened Kimre Philadelphia office.
- **2017** ● Kimre achieved the lowest dust and ammonia emissions of any urea granulation facility in the world.
- **2019** ● Kimre celebrates 45 years of operations.

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Fertilizer INTERNATIONAL index 2019

A complete listing of all articles and news items that appeared in *Fertilizer International* during 2019.

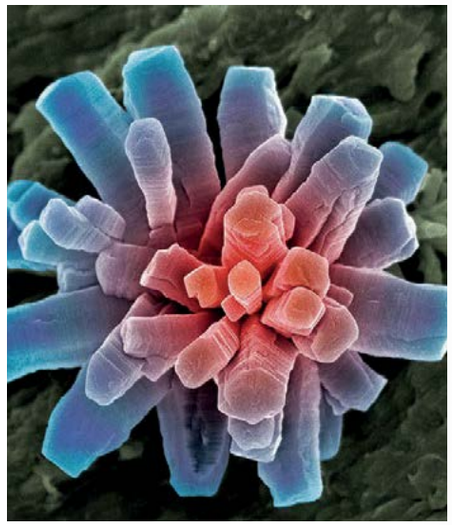

PHOTO: STEVE GSCHMEISSNER/SCIENCE PHOTO LIBRARY

A calcium phosphate crystal.

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PHOTO: ISTOCKPHOTO.COM / LEONID ANDRONOV

The AFA welcomes you to Cairo

Left: Panoramic view of Cairo, Egypt.

The theme of the 26th Arab Fertilizer Association Annual Fertilizer Forum & Exhibition is 'Reshaping the industry future'. This year's Forum will be held at the Semiramis Intercontinental, Cairo, 11-13 February 2020. New AFA Secretary General, **Raed Soub**, provides a preview of what is the Arab region's showcase annual fertilizer event.

PHOTO: AFA

New AFA Secretary General, Raed Soub.

The Arab Fertilizer Association (AFA) is made up of Arab companies and institutions involved in fertilizer production, trade and allied fields. Established in 1975, the AFA's aims include the development of the Arab fertilizer industry – and maximising its contribution to global food security.

Arabic countries are increasingly taking a lead when it comes to the world-wide supply and trade in fertilizers and associated raw materials. Globally, the Arab region possesses around one-third of gas reserves and 70 percent of phosphate rock reserves, for example.

The AFA promotes the sustainable use of fertilizers and believes this involves taking a long-term approach and making balanced judgments based on social, environmental and economic considerations.

A warm and hospitable Egyptian welcome

Eng. Raed Soub, the AFA's new Secretary General, is looking forward to welcoming delegates to Egypt in February:

"AFA International Annual Forum is considered the pre-eminent economic fertilizer industry event in the Middle East and Arab region. Attendance is expected to reach 500 participants from more than 30 countries worldwide. They include the chairs of Arab and international fertilizer companies, heads of relevant international associations and organisations, experts, executives and general managers, representing more than 100 companies and industry bodies.

"Accordingly, the Arab Fertilizer Association would like to invite you to participate with more than 400 leaders in the 26th Annual Fertilizer Forum and Exhibition – it is an opportunity that should be seized. Accordingly, note it down and reserve your seat to meet with fertilizer sector decision-makers from the Arab region and the rest of the world."

Forum programme

The AFA's Forum programme for 2020 include three days of plenary sessions starting on Tuesday 11th February 2020. This year, the Forum's main themes include:

- Fertilizer Policies
- Factors shaping the fertilizer Industry
- Global market overview and the supply and demand outlook
- Oil & gas markets and their impact on fertilizer production
- Fertilizer awareness and use efficiency
- The African fertilizer market
- Fertilizer industry sustainability
- Helping achieve world food security
- Fertilizer industry insurance
- Updates on the dry bulk freight market
- Latest innovations in water-soluble fertilizers.

Additionally, the wide-ranging commercial exhibition running alongside the Forum allows industry, trade and freight companies, from within and outside the Arab region, to showcase their products and services to a high-level national and international audience of professionals.

Table 1: **Arab region fertilizer production and exports, 2017-2018**

	Production ('000 t)			Exports ('000 t)		
Product	**2017**	**2018**	**Share of world total, 2018 (%)**	**2017**	**2018**	**Share of world trade, 2018 (%)**
Ammonia	18,685	19,220	11	4,490	4,540	25
Urea	23,200	23,596	15	19,757	20,397	42
Ammonium nitrate	1,365	1,150	3	59	51	-
Phosphate rock	59,402	59,229	28	21,852	21,262	68
Phosphoric acid (P_2O_5)	8,228	9,323	20	2,436	2,424	55
TSP	1,854	1,824	71	1,815	1,504	87
DAP	11,639	12,653	42	9,913	10,900	76
Potash	2,320	2,436	4	2,166	2,198	4
Sulphur	10,185	10,185	18	9,146	9,146	22

Source: AFA

A growing market share

A natural abundance of a wide-range of raw materials – including natural gas, phosphate rock and potash – has enabled the Arab region to establish itself as a major international fertilizer industry hub. The latest production and export figures reveal how Arab producers have consolidated their leading role in the global production and trade of urea, phosphate rock, phosphoric acid and phosphate products, while also being key players in fertilizer raw materials such as ammonia and sulphur.

Arab fertilizer production is particularly export-oriented and in 2018 the region's exports accounted for around:

- 87 percent of world TSP trade
- 76 percent of world DAP/MAP trade
- 68 percent of world phosphate rock trade
- 55 percent of world phosphoric acid trade
- 42 percent of the world urea trade
- 25 percent of world ammonia trade
- 22 percent of world sulphur trade.

Arab countries currently have a 11 percent share of total world **ammonia** production and a 25 percent share of world ammonia trade. Saudi Arabia is the leading Arab ammonia producer accounting for 27 percent of regional production, followed by Egypt (24%), Qatar (20%), Algeria (8%) and Oman & UAE (7% each). Arab producers exported 4.5 million tonnes of ammonia in 2018. The main ammonia exporter is Saudi Arabia with a 35 percent share of regional exports, followed by Algeria (32%), Egypt (14%), Qatar (12%), Oman (3%), Libya (2%) and Bahrain (1%).

Arab countries have a 15 percent share of total world **urea** production and a 42 percent share of world trade. Production is concentrated in Egypt with a 25 percent share of regional production followed by Qatar (24%), Saudi Arabia (20%), UAE (9%), Oman (8%) and Bahrain (3%). Urea production is highly export-oriented. Qatar, notably QAFCO, is the leading regional urea exporter. Its urea exports of 5.4 million tonnes in 2018 accounted for 27 percent of total Arab region urea exports. Arab urea producers shipped a total of 20.4 million tonnes in 2018.

Arab **phosphate rock** producers have a 28 percent share of world production and a 65 percent share of world trade. OCP, Morocco, is the regional leader with a 58 percent slice of total Arab region production. Jordan (13%), Saudi Arabia (12%), Egypt (10%), Tunisia (4%) and Algeria (3%) are also major regional producers. OCP, the world's largest exporter of phosphate rock, has a 53 percent share of the region's exports. Jordan, Egypt and Algeria also contribute significantly to phosphate rock exports from the region.

Arab **phosphoric acid** producers have a 20 percent share of world production and a 55 percent share of world trade. Morocco again predominates in this sector, with a 65 percent share of regional production. The other main regional producers are Saudi Arabia (22%), reflecting the increasing contribution of Ma'aden, as well as Tunisia (9%) and Jordan (6%).

Arab countries also have a sizeable slice of the **triple superphosphate** (TSP) market, amounting to 71 percent of world production and 87 percent of world trade. OCP is again the market leader, supplying 64 percent of regional TSP output, together with Tunisia and Lebanon (14% each).

In the **diammonium phosphate** (DAP) market, Arab countries contribute 42 percent to world production and 76 percent to world trade. Morocco's OCP and Saudi Arabia's Ma'aden are the leading regional producers (45% each) supplemented by production from Jordan (7%) and Tunisia (3%). Saudi Arabia is emerging as a major player in the world DAP market, being responsible for 33 percent of the Arab regional exports, versus Morocco's 57 percent share

Jordan's APC is the sole **potash** producer in the Arab region, its output accounting for four percent of world production and trade.

Arab countries, especially those in the Gulf, enjoy a high profile in the **sulphur** sector globally, contributing 18 percent to world production and 22 percent to world trade. The UAE leads the way with a 46 percent share of regional sulphur production, supplemented by sizable output from Saudi Arabia (34%) and Qatar and Kuwait (9% each). Much of the region's sulphur output is exported.

Investments in new capacity

New capacity continues to be developed throughout the Arab region, enhancing the contribution Arab countries make to global fertilizer capacity and supply. Looking to the future, by 2025, additional production capacity in Arab countries will undoubtedly raise the region's contribution to world fertilizer production and trade even further. ■

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The year ahead: rebounding from contraction?

We look ahead at fertilizer industry prospects for the next 12 months, including supply and demand growth, and explore the key agricultural, macroeconomic and geopolitical drivers likely to shape the market during 2020.

Medium-term prospects for the world fertilizer market remain limited. Insipid demand growth of around one percent year-on-year is expected over the next five years. This partly reflects the steady decline in the growth rate of world agriculture. Improvements in nutrient use efficiency and more nutrient recycling are also expected to depress primary fertilizer demand[1].

Changes within individual countries are also shaping the overall market. Declining fertilizer consumption in China, in particular, is acting as a downward drag on the world fertilizer market. The continued reliance on the subsidy-dependent Indian market, meanwhile, looks increasingly unsustainable over the longer term, being contingent on continuing government policy support.

North America's long shadow

Looking back at last year, unfavourable North American market conditions had a particularly damaging effect. Indeed, the unprecedented crash in US consumption in spring 2019 (see box) actually tipped world fertilizer demand into reverse in 2018/19[1]. This contraction was compounded by a number of other negative factors, including:

- Low international prices for most crops
- Unfavourable weather in eastern Australia
- Currency depreciations in Turkey and Pakistan, both key fertilizer-importing countries
- China-US and Russia-Ukraine trade tensions
- Re-imposition of sanctions against Iran.

Global growth slows

Worryingly, the International Monetary Fund (IMF) has downgraded its global growth forecast for 2019 to just three percent – its slowest pace since the global financial crisis of a decade ago – describing this as a "synchronized slowdown".

"This is a serious climb down from 3.8 percent in 2017, when the world was in a synchronized upswing," commented Gita Gopinath the IMF's chief economist.

She blamed subdued global growth on:

- Rising trade barriers
- Elevated uncertainty surrounding trade and geopolitics
- Idiosyncratic factors causing macroeconomic strain in emerging markets
- Structural factors in the advanced economies – such as low productivity growth and ageing demographics.

Global growth looks set to improve modestly to 3.4 percent in 2020, according to the IMF, albeit a downward revision of 0.2 percent from the fund's April projection. However, it describes this recovery as "precarious"and narrow rather than broad-based.

For the advanced economies, growth is actually projected to slow to 1.7 percent in 2019 and 2020. Growth rates in emerging market and developing economies, in contrast, are projected to pick-up from 3.9 percent in 2019 to 4.6 percent in 2020. Turkey, Argentina, and Iran are all expected to recover from shallow recessions. After slowing in 2019, growth is also expected to accelerate in Brazil, Mexico, India, Russia, and Saudi Arabia this year.

Complex demand drivers

Fertilizer demand is influenced by a range of factors, some of which are harder to predict than others. In the short-term, the main drivers of demand include:

- Farm economics and the macroeconomic outlook
- Crop prices and fertilizer-to-crop price ratios
- Crop mix, growing areas and crop yields
- Soil nutrient levels and nutrient replenishment
- Policy, regulation and fertilizer subsidies
- Sustainability, nutrient management and recycling.

The importance of these factors varies from country-to-country and region-to-region. Adding to the complexity, these primary drivers are in turn influenced by a host of secondary considerations.

Macroeconomic conditions, by triggering slowdowns or expansions in global, regional and national growth, control overall economic demand and affect the health of agricultural markets. **Farm economics** and attendant issues such as credit availability and barter ratios have a more direct impact on the ability of farmers to purchase fertilizers.

Crop prices and fertilizer-to-crop price ratios act as key controls on crop nutrient demand as they play a critical role in determining farm buying power and fertilizer affordability. Crop prices in turn are driven by the **harvest size** annually, **stock levels** and **demand** for agricultural commodities. Fertilizer industry analysts pay particularly close attention to the prices of cereals, oilseeds, cotton, sugar and palm oil, the main fertilizer-consuming crop types globally.

The **biofuels market** is also an important driver of fertilizer demand due to large-scale cultivation of maize and sugarcane for ethanol and oilseed rape (canola) for biodiesel (*Fertilizer International* 474, p22). Crop failures due to extreme weather events such as the 2015/16 **El Niño** (*Fertilizer International* 475, p38) can also affect fertilizer demand in the short-term. ■

2020 MARKET OUTLOOK

Spring 2019: The worst US planting season in history

Record rainfall disrupts

Canadian fertilizer giant Nutrien infamously described spring 2019 as "the worst US planting season in history". It noted that record rainfall in the first six months of the year prevented crop planting over a massive 10 million acres – a new US record. This followed and compounded a poor US fall application season for fertilizers in 2018.

Chuck Magro, Nutrien's president and CEO, said as early as last summer that "US weather in the first half was so severe it nearly eliminated global demand growth for crop inputs", a prediction largely confirmed by IFA's latest global demand estimate. Magro did, however, expect a strong US rebound in 2020 due to lower crop inventories and higher crop prices, with demand for grains and oilseeds still growing.

Phosphate plummets

Based on current IFA estimates, a fall in phosphate use was responsible for more than 75 percent of the total 1.3 million nutrient tonne decline in world fertilizer demand in 2018/19 (Table 1). North American market conditions are again implicated.

Bad fall 2018 and spring 2019 application seasons in the US were exacerbated by a large build-up of phosphate import volumes. The consequent carry-over of phosphate inventory has remained a concern in North America. "With a poor fall season and then a disappointing spring season, probably about 800,000 tons of [product] demand was lost. At the same time, we had one million tons more imports into the US, exacerbating the problem along with the flooding along the [Mississippi] river," Mosaic commented last July.

Not only North America

North America market conditions were not the sole factor at play, however. Significant declines in fertilizer use in Turkey, China, Vietnam, Ukraine and France – totalling around 1.1 million nutrient tonnes – also took place in 2018/19. These falls were, however, largely offset by demand gains in India, Argentina, Myanmar, Thailand and Russia. The upshot of this is that global fertilizer demand would have remained stable in 2018/19 were it not for exceptionally bad US agricultural conditions. ■

The IMF reports that major central banks have relaxed monetary policy to reduce the downside risks to growth. This pre-emptive move should help offset the negative impact of the US–China trade dispute, which alone is expected to cut global GDP by 0.8 percent in 2020. Nevertheless, the IMF has singled out advanced Asian economies, including Hong Kong, Korea, and Singapore, for some of the biggest downward revisions to growth – due to their common exposure to China's growth slowdown and the fallout from that country's trade dispute with the US.

Oil prices fluctuated in 2019 but fell year-on-year. They rallied to exceed $71/barrel in April, their highpoint of the year, only to bottom at $55 in August, before rebounding back above $60 in September.

Oil prices were pushed higher in the year's first-quarter by a host of factors, including outages in Venezuela and US-Iran tensions, only to decline from late spring onwards. The prospect of lower demand from a faltering global economy was amplified by a build-up of US crude stocks. Prices subsequently recovered in September following an attack on two key Saudi Arabian oil installations. This temporarily knocked out 5.7 million barrels per day of production – about half of Saudi Arabia's total and equivalent to 5 percent of global oil production. This stoked fears of oil market disruptions and escalating tensions with Iran.

Looking ahead, average oil prices, projected at $61.8 a barrel in 2019 – itself a 9.6 percent year-on-year decrease from the 2018 average – are forecast to decline further to $57.9/barrel in 2020, and ultimately to around $55/barrel by 2023 – a trend linked to "subdued medium-term demand prospects".

Food prices surge to two-year high

As 2019 drew to a close, the FAO's Food Price Index (FPI) reached a 26-month high in November 2019, averaging 177.2 points. This pushed the index up by nearly 10 percent (15.4 points) from a year ago.

November's price hike – driven largely by significant surges in the prices of meat and vegetable oils – pushed the overall value of the FPI to its highest level since September 2017. Sugar prices also increased in November, while dairy prices remained steady, and cereal prices drifted downwards.

The November 2019 vegetable oil price index (150.6 points) reached its highest level in 18 months. The rise was led by firming palm oil values, although soy, rapeseed and sunflower oil prices also increased. International palm oil quotations rose for the fourth consecutive month in November, continuing the recent rebound from the price lows that have characterised the past 12 months.

The latest increase in the sugar price index (181.6 points in November) was driven by the expectation that world sugar consumption will surpass production. Poor growing conditions in Thailand, India, France and the US in 2019/20 have increased the chances of a fall in global stocks.

The cereal price index, in contrast, declined to 162.4 points in November. Large export supplies and stiff export competition weighed on international wheat prices, while rice values also fell to six-month lows, pressured by new crop arrivals and sluggish import demand.

Ag commodity outlook: no respite from risks

Millions of the world's farmers face impoverishment in 2020 because of persistent geopolitical risks and intense price pressures, according to the annual outlook from agribusiness specialists Rabobank.

Strong headwinds – including the US-China trade war, fallout from African swine fever (ASF) and low crop prices – will take their toll on agricultural commodity producers next year, predicts Rabobank.

Soybeans, coffee and sugar will be particular key commodities to watch in 2020, in its view.

Although the bank foresees price increases in 2020, coffee and sugar are

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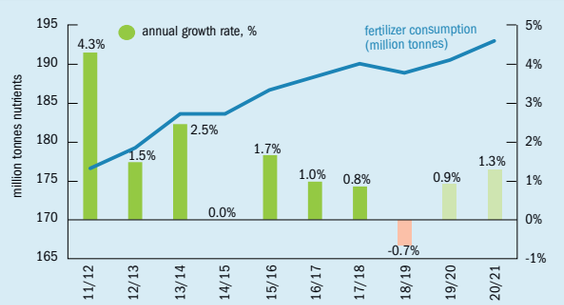
Fig. 1: **World fertilizer consumption (nutrient tonnes) and annual growth rate: 2011/12-2020/21**



Note: 2018/19 = Estimated. 2019/20 & 2020/21 = Forecast. *Source IFA (November 2019)*

still likely to trade below the cost of production for much of the year – damaging the livelihoods of millions of coffee and sugar farmers as a result. The oversupply of coffee and low prices in 2019 have already pushed millions of farmers – mostly in Central America, East Africa and Southeast Asia – into poverty.

In 2020, global agriculture faces a continuation or escalation in the US-China trade war, alongside further increases in productivity on the back of more benign global weather, and the ongoing impact of the ASF crisis in Asia. These factors mean farmers will need to cope with further uncertainty in 2020, after years of relatively low prices.

Geopolitics, particularly trade disputes, looks set to be the key driver of grain and oilseed prices this year, in Rabobank's view. The soybean market in particular will continue to be at the mercy of the US-China trade war, although coffee and sugar prices look set to recover from decade lows.

Stefan Vogel, Rabobank's head of agri-commodity markets, said: "The world's farmers have endured a difficult year with headwinds caused by geopolitical tensions, disease and weather. Yet sadly for them, 2020 looks like offering no immediate respite.

"In the worst-case scenario, coffee farmers face the prospect of stubbornly low prices while trade tariffs threaten soybean farmers.

"The hope is that the worst does not occur. In a more favourable scenario, the US and China resolve their trade dispute, China begins to replenish pork herds, stimulating demand for soybeans, and the coffee market rebalances, increasing the prices paid to farmers for their beans."

There are downside risks, however, with Rabobank warning of a significant chance of recession in US, the world's largest economy, in the second half of 2020 – a downturn that could reduce global demand for staples such as coffee and cocoa. The main impact of such a recession, though, would be a synchronised global slowdown. This could weaken currencies in key commodity-producing countries with negative consequences. A weaker Brazilian real, for example, would largely thwart any recovery in coffee and sugar prices.

Fertilizer demand

Following an unexpected market contraction last year, the International Fertilizer Association (IFA) expects world fertilizer demand to recover slowly as we move into 2020 and beyond.

Global fertilizer consumption declined year-on-year in 2018/19 for the first time in a decade, according to IFA estimates, falling by 0.7 percent to 188.8 million nutrient tonnes (Table 1, Figure 1)[2]. This decline in global demand was especially marked for one nutrient (phosphate) and strongly affected by one factor in particular – a sharp weather-related contraction in US fertilizer use (*Fertilizer International* 492, p4; see box). Indeed, North American fertilizer demand fell by an unprecedented 5.7 percent in 2018/19, equivalent to 1.4 million nutrient tonnes[2].

IFA expects fertilizer demand to return to growth this year driven by a strong recovery in North America. However, the overall 0.9 percent recovery in global demand forecast in 2019/20 – equivalent to a 1.8 million tonne increase to 190.6 million nutrient tonnes (Table 1) – is still below the medium-term trend. It also represents a major downgrade in fertilizer consumption since IFA's previous June 2019 forecast[2].

Nevertheless, in a complete reversal on the previous year, demand in 2019/20 should be boosted by a resumption of phosphate consumption, with a healthy year-on-year percentage rise in demand for this nutrient.

The market recovery in 2019/20 will also be aided by rising fertilizer use in India, Brazil, Russia and Canada. This will offset a significant – albeit largely expected – decline in consumption in China of around one million nutrient tonnes. Fertilizer use is also expected to fall in Southeast Asia (Indonesia, Malaysia, Thailand), linked to unfavourable weather and lower palm oil prices, and parts of Latin America (Colombia) in 2019/20[2].

Table 1. **Global fertilizer demand forecast, million nutrient tonnes***

Nutrient	2020/21f (million tonnes)	2019/20f (million tonnes)	2018/19e (million tonnes)	2017/18 (million tonnes)	2016/17 (million tonnes)
N	108.2 (+0.9%)	107.2 (+0.6%)	106.5 (+0.1%)	106.4	107.1
P_2O_5	46.5 (+1.2%)	46.0 (+1.5%)	45.3 (-2.1%)	46.3	45.4
K_2O	38.3 (+2.5%)	37.4 (+0.9%)	37.0 (+-1.0%)	37.4	35.9
Total	193.0 (+1.3%)	190.6 (+0.9%)	188.8 (-0.7%)	190.1	188.8

**Year-on-year percentage increase in parentheses. e=estimate. f=forecast.* *Source: IFA (November 2019)*

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Looking further ahead, fertilizer consumption is forecast to accelerate into next year, with growth returning closer to the medium-term average. IFA's preliminary forecast is that growth in global fertilizer use will pick up by 1.3 percent and total 193.0 million nutrient tonnes in 2020/21 (Table 1, Figure 1). This is based on an expectation of higher crop prices and average weather conditions. Increases in potash consumption are forecast to be particularly firm. Growth next year, although broad-based, looks likely to be led by Indonesia, Brazil and India[2].

Global production and trade

Between 2018 and 2023, the global industry expects to invest close to $110 billion in constructing 70 new fertilizer manufacturing units, these providing a total of 65 million tonnes of extra production capacity. Large-scale investments in nitrogen capacity will take priority, accounting for two-thirds of planned capital expenditure over the next five years[1].

The global supply of primary fertilizer raw materials (ammonia, phosphate rock and potash) is expected to grow by 2.2 percent to 260 million tonnes nutrients in 2020[2]. This total does, however, include tonnages for industrial and other non-fertilizer uses, estimated at 51 million tonnes in 2019.

Unusually, increases in potash production capacity were outweighed by decreasing ammonia and phosphoric acid capacity in 2019, resulting in a net reduction in global capacity of 1.7 million tonnes nutrients, according to IFA estimates. This capacity contraction in 2019 reflected already announced closures and mothballing of ammonia, potash and phosphate production units. This contraction looks like being a one-off, however, and is expected to be reversed by a substantial 6.3 million tonne increase in nutrient supply in 2020[2].

Urea: Preliminary estimates suggest that global urea exports – equivalent to almost 30 percent of world production (176 million tonnes) – increased marginally (+0.6%) to 48.5 million tonnes in 2019. China's return to the urea market was a major development last year. Urea exports to Indonesia, Canada and Ukraine increased significantly in 2019[2].

World urea capacity is projected to grow by just one percent in 2019 and 2020 to reach 213 million tonnes. Capacity is expected to recover this year after faltering in 2019. The capacity stall was linked to the ongoing decrease in Chinese capacity (-2.4 million tonnes) plus plant closures or mothballing in Romania, Kuwait and Brazil (-2.4 million tonnes). New urea capacity is, however, expected in India (+2.6 million tonnes), Nigeria (+2.4 million tonnes) and Azerbaijan, Uzbekistan and Russia (+1.5 million tonnes) in 2019 and 2020[2].

Phosphates: Global production of finished phosphates increased in 2019, rising to 74 million tonnes, according to preliminary IFA estimates. This was thanks to higher monoammonium phosphate (MAP) output and a strong recovery (+9% year-on-year) in diammonium phosphate (DAP) production. DAP exports expanded by seven percent year-on-year in 2019, with extra tonnages emerging from Morocco, Saudi Arabia, China and the US. DAP import growth was led by Turkey, India and Canada. MAP exports also increased strongly in 2019, being partly driven by with a robust recovery (27% year-on-year) in internationally-traded Chinese product. Rising MAP sales to Brazil and Canada were particularly noteworthy[2].

Incremental increases in finished phosphates capacity are forecast in 2019 and 2020. These will mainly occur in Morocco, Saudi Arabia and Egypt (+1.4 million tonnes P_2O_5 collectively) together with capacity expansions in Russia, Brazil, India and Turkey. This will be partially offset by plant shutdowns and mothballing in North America[2].

Potash: The soft conditions in the global potash market that prevailed in 2019 could well continue into 2020. Indeed, IFA expects the potash market to remain in a supply-driven phase in the near term, with new capacity projects in Russia and Belarus adding substantial export-dedicated production volumes. IFA is, however, forecasting a recovery in global MOP (muriate of potash) trade this year, with world demand rising to 53 million tonnes, a level last seen in 2017/18[2].

World potash capacity is forecast to rise by 4.8 percent (+2.9 million tonnes K_2O) during 2019 and 2020 to reach 62.8 million tonnes K_2O. This will be largely driven by an expansion in Russian MOP capacity (+1.4 million tonnes). Preliminary figures, however, suggest world potash capacity grew only marginally in 2019 (+0.2%, +0.1 million tonnes K_2O). Restructuring in Germany and the UK removed significant MOP capacity last year (-0.4 million tonnes), partly offset by robust growth in sulphate of potash (SOP) capacity (+0.3 million tonnes)[2].

Summary analysis

Fertilizer demand growth has been on a downward trajectory over the last ten years.

In retrospect, the market seems to have undergone a sea change around a decade ago. Global fertilizer demand – which dropped sharply in 2008/09 but rebounded in 2009/10 and 2010/11 – has subsequently grown at a slower pace. The average annual growth rate between 2011/12 and 2017/18, for example, was just 1.2 percent. That compares with growth of 2.6 percent p.a. between 2001/02 and 2007/08, the equivalent period in the previous decade[2].

Indeed, global growth in fertilizer use has slowed sharply in recent times, falling from 4.3 percent in 2011/12 to 0.8 percent in 2017/18. This growth slowdown has been partly driven by lower agricultural crop prices. Other factors include government policies and adverse weather in large consuming countries[2].

Contracting consumption in China since 2015/16 has acted as a drag on world fertilizer use. It is therefore, India, once again, which looks set to be the strongest driver of market growth in 2020 and into 2021, although the subcontinent is no longer the engine of demand growth it once was. Instead, since 2011/12, growth in world fertilizer consumption has become much more dependent on smaller, more dynamic markets in three regions: Latin America (Brazil, Mexico), Eastern Europe (Ukraine, Russia) and Africa (Ethiopia, Nigeria, South Africa).

A notable feature of the current short-term outlook is the volatility in fertilizer demand with a series of alternate year-on-year expansions and contractions expected in a number of key markets. This is true of the United States, Indonesia and Argentina. Fertilizer consumption in the US, for example, is likely to experience zero growth between 2017/18 and 2020/21 because of this volatility.

Major uncertainties and downside risks also abound. These include the slowing pace of world economic growth, the state of US-China trade relations, and the serious swine fever outbreak in China and neighbouring countries. ■

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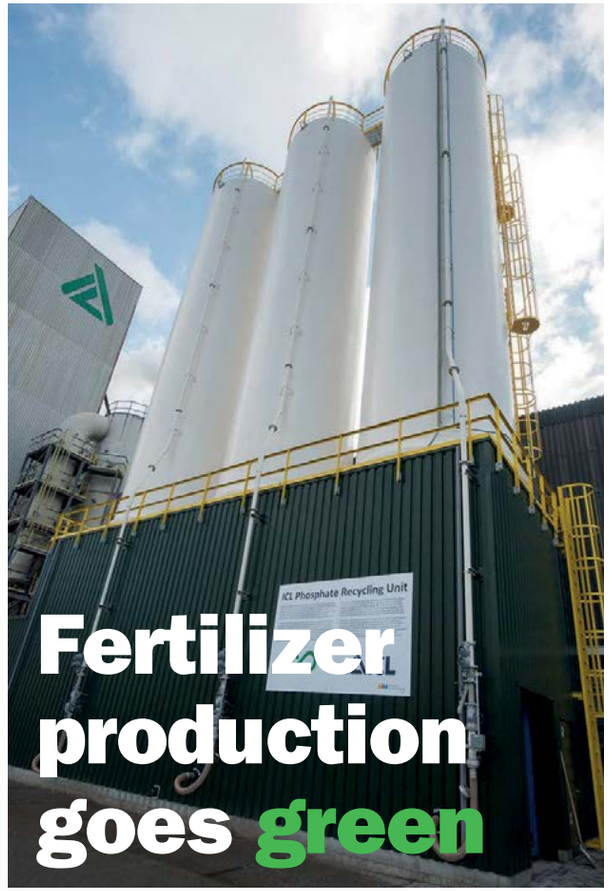

Fertilizer production goes green

Left: ICL's phosphate recycling unit, Amsterdam.

Leading nitrogen and phosphate producers, including ICL, OCP and Yara, have all launched major sustainable fertilizer production projects. The aim is to incorporate recovered nutrients or low-carbon feedstocks into their manufacturing processes.

The last 18 months has been a breakthrough period for fertilizer industry sustainability. A number of major fertilizer producers, in tandem with leading technology providers, have committed themselves to incorporating low-carbon feedstocks and/or recovered nutrients into their manufacturing processes.

Fertilizer majors such as Yara International have gone outside of the sector to find world-class partners with expertise in low-carbon-technology and the circular economy. They include waste management giant Veolia, Nel Hydrogen – the world's largest electrolyser manufacturer – and the French multinational electrical utility ENGIE.

Such partnerships demonstrate the fertilizer sector's seriousness about developing new sustainable production technologies and implementing these commercially at large-scale. In this article, we describe how the fertilizer industry is embracing the circular economy *and* starting an irrevocable shift towards a low-carbon future.

Europe at the vanguard

European-based companies and institutions, in particular, are leading the way when it comes to taking practical steps towards low-carbon fertilizer production and nutrient recovery. Casale, Haldor Topsoe and thyssenkrupp Industrial Solutions, for example, are all developing 'green' ammonia production processes (*Fertilizer International* 488, p33).

Fertilizers Europe helped set the tone by launching 'Feeding Life 2030', its new long-term strategy for the European fertilizer industry at the end of 2018.

The strategy, released to coincide with the trade association's 30th anniversary, has two major themes: firstly, the importance of plant nutrients in moving towards a more productive, sustainable food system in future and, secondly, the need to shift to lower-carbon or carbon-free fertilizer manufacturing, particularly for ammonia production.

The future of EU farming will involve "applying more knowledge per hectare", according to the strategy, an approach which echoes Yara International's "knowledge grows" ethos.

"Rapid technological development and innovation offer the prospect of meeting future food needs more sustainably. Digital farming offers big potential for further progress in nutrient management in Europe," said Javier Goñi del Cacho, president of Fertilizers Europe and Fertiberia's CEO.

Fertilizer manufacturing in Europe will also need to reduce its carbon footprint to meet EU climate and energy policy objectives. The strategy sets out a vision in which around 10 percent of the EU's ammonia production by 2030 will come from hydrogen generated by water electrolysis powered by renewable energy. Large-scale and low-cost production of ammonia via water electrolysis – the so-called 'green' ammonia route – could

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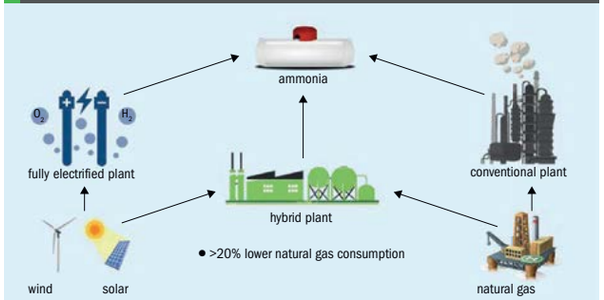
Fig. 1: **Hybrid ammonia plant that combines conventional steam methane reforming (SMR) with water electrolysis**



Source: Topsoe

be economically-viable within a decade, according to some estimates.

The strategy also proposes a valuable role for ammonia as a liquid energy carrier and storage medium, to help level-out the fluctuations in intermittent renewable electricity generation.

"Europe is forging ahead with the transition to clean energy, and is relying increasingly on renewable energy sources. We are a part of this drive. The nitrogen fertilizers industry, as a producer of ammonia, offers the key to unlocking clean energy potential by acting as a carbon-free energy storage medium," commented Javier Goñi del Cacho.

'Feeding Life 2030' is aligned with EU policy for a decarbonised and carbon-neutral European economy by 2050. This is to be achieved by a mix of energy efficiency, higher renewable electricity generation, adoption of low-carbon energy carriers, and carbon pricing.

Europe should be well-placed to take advantage of any shift to green ammonia production as the region has world-leading engineering companies for both wind power generation and water electrolysis. thyssenkrupp Industrial Solutions (tkIS), for example, is a global leader in the manufacture of large-scale electrolysis units.

One pathway for introducing and rolling-out green ammonia technology is installing water electrolysis units as part of revamps, creating hybrid steam methane reforming (SMR)/electrolysis ammonia plants (Figure 1).

Conventional SMR could also be converted into a carbon-free production process using carbon capture and storage (CCS) – the so-called 'blue' ammonia route. CCS may become a reality in parts of Europe by 2030, suggests Fertilizers Europe.

The use of ammonia as a liquid energy carrier could also grow into a lucrative end-market for European producers. Such a development could help Europe's nitrogen industry diversify and become an important and integral part of the EU's emerging low-carbon energy infrastructure.

Yara creates low-carbon and circular economy business units

In January 2019, Norway's Yara International stepped up its sustainability efforts by creating two new business units. The two units, Decarbonise and Circular Economy, are headed by Sam Van Den Broeck and Maria Silvia Tonti, respectively.

The Decarbonise unit has been given the task of reducing Yara's overall greenhouse gas (GHG) emissions. Its role will include the ramp-up of zero carbon nitrogen (e.g. green ammonia) production, reducing in-field agricultural GHG emissions and developing green energy carriers. The Circular Economy unit will take a lead on resource efficiency – doing more from less. It will also seek to generate value from waste through nutrient recovery and recycling.

Yara kick-started its decarbonisation efforts in February last year by unveiling a new partnership with giant French electricity utility ENGIE. The focus of this new collaboration will be the use of green technology in fertilizer production.

The two companies are initially working together on a feasibility study. The goal is to design a green hydrogen plant that can be integrated 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 from renewable power instead. Achieving this goal will help Yara cut Pilbara's CO_2 emissions.

The two partners have much to gain from the new collaboration. ENGIE's 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 CO_2-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 in 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 within Europe's emerging circular economy. Last January, it signed an agreement with French conglomerate Veolia to develop a

PHOTO: YARA

Yara's Pilbara ammonia plant, Western Australia.

circular economy approach to nutrient recycling, one that 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 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 Angibaud 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." said 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 by 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.

Porsgrunn green ammonia project

Yara International has teamed up with **Nel Hydrogen** to pilot water electrolysis technology at its Porsgrunn ammonia plant in Norway. The two Norwegian companies are collaborating on the installation of a five megawatt (MW) capacity electrolyser at the Porsgrunn plant by 2022. This is expected to contribute around one percent to Porsgrunn's hydrogen output initially.

Nel's next-generation, pressurised alkaline water electrolyser technology will be tested by Yara under real operating conditions as part of a collaborative project unveiled in August 2019. The goal is to produce hydrogen commercially using renewable electricity. This in turn will be used for either sustainable fertilizer production or the production of green ammonia.

The project is supported by Norway's Research Council, Innovation Norway and Enova through the PILOT-E programme – a funding scheme that aims to speed-up the development and implementation of green energy technology.

Yara views the link-up with Nel as an important step towards it ambition to become carbon neutral by 2050.

"We're excited to formally launch the partnership with Nel and work towards developing green ammonia and low carbon fertilizer. We have already removed about half of our direct GHG emissions in the past few decades, and we're working towards carbon neutrality by 2050. Producing fertilizer with carbon-free hydrogen will be a very important step towards that goal," said Yara's Tove Andersen, its executive vice president for production.

"We are very pleased with the partnership with Nel. Our ammonia

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Yara's Porsgrunn production site.

PHOTO: YARA

plant will make the first small step towards carbon-free fertilizer production. When further developed, Yara Porsgrunn will be in a unique position also due to the low carbon footprint from our nitric acid plants," added Jon Sletten, the Porsgrunn plant's manager.

Water electrolysis holds the key

Yara says its ultimate goal is to be a "market shaper" for green ammonia and low-carbon fertilizer production. Nel Hydrogen, being the world's largest electrolyser manufacturer, should be a strong partner in helping bring this about.

Nel can trace its roots back to 1927, when Norsk Hydro – the company which later became Yara – first developed large-scale electrolysers to generate hydrogen to produce ammonia for fertilizer manufacture. Nel has sold more than 3,500 electrolyser units in 80 countries globally since it first began selling these in the 1970s.

Today, Nel manufactures both alkaline and PEM (proton exchange membrane) electrolysers, and operates production plants in both Notodden, Norway, and in Wallingford, Connecticut in the US. The company is currently developing the next generation of large-scale, pressurised alkaline electrolysers as well as larger PEM stacks. These should help deliver substantial cost reductions.

Nel has also unveiled plans to scale-up its manufacturing capacity by opening a new production plant for alkaline electrolysers at Herøya Industrial Park in Norway. This should increase its electrolyser production capacity by 360 MW/year initially, with a further potential expansion to 1 GW/year in future.

Fig. 2: **Modular, skid-mounted thyssenkrupp water electrolysis unit**

Source: thyssenkrupp

Green ammonia is a hot industry topic currently, particularly in Europe. Another low-carbon energy collaboration, this time in the Netherlands, was announced between **Proton Ventures** and **Duiker Combustion Engineers (CE)** in July last year. The strategic link-up will turn green ammonia – generated by Proton's mini ammonia plants from renewable electricity – into high temperature heat using Duiker CE's stoichiometry controlled oxidation (SCO) technology.

Hans Vrijenhoef, CEO Proton Ventures, said: "The SCO technology of Duiker CE opens new possibilities in applying local ammonia production… such as the conversion of power plants to cleaner fuels."

thyssenkrupp launches new water electrolysis tech

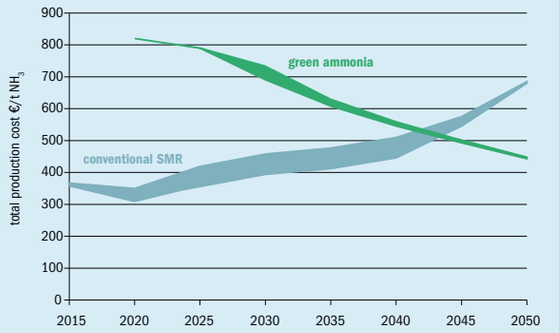
Germany engineering giant thyssenkrupp is also focussed on making hydrogen production from renewable energy economically feasible. The company launched a new industrial-scale water electrolysis unit in mid-2018.

The new highly-economical electrolysis unit developed by thyssenkrupp produces hydrogen at scale by using a large area active cell (2.7 m^2) at an efficiency of more than 82 percent. The innovative cell incorporates 'zero-gap' technology which almost eliminates the distance between electrodes and the membrane.

Sami Pelkonen, CEO of the electrolysis and polymers technologies business unit at thyssenkrupp Industrial Solutions said: "With our water electrolysis process, we have successfully brought a technology to market maturity which is of major significance for the energy transition. Green hydrogen, as a clean, CO_2-free starting point, can be used in a variety of ways: for energy storage, mobility, and the production of sustainable chemicals."

Importantly, the technology is modular. The pre-fabricated skid-mounted modules are easily integrated into existing plants (Figure 2). Projects can be scaled-up by adding a number of these modules, potentially delivering hundreds of megawatts of capacity. The technology has already been commissioned successfully as part of thyssenkrupp's Carbon2Chem project. This is using steel production emissions as raw materials for chemical production.

Fig. 3: **Projected cost reductions for green ammonia production vs conventional steam methane reforming (SMR)***



*See text for assumptions.

Source: Cefic/Dechema (2017)

Haldor Topsoe unveils green ammonia project

Haldor Topsoe, is collaborating with academia and industry on the new SOC_4NH_3 research project. The partners are developing solid oxide cell electrolysis for CO_2-free green ammonia production. The project is aiming to demonstrate the technology and bring it 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 Bøgild 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 wind-power, 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 CO_2 emissions," said Lars Ottosen, head of biological and chemical engineering, University of Aarhus.

> **"Ammonia can be used for transportation and efficient storage of energy. The greatest advantage of ammonia is that it has a high energy density…**

"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 SOC_4NH_3 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, exports and jobs.

Cost reductions and investment crucial

Cefic, the European Chemical Industry Council, published a landmark study on low-carbon energy and feedstocks in 2017. This set out a pathway for the transition of Europe's chemical sector to carbon neutrality by 2050 (*Fertilizer International* 483, p20).

The Cefic study suggested that green ammonia produced using renewable energy could become cost-competitive with conventional ammonia production in Europe within 20-25 years (Figure 3). This would require green ammonia production costs to fall below €500/tonne – plus a number of major assumptions, including:

- A stable electricity price of around €40/MWh
- Drastic falls in the investment (capex) cost of water electrolysis units from €1,450/kW to €375/kW
- A large rise in the carbon price (CO_2 emissions certificates) in Europe to €196/tCO_2.

If and when the above conditions are met, the massive ramp-up of investment necessary is likely to be the main barrier to the low-carbon transition. Cefic calculated, for example, that an industry-wide transition to green ammonia in Europe – in terms of retrofitting and new plant capacity – could be as high as €76.6 billion out to 2050. That is 7-8 times higher than the business-as-usual investment of €9.1 billion expected over the next 30 years. These figures do

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not include the extra investment necessary to decarbonise urea production, potentially an additional €32.9 billion (*Fertilizer International* 483, p20).

OCP targets renewable feedstocks

Morocco's OCP Group has launched its own 'green' fertilizer production initiative in collaboration with Germany's Fraunhofer Institute.

The two partners will work jointly on producing hydrogen and ammonia using renewable electricity. The collaboration forms part of memorandum of understanding (MoU) between OCP Group and the Fraunhofer Institute for Microstructure of Materials and Systems (IMWS) signed in 2018.

Fraunhofer IMWS will help OCP to develop a green ammonia project at the Green Energy Park in Ben Guerir, Morocco. The option of establishing an African Institute for Solar Ammonia is also being discussed. A pilot plant to produce hydrogen from renewable sources is already being built in Leuna, Germany, as part of a project led by the Fraunhofer Institute.

Professor Ralf Wehrspohn, director of Fraunhofer IMWS, said: "Green hydrogen and green ammonia offer tremendous potential to… supply raw materials to the fertilizer industry. They also reduce the industry's dependency on oil, natural gas and any other fossil fuel."

Mostafa Terrab, OCP Group's chairman, said: "Responsibility for the environment has always been important to us… as a fundamental principle of our circular economy approach. The use of green ammonia fits in with this strategy. It can help conserve valuable resources and provide our customers with sustainable new products. That's why we are looking forward to strengthening our cooperation with Fraunhofer."

ICL opens phosphate recycling unit

ICL opened an innovative phosphate recycling unit at its Amsterdam fertilizers production site in the Netherlands in 2019.

In an industry first, the new unit allows ICL to incorporate recovered phosphate from secondary sources in the industrial-scale production of phosphate-based fertilizers.

The unit, which uses large-scale alternative sources of phosphate such as sewage sludge ashes and bone meal ashes, was formally opened by officials from the City of Amsterdam and the province of North Holland in March last year.

ICL described the unit as a "circular innovation" and an example of the company's strong commitment to sustainability.

"By using phosphate from alternative sources, we provide society with an innovative circular solution and also prepare ourselves for a future where phosphate rock will become an increasingly scarce source. This installation will allow ICL to continue with the production of fertilizers that help feed the world for many years to come in a sustainable way," ICL said in a statement.

The company made clear that the unit was just the start of its plans: "Our ambition is to further increase the use of phosphate coming from alternative sources in the coming years, with ICL as one of the international frontrunners in phosphate recycling."

ICL to sell recovered nutrients

ICL Specialty Fertilizers have also entered into a long-term sales and distribution agreement and strategic partnership with Vancouver-headquartered Ostara Nutrient Recovery Technologies.

As part of these new agreements, ICL will now market and sell Ostara's *Crystal Green*, a struvite-based phosphate fertilizer, into the EU, supplying the turf and lawncare markets.

Crystal Green is recovered from municipal wastewater at 15 plants worldwide using Ostara's Pearl technology. It is a continuous-release fertilizer incorporating the company's trademarked *Root Activated* phosphorus.

Advantageously, *Crystal Green* contains virtually no cadmium or other heavy metals. It also only releases phosphorus, nitrogen and magnesium in response to the organic acids produced by growing roots. This ensures that phosphorus is available for uptake when required by plants, while at the same time reducing the environmental impact caused by leaching and nutrient run-off.

"It is more important than ever before to grow higher quality turf grass with lower inputs, and we at ICL Specialty Fertilizers are dedicated to bringing new products and technologies to our global network that support this philosophy," said ICL spokesman Arne Padt. "Our partnership with Ostara provides ICL Specialty Fertilizers access to a unique, clean, circular economy phosphorus source with a technology that has proven to give better rooting to turf grass than traditional phosphorus sources."

Padt added: "As phosphorus is recognized by the EU as a critical raw material, ICL Specialty Fertilizers is proud to use this clean phosphorus source derived from recycling."

"Ostara is forging the path in resource recovery and reuse. Together [with ICL Specialty Fertilizers] we are excited to offer the European market a product that exemplifies the circular economy concept while also improving plant health," said Molly Biedenfeld, Ostara's vice president for nutrient market development and sales. "With the EU's increased scrutiny of cadmium levels and other heavy metal concentrations in fertilizer, *Crystal Green* is uniquely positioned to benefit EU market participants."

Opening ceremony for ICL's Amsterdam phosphate recycling unit.

PHOTO: ICL

> **"Novaphos IHP technology can make a major impact on phosphate sustainability by opening up new sources of phosphate rock while significantly reducing wastes."**

Novaphos produces high-quality acid

Florida-based Novaphos Inc (formerly JDCPhosphate) has successfully manufactured high-quality super-phosphoric acid (SPA) continuously using its proprietary improved hard process (IHP).

This was finally achieved in 2018 during prolonged operation of the company's IHP demonstration plant in Fort Meade, Florida.

Highly-innovative kiln-based IHP produces phosphoric acid from a low-quality phosphate rock feedstock, without creating phosphogypsum waste. Instead, the process generates *J-Rox*, a commercially-useful aggregate, as co-product.

During recent operations, Novaphos was able to continuously manufacture super-phosphoric acid using locally-sourced phosphate mine waste. This contained around 14 percent P_2O_5 alongside high levels of silica and other impurities such as magnesium oxide. This was combined with clay and petroleum coke to form the feed for the kiln.

A high-grade SPA end-product was obtained (68 percent P_2O_5) with minimal impurity levels (<2.5 percent). The process eliminated up to 90 percent of cadmium in the phosphate feed. This was captured in the plant's pollution control scrubbing system, leaving levels of around two ppm in the SPA. The process also significantly reduced levels of lead and arsenic.

"This is a major milestone for Novaphos and our technology, showcasing IHP's value as a cost-efficient and scalable new process," said Timothy Cotton, Novaphos' CEO.

He added: "Given the limited phosphate rock reserves in the world, it will be critical for future generations that we waste as little as possible of these vital resources. At the same time, we need to minimise the production of toxic phosphogypsum wastes and reduce the level of harmful impurities in phosphate products."

Luc Maene, former director general of the International Fertilizer Association (IFA), commented, "For many years I have been hoping that innovative technologies will improve the sustainability of the phosphate sector, which is so critical for food production and so dependent on a limited natural resource. Novaphos IHP technology can make a major impact on phosphate sustainability by opening up new sources of phosphate rock while significantly reducing wastes."

As a next step, Novaphos plans to commercially deploy IHP technology, after completing process design engineering for a full-scale production process. The company says it has started a dialogue with major phosphate producers and engineering companies to fully commercialise Novaphos technology.

"Our new name [Novaphos] signifies our readiness to move into the next phase," said Timothy Cotton. "We will work with industry partners to commercialise our technology for making phosphate products that are vital to global food production." ■

GREEN AMMONIA: KEY FACTS

Wind, solar and other forms or renewable energy can be exported as electricity or converted into 'green' ammonia or hydrogen. Green ammonia could lead to a future where farmers use fertilizers manufactured by sunlight, ammonia producers become leaders in the new energy market, and ammonia capacity worldwide increases exponentially.

Green ammonia vs green hydrogen

Advantages over hydrogen:

- Ammonia has better power density than hydrogen and does not have to be kept at extremely low temperatures or under high pressure to be stored
- Ammonia is regarded as one of the more attractive options for zero emission shipping due to its energy density and ease of handling
- A premium price could be demanded for green ammonia products
- Ammonia as an energy carrier could command a high price relative to hydrogen fuel.

Green ammonia as a fuel

Main advantages:

- Zero carbon fuel
- Well-established trade
- Can be 100 percent produced from electrical energy
- Can be easily converted into hydrogen and nitrogen
- High energy density – can be stored at <20 bar
- Low opex and losses in storage
- High hydrogen density
- Low risk of fire – a specific ratio of NH_3 and air (15-25%) is required to sustain combustion.

Main weaknesses:

- NOx emissions
- Odour and toxicity.

World hydrogen market

- Today, most of the approximately 55 million tonnes of hydrogen produced annually is not CO_2-free
- Ammonia production accounts for >50 percent of the total hydrogen market which is currently >95 percent fossil fuel based (from gas, oil, coal etc.)
- Green hydrogen produced from renewable power via electrolysis is fully renewable and CO_2-free
- But only one percent of hydrogen is produced from water electrolysis currently, the rest coming from steam methane reforming and gasification
- Green hydrogen has the potential to decarbonise a large range of applications
- It offers massive CO_2 reduction potential for power, gas, transport and industry. ■

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Recycled nutrients for NPK production

Two EU projects are developing and bringing to market a new generation of fertilizers derived from bio-wastes, as Fertiberia's **Maria Cinta Cazador Ruiz** explains.

Bio-waste streams are a potentially valuable resource – one that is under-utilised at present.

Turning currently discarded bio-wastes into products with value – so called valorisation – has obvious attractions. It meets EU waste management policy objectives, for example. And, by eliminating waste and maintaining materials in economic circulation, this approach is also in keeping with circular economy principles.

Mineral fertilizers feed the world and play a vitally important role in supplying nutrients to crops globally. But their production relies heavily on finite resources. The European fertilizer industry is particularly dependent on imports of primary raw materials. This exposes EU fertilizer producers to security of supply risks and price volatility.

Equally, there is a common misconception that all bio-wastes – regardless of their origin and composition – can become effective fertilizers. This is simply untrue. Crucially, bio-wastes must be free of potential harmful compounds if they are to be transformed into effective plant nutrients. To increase crop yields, they must also contain nutrients in plant-available form.

Spain's Fertiberia has been at the vanguard in developing bio-wastes for use in fertilizer production – as an effective alternative to conventional mineral raw materials.

The NewFert project

Society is facing a 'resource crunch' due to a combination of water, food and minerals scarcity and increasing waste generation. These problems will only get worse in future as the global population continues to rise. Waste generation is in fact one of the world's most alarming environmental problems: the EU alone produces more than 2.5 billion tonnes of waste annually.

The recent EU-funded *NewFert* project specifically addresses Europe's enormous waste management challenge. Its purpose was to develop nutrient recovery processes capable of transforming bio-wastes into high-quality and valuable fertilizer products.

NewFert's full project title is 'Nutrient Recovery from Bio-based Waste for Fertiliser Production'. The overall aim was to develop new value chains from solid and liquid waste residues. More specifically, the project attempted to manufacture a new generation of fertilizers using ashes from waste incineration and livestock effluents, among others.

NewFert's main focus was developing new bio-refining technologies capable of increasing nutrient recovery from waste – and creating a technically feasible and cost-effective industrial nutrient recycling scheme. Mitigating the environmental and socio-economic impact of conventional fertilizer production – by replacing non-renewable/fossil-derived raw materials with bio-based nutrient sources – was an equally important project objective.

The *NewFert* consortium was led by Fertiberia and comprised of five other partners, each possessing different but complementary areas of expertise:

- University of Leon (Spain)
- Drage & Mate International (Spain)
- Proman Management (Austria)
- Institut National de Recherche en Sciences et Technologies pour L'environnement (France)
- Kompententzzentrum Wasser Berlin Gemeinnutzige (Germany).

These organisations cover the whole value chain of nutrient recovery, including bio-based industries, SMEs, research & technology companies and academia. The project's delivery plan was divided into eight different work packages.

From bio-waste to promising nutrients

An EU bio-waste screening and mapping exercise was initially carried out as part of the project.

Fertiberia developed a specific tool for assessing the potential suitability of bio-wastes for processing into fertilizing products. This was based on a list of bio-waste requirement criteria. A number of parameters (physico-chemical characteristics, supply, logistics, safety aspects, etc.) were determined for each bio-waste selected.

Around 30 percent of the 50 bio-based materials identified were found to comply with the required criteria.

Piloting nutrient recovery processes

Three novel nutrient recovery processes were developed and validated at pilot plant scale as part of the project:

1. **Phosphorus recovery from ashes.** This process extracted phosphorus present in ashes sourced from agro-food industry and waste water treatment plants and converted this into plant-available form (Figure 1). The ashes were firstly chemically treated by acid leaching and then neutralised. Phosphate salts were finally produced using a thermally-efficient reactor.
2. **Phosphorus and nitrogen recovery from pig slurry**. Nitrogen and phosphorus present in pig farm slurry were extracted and crystallised as struvite using biological acidification.
3. **Nitrogen recovery and organic matter removal from pig slurry**. In this synergistic process, nitrogen from pig slurry was recovered via bio-electrochemical systems (BES), while, simultaneously, microorganisms were used to reduce the organic matter content of the bio-waste stream (Figure 2).

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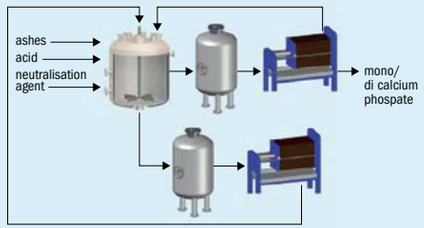
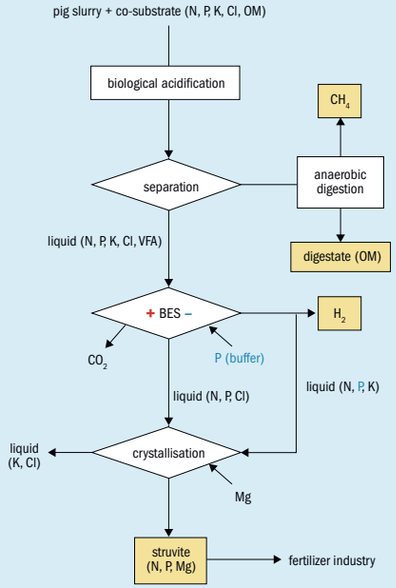
Fig. 1: **The DMPhos phosphorus recovery process**



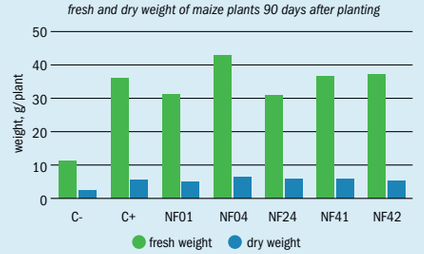
Source: Drage Mate International/Fertiberia

Fig. 2: **Nitrogen recovery and organic matter removal by a combined biological acidification and BES process**



Source: University of Leon/Fertiberia

Fig. 3: **Agronomic results obtained using bio-based NPK fertilizers (NF01, NF04, NF24, NF41 and NF42) vs no fertilization (C-) and standard NPK fertilization (C+)**



Source: University of Leon/Fertiberia

A new family of bio-based NPK fertilizers

The project included technological validation at pilot plant scale. This successfully incorporated the most promising bio-based materials into a fertilizer production value chain. The following results were achieved:

- Development of a new family of NPK fertilizers
- 15 percent of the nutrient content of these NPK products was derived from bio-based materials
- 100 percent of their nutrient content is plant-available
- More than 80 percent of their nutrient content is water-soluble
- At least 10 percent of the combined nitrogen (N) and phosphorus (P_2O_5) content is from bio-based materials.

The agronomic performance of all of the bio-based NPK fertilizer formulations was validated using greenhouse trials to determine crop yields. In most cases, the crop response was found to be identical to that obtained with the conventional NPK equivalent (Figure 3). These results generally demonstrated the agronomic suitability of NPK fertilizers that partially incorporate bio-based nutrients.

Next steps: the *B-Ferst* project

Building on the positive results of the *NewFert* project, a new project *B-Ferst* was launched in May 2019. (Its full project title is 'Bio-based fertilising products as the best practice for agriculture management sustainability'.)

The new project's main aim is to validate and implement *NewFert*'s bio-refining technologies at demonstration scale. Eight new bio-based fertilizers will be produced at this industrial scale. These will incorporate recovered nutrients from bio-wastes, specialised organic matter, biostimulants and coating agents.

B-Ferst will demonstrate how the production of these products can be integrated into both farm and fertilizer industry value chains. New logistics models and satellite technologies will be demonstrated by conducting three agronomic field trial campaigns at five separate European sites.

The successful implementation of these technologies at industrial scale could significantly reduce the use of non-renewable raw materials by fertilizer producers. That would contribute greatly to the necessary shift by the fertilizer industry to processes based on circular economy principles and 'green' production technology. ■

Further information

The *NewFert* project (www.newfert.org) and The *B-Ferst* project (www.bferst.eu) both received funding from the Biobased Industries Joint Undertaking, part of the EU's Horizon H2020 research and innovation programme (grant agreements nº 668128 and nº 837583, respectively).

Fertilizers go circular

Tudela food-industrial park, Spain.

PHOTO: INCRO

Antonio Sancho, Incro's managing director, gives a personal view on the circular economy and shares his experience of manufacturing high-quality liquid fertilizers from food industry wastewater.

That was then...

Only a decade ago, this article would have been highly theoretical and, lacking a receptive audience, have probably gone largely ignored.

No doubt I would have needed to start with a reminder of basic school biology – the essential role phosphorus plays in all living things. The article would also have explained how phosphorus ends up in a wide range of waste generated by farming, food production and industry.

It would also have been necessary to point out some regrettable facts – that millions of tonnes of phosphorous end up in landfill each year or, even worse, polluting our rivers and ecosystems. Exactly the type of green language that makes many uncomfortable.

Finally, I would turn to my central proposition:

- That, in future, the fertilizer industry should recover nutrients as highly valuable products
- And, by doing so, would improve our environment, increase the contribution our sector makes to the economy, and empower fertilizer production from local sources.

Of course, that would probably have been the exact moment when many readers would have skipped to the next article. The only readers left – possibly one in a hundred – would be those interested in looking at a few laboratory test results!

This is now

Fortunately, those days are long gone. Nowadays, the fertilizer industry's pursuit of the circular economy has turned from a leftfield idea into a cold, concrete fact. We have been compelled to act due to our sustainability needs as an industry, and by new legislation driving reforms in this direction.

Crucially, the EU finally published its new fertilising products regulation in 2019. This introduces legislation covering fertilizers derived from secondary raw materials for the first time. If you can ignore its jargon and somewhat patronising language, this highly positive regulation opens the gate to producing and placing on the market a whole new generation of safe and effective fertilizers.

Subsequently, the Joint Research Centre (JRC) of the European Commission, an independent science and knowledge service located in Seville, published a proposed legal framework for these new types of waste-derived fertilizer products. This covers precipitated phosphate salts and materials generated by thermal oxidation, pyrolysis and gasification.

The good news is that I am now confident that you – today's reader – will be much more eager to learn about this subject. That's because I bring to you, not just a few lab test results, but an *actual* industrial case instead.

A leadership role

Spanish industrial group Fertiberia has taken a leadership role in turning the circular economy concept of high-quality innovative fertilizers into a reality. In particular, its engineering company, Incro, S.A., has been instrumental in carrying out the flagship *Oleofat* project. Valuably, this pioneering project has successfully transformed industrial wastewater into a liquid fertilizer (almost 13% P_2O_5, cadmium-free), at the same time generating recycled water for farming and industrial purposes.

The Oleofat company is located in Tudela food-industrial park, Spain. It valorises (obtains value from) vegetable oil by-products and bio-wastes by transforming these into sustainable biodiesel and valuable compounds such as tocopherols, squalene and phytosterols. The by-products utilised include oil tank bottoms, degumming sludge and fatty acid waste from vegetable oil refining (soapstocks).

At Oleofat's premises, these raw materials are treated with sulphuric acid and then, at a later stage, decanted to separate fatty acids from wastewater. High added-value products, derived from the subsequent processing of fatty acids, are delivered for animal feeding, cosmetics and the emerging 'nutraceutical' industry.

Wastewater, the Achilles' heel

This entrepreneurial success story does, however, have one Achilles' heel: difficult to dispose of wastewater.

Oleofat's wastewater is strongly polluted with a low pH, high organic matter content (not biologically treatable) and a large amount of salts, mainly sulphates (Table 1).

Oleofat's wastewater, because of its phosphate load, used to be sent to a local biogas plant. But after plant corrosion became a problem it was temporarily sent

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Table 1: **Wastewater composition following nitric or sulphuric acid treatment***

	Wastewater	
	H_2SO_4 base	**HNO_3 base**
pH	1.70/5.98*	2.28/6.40*
Conductivity (µS/cm)	59,260	78,240
DQO (ppm)	57,290	90,630
Sulphate (ppm)	43,200	<20
Phosphate (ppm)	14,080	24,640
Nitrate (ppm)	-	45,200

**Corrected pH prior to concentration* *Source: Incro*

for disposal to the local sewage treatment plant instead.

The lack of a long-term wastewater solution threatened Oleofat's viability as a company. Because of this, Incro was asked to intervene and come up with a suitable wastewater treatment option. Early on we identified a definite opportunity to implement a circular economy approach involving the fertilizer industry.

Incro proposed concentrating wastewater to enrich its P_2O_5 content. The liquid concentrate obtained would then be delivered to Fertiberia's liquid fertilizer plant at Agralia where it would be valorised (transformed into a valuable product).

Furthermore, by switching from sulphuric acid to nitric acid in the Oleofat process, it was possible to improve the quality of the wastewater by replacing sulphates with nitrates. The resulting change in composition generated a liquid fertilizer with even higher added-value. In an additional benefit, the water obtained as a distillate during the concentration process was suitable for reuse elsewhere in the food-industrial park.

From wastewater to liquid fertilizer

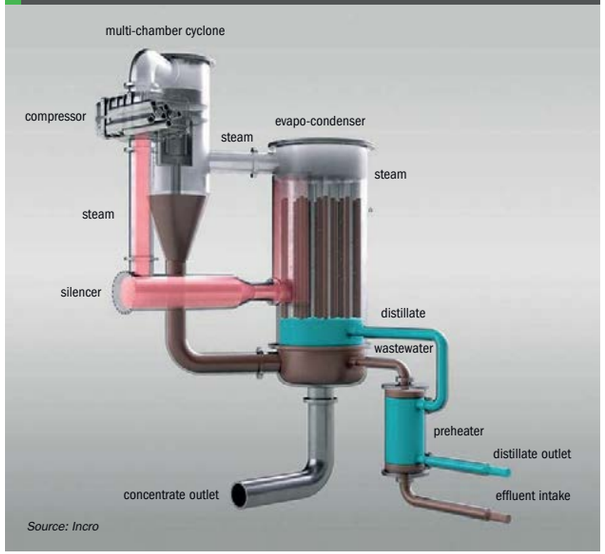
Incro employed its proprietary mechanical vapour compression (MVC) technology to obtain a concentrate and distillate from the wastewater (Figure 1). This unit incorporates a highly efficient and low operating cost evaporator that concentrates the wastewater close to its precipitation point. Its dual-use design allows treatment with either sulphuric or nitric acid, depending on acid market prices and/or the end-destination of the concentrate.

The concentrate obtained is suitable for use as a liquid NPK fertilizer, containing 4.0 percent nitrogen (as nitrate), 12.9 percent phosphorus (P_2O_5), 0.7 percent potassium (K_2O) and 17.3 percent organic carbon, while also being free of heavy metals and pathogens (Table 2). Its nitrate content is, of course, derived from the nitric acid used to extract the phosphate from the bio-waste. Annually, Incro's MVC unit has the capacity to handle around 10,000 tonnes of wastewater and produce 3,000 tonnes of liquid fertilizer from this.

Conclusion

The Incro-Oleofat project shows how secondary raw materials – to use EU jargon – can be transformed into high quality, saleable products. But, above all, it symbolises a real, actual example of phosphate recovery by the fertilizer industry and the circular economy in action. ■

Fig. 1: **Incro's MVC wastewater treatment unit**



Source: Incro

Table 2: **Composition of the liquid fertilizer (process concentrate)**

Concentrate	
Total nitrogen (N), of which:	4.5 %
• N, organic	0.4 %
• N, ammonia	<1.0 %
• N, nitrate	4.0 %
• N, urea	<1.0 %
Phosphorus (P_2O_5)	12.9 %
Potassium (K_2O)	0.70 %
Organic carbon	17.3 %
Humic acids	<1.0 %
Chrome (VI)	<2 ppm
Nickel	<4.0 ppm
Copper	<2.5 ppm
Zinc	122 ppm
Cadmium	<0.50 ppm
Chrome	<1.0 ppm
Plumb	0.42 ppm
Mercury	<0.01 ppm
Salmonella	Absent in 25 ml
E Coli	<3 NMP/ml

Source: Incro

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phosphates & potash INSIGHT

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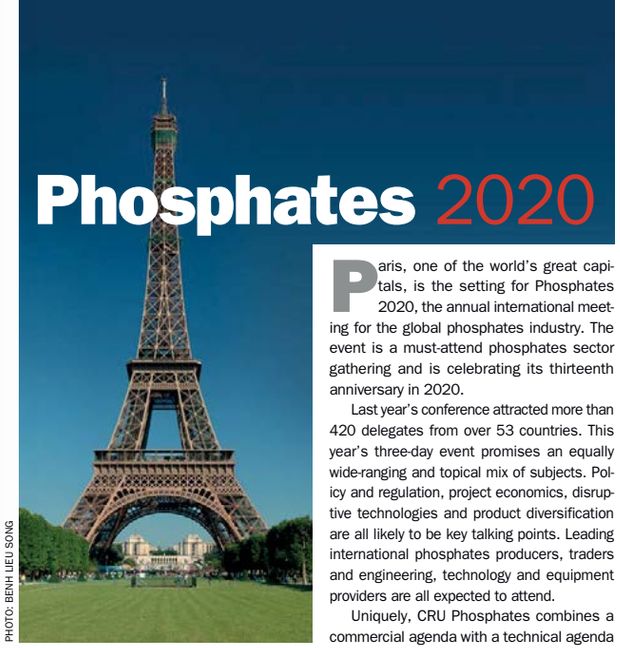

PHOTO: BENH LIEU SONG

CRU events will convene the 2020 Phosphates International Conference & Exhibition in Paris at the Marriott Rive Gauche between 8-10 March.

Paris, one of the world's great capitals, is the setting for Phosphates 2020, the annual international meeting for the global phosphates industry. The event is a must-attend phosphates sector gathering and is celebrating its thirteenth anniversary in 2020.

Last year's conference attracted more than 420 delegates from over 53 countries. This year's three-day event promises an equally wide-ranging and topical mix of subjects. Policy and regulation, project economics, disruptive technologies and product diversification are all likely to be key talking points. 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 2020 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:

- Global and regional market outlooks
- Phosphate rock market dynamics
- Mining projects update
- Market developments for complex and specialty fertilizers
- Feed, industrial and specialty products.

The event also offers a separate but equally strong technical and operational programme (see page 42). The afternoon of Monday 9th March also has a special theme this year: the role of phosphate producers in the circular economy. This will cover regulation, sustainability and innovation.

Some key reasons to attend:

- Get the CRU View on phosphate supply, demand and prices across the globe in 2020 and beyond
- Hear from incumbent producers and new project developers
- Gain an understanding of the new EU Fertilising Products Regulation (FRP)
- Learn about new technologies, processes, materials and equipment innovations in the technical showcase
- Understand the key drivers shaping the feed, industrial and specialty markets
- Let expert exhibitors answer your technical questions.

Phosphates market overview

Chris Lawson, CRU's head of fertilizers, sets the scene for Phosphates 2020 with this personal take on the state of the industry:

Phosphate markets end the decade at a new low

"Phosphate fertilizer markets suffered consistent losses throughout 2019, ending the decade with the lowest prices since 2006. A combination of poor demand and new volumes entering the supply chain from Morocco and Saudi Arabia tipped the market into oversupply. With ammonia and sulphur prices also tanking, DAP and MAP prices were unrelenting in the slide downwards, with margins to producers also squeezed.

"Producers in China remain under increasing pressure. Tight environmental regulations remain, although new measures were few and far between in 2019. More pressing was yet another decline in domestic consumption, offsetting production cuts and resulting in another year of strong export sales – adding to global oversupply.

"While China is undoubtedly the marginal producer and exporter, producers in the US took the mantle of swing producer in 2019. Mosaic twice announced production cuts to attempt to balance the market, most recently idling its Faustina facility in Louisiana for three months. This is evidence of the structural supply shift that has occurred over the past decade – in 2010 the US imported 0.5 million tonnes of DAP+MAP and exported almost 6 million tonnes… come 2019 we estimate it imported 3.3 million tonnes and exported 3.2 million.

"Producer margins tightened throughout 2019, and as the year closed out Mosaic, OCP, PhosAgro and the Chinese consortium of producers all announced short-term cut backs in production. This has helped to place a floor on prices in some markets and spur a recovery in others, meaning the market has begun 2020 on a more positive note.

"Poor North American demand in 2019 was a weather-related blip, rather than a structural consumption shift, and is expected to recover sharply in 2020. Meanwhile, the outlook for consumption for other countries (excluding China) remains strong for 2020 and beyond. This, combined with a slowdown in new supply over the medium-term, will be more supportive of prices. A gradual recovery is anticipated in 2020, before more substantial increases beyond 2021.

"Despite the currently depressed state of the market, investment interest remains active. New capacity developments for Russia, Morocco, Saudi Arabia, Egypt and even Togo were announced through 2019. Investments in these low-cost regions will continue to shift the structure of the industry. But developments in China will remain the most important factor to determining prices – and future investment and strategic decisions – over the coming five years.

"Outside of market fundamentals, the concept of environmental and social governance, new project economics, potentially disruptive technologies and product diversification are the key industry talking points. All of these will be discussed in detail at the upcoming CRU Phosphates conference." ■

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Technical programme highlights

A selection of abstracts from Phosphates 2020's technical and operational programme.

How much metallurgical testing is enough?

Metallurgical testing requires an understanding of geology, particularly the variability of the ore in the ground. Bulk samples from large diameter cores can be used for test purposes. But a trial mining pit is typically required for the larger samples (i.e. 50 to 100 tonnes) needed for pilot plant testing.

Worley asks how much metallurgical testing is necessary to guarantee the success of a phosphate rock project. Essentially, the test programme needs to assess if beneficiation is capable of producing a saleable concentrate or product for use downstream. This firstly requires an appraisal of ore mineralogy and characteristics, especially mechanical properties such as grindability, abrasion, density etc. Results obtained are used to formulate a suitable approach for upgrading run-of-mine ore and delivering a commercially-acceptable phosphate rock concentrate.

The second stage of metallurgical test work then optimises the process, including reagents, to improve ore grade, recovery and operating costs. Finally, proving the flowsheet requires semi-continuous pilot plant testing.

Beneficiation of rock phosphates using X-Ray sorting machines

TOMRA shares the lessons learnt from two-years of operational experience at the Ma'aden Wa'ad al Shamal Phosphate Corporation (MWSPC). TOMRA's sorting machines are installed at MWSPC's 13.5 million t/a capacity beneficiation plant where they pre-process run-of-mine (ROM) ore using XRT (X-Ray Transmission) technology.

TOMRA's machines can treat 1,800-2,000 t/h of feed material, about 50-60 percent of the total ROM. The machines, which recognise and separate materials based on differences in atomic density, reduce silicon content by removing unwanted chert from phosphate (apatite).

Importantly, XRT technology achieves a high apatite recovery during the sorting process. Eliminating chert also realises substantial cost savings for MWSPC by reducing downstream equipment wear and associated maintenance costs.

Gemini anionics – a new surfactant family for phosphate flotation

Results are presented for a novel family of anionic Gemini surfactants from **Nouryon**. These environmentally-friendly dimeric compounds have been developed and evaluated as collectors in the direct flotation of apatite from carbonate-rich and siliceous phosphate ores. Using these novel dimeric collectors, it was found that a significant reduction in dosage (half or more) is achievable, in comparison to currently-used monomeric collectors. Gemini surfactants are not only more dose-efficient, they also show outstanding selectivity for apatite in phosphate/carbonate/silicate systems.

Purified phosphoric acid from low-grade phosphate rock

Tenova Advanced Technologies (TAT) have developed a process for producing food-grade purified phosphoric acid (PPA) from low-grade phosphate rock. The process involves leaching highly impure (up to 2.5% Fe_2O_3 and F <4.5%) and low-grade (25-30% P_2O_5) phosphate rock and recovering P_2O_5 by solvent extraction (SX). This delivers food-grade PPA as final product (>61% P_2O_5, <5 ppm Fe, <10 ppm F and <1 ppm heavy metals). Overall recovery is 87 percent minimum.

Optimising industrial processes with a digital platform

Prayon shares its experience of developing a digital platform specifically for phosphates production. This automates the collection of industrial data from a phosphate manufacturing plant. Using machine learning and artificial intelligence, the platform can then help operators control their plants properly by predicting and explaining operational deviations. In future, by working out generic solutions and creating specific tools, digital platforms have the potential to keep phosphate plants within their 'excellence zone' and operating at peak performance.

What is eco-friendly and sustainable?

In fertilizer production, it is important to understand exactly what being sustainable or eco-friendly entails. In this presentation, **ArrMaz** takes a deep dive into sustainable chemistry – what it is, how it can be applied, and what it means for the fertilizer industry. Case study results are presented for eco-friendly ArrMaz coatings. These renewable and biodegradable coatings generate zero or minimal waste during production. They are suitable for phosphates and other industry substrates such as nitrogen- and potash-based fertilizers.

PHOSFLOW® technology for the mitigation of scale growth

Mineral scale accumulates on heat exchangers and in pipelines when dissolved elements become supersaturated at different points in the phosphoric acid production process. The use of chemical inhibitors can reduce the rate of mineral scale accumulation – and are an effective way of avoiding the production inefficiencies scaling can cause. The use of **Solvay**'s *PHOSFLOW®* technology has been successfully demonstrated at the Grupo Fertinal-Agroindustrias plant in Mexico. In this case study, *PHOSFLOW®* 1400 was used in the plant's heat exchangers for scale inhibition. Trial results show the benefits for the operational lifetime and efficiency of the evaporator.

IMACID expansion project increases phosphoric acid production

Andritz Separation supplied IMACID with a new tilting pan filter as part of an expansion project. IMACID was looking for a new filter that could produce up to 950 tons/day P_2O_5, offered maximum reliability, and used a minimal amount of water for filter cloth washing.

Andritz supplied IMACID with its model 36-250 tilting pan filter designed for arid climates. The company has already supplied six of these models to the Umm Wu'al phosphoric acid plants in Saudi Arabia. The new tilting pan filter was able to take full advantage of the excess sulphuric acid available and, consequently, was able to produce 22 percent more P_2O_5 capacity (1,650 tons/day P_2O_5) than the plant's rated capacity of 1,350 tons/day P_2O_5.

Solving foaming problems in phosphoric acid production

Managing the formation of foam is a common challenge in the phosphate production process. It can decrease production output and be a safety concern. Although foaming is a notable reactor problem, it can also occur in other parts of the process. Its downstream effects can also be widespread, with consequences for beneficiation, evaporation and granulation. In this presentation, **Nalco Water** will discuss its recent experience of solving foam problems in the phosphate production process. An effective approach that combines advanced chemistries with advanced application technologies is described. ■

ICL Amsterdam NPK production plant.

Europe's phosphate industry

Leading EU phosphate and NPK fertilizer producers are profiled, including EuroChem, Fertiberia, Grupa Azoty, ICL, Prayon and Yara.

Table 1: **Yara's European NPK production sites***

	Siilinjärvi, Finland	Uusikaupunki, Finland	Porsgrunn, Norway	Glomfjord, Norway	Montoir, France	Ravenna, Italy
Product	**Production capacity ('000 tonnes)**					
Ammonia			500			
Nitric acid	200	500	1,500	400	300	400
Phos acid	300					
Phos rock	1,000					
NPKs	500	1,200	2,200	600	300	400
Nitrates		200			400	400
CN			900	200		

*last updated March 2018. Source: Yara

Yara's production might

Yara International is Europe's leading phosphate rock and NPK producer. The company's Siilinjärvi mine in Finland – the EU's only phosphate mine – produces around one million tonnes of phosphate rock concentrate and 300,000 tonnes of phosphoric acid annually.

Yara's combined European operations provide 5.2 million tonnes of NPK production capacity (Table 1), more than 80 percent of the company's total global NPK capacity of 6.2 million tonnes. This is divided between six sites in four European countries: Siilinjärvi and Uusikaupunki in Finland, Glomfjord and Porsgrunn in Norway, Montoir in France and Ravenna in Italy.

Yara is a market-leading producer of NPKs, selling 5.9 million tonnes globally in 2018. That volume placed Yara well ahead of competing NPK producers such as Coromandel, Gresik, Iffco and PhosAgro. The NPK market is a lucrative one for Yara. The company's compound NPK products, marketed under the *YaraMila* brand name, sell at a price premium of around $86/t relative to commodity blends. This total does, however, also include premiums generated by the company's calcium nitrate, fertigation and micronutrient product ranges.

Premium products able to deliver high margins – including compound NPKs and micronutrient (*YaraVita*) products – feature strongly in Yara's fertilizer portfolio, being responsible for around two-fifths of global sales volumes in 2018. These value-added products generated a total premium in excess of one billion dollars – versus the commodity fertilizer alternatives – according to Yara calculations.

Increasing the capacity to produce and sell premium products is an integral part of Yara's future growth strategy. This has been partly delivered by expanding European NPK output. An NPK expansion at the Uusikaupunki site in Finland came on-stream in the third quarter of 2016. Further NPK capacity additions in Norway – by 70,000 tonnes at Porsgrunn and 50,000 tonnes at Glomfjord – were also completed during 2018.

EuroChem: a focus on quality

EuroChem Group operates three phosphate plants with the combined capacity to produce around 4.3 million tonnes of NPK products, phosphate fertilizers and feed phosphates. The Group owns three NPK/phosphate operations within or adjacent to the EU market,

Phosphorit is a leading Russian producer of phosphate fertilizers and feed phosphates. It is located close to the Baltic coast at Kingisepp, northwest Russia, adjacent to the new EuroChem Northwest ammonia plant.

Located in Belgium with port access, the large-scale EuroChem Antwerpen production complex consists of a number of production units for nitric acid, NPK, AN/CAN and nitrophosphoric acid.

EuroChem subsidiary Lifosa is one of the EU's leading phosphate fertilizer pro-

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ducers. Located in Kedainiai, Lithuania, the company, which dates from 1959, manufactures:

- Technical-grade sulphuric acid
- Diammonium phosphate (DAP)
- Phosphoric acid
- Water-soluble monoammonium phosphate (MAP) crystals
- The feed phosphate MCP (monocalcium phosphate).
- Aluminium fluoride (AlF_3).

EuroChem has channelled more than $210 million of investment into Lifosa over the last 10 years. Much of this capital expenditure has been targeted at establishing water-soluble phosphate production capabilities. A new, highly-efficient, $16 million water-soluble fertilizer unit_opened in October 2018. The new 25,000 t/a capacity plant produces water-soluble urea phosphate. Its completion followed the commissioning of a 30,000 t/a capacity water-soluble monoammonium phosphate (MAP) production unit at Lifosa in 2017.

Lifosa produced 805,000 tonnes of DAP and 165,000 tonnes of feed phosphates in 2017 and is recognised for its high-quality products. The company is well-placed for the export market, having access to the ice-free port of Klaipeda on Lithuania's Baltic coast, some 210 kilometres away from its Kedainiai operations.

EuroChem Group acquired Lifosa in 2002. The purchase helped secure Lifosa's long-term future and competitiveness by providing access to a supply of high-purity, low-cost igneous phosphate (apatite) rock from EuroChem's Kovdorskiy mine at Kovdor in Russia's Kola peninsular. In 2015, EuroChem announced plans to invest $104 million in expanding Kovdorskiy's production capacity by 948,000 t/a, raising total rock concentrate capacity to 3.4 million t/a by 2018.

Lifosa has been producing feed phosphates for nearly two decades. The company's original dicalcium phosphate (DCP) plant dates from 2001. This was followed by a monocalcium phosphate (MCP) unit in 2002 and a mono dicalcium phosphate (MDCP) unit in 2004.

Prayon: water soluble phosphates

Belgium's Prayon Group's is an acknowledged leader in wet-process phosphoric acid production globally. The company was founded in 1982, although its roots in Belgium's Liège region stretch back more than 100 years. Currently, some 50 percent of phosphoric acid production sites globally use Prayon technology while 70 percent use Prayon equipment.

The Group brings together over 20 companies located in more than 10 countries, employing 1,450 people and generating a turnover of €500 million. The company is jointly owned by OCP Group and Société Régionale d'Investissement de Wallonie (SRIW).

Prayon is also a world-leading producer of high-purity phosphate chemicals for the fertilizer, detergent, food additives and technical markets. The company's production arm manufactures purified phosphoric acid (PPA) using a proprietary solvent extraction process. This acid is available in different grades and concentrations for use in the production of a wide range of technical- and food-grade products.

Prayon's production sites in Engis and Puurs, Belgium, have the capacity to produce 250,000 tonnes of P_2O_5 per year. Emaphos, a joint venture between Prayon, OCP and Chemische Fabrik Budenheim (CFB) located at Jorf-Lasfar, Morocco, provides a further 150,000 tonnes of P_2O_5 capacity.

Prayon manufactures over 300,000 tonnes of phosphate salts each year from Engis and Puurs in Belgium, Les Roches de Condrieu in Lyon, France, and Augusta, Georgia in the US. Production output includes sodium, potassium, calcium, ammonium and aluminium phosphates. Many of these products are marketed under the *Europhos* brand name and targeted at food and technical/industrial markets.

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

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

ICL Fertilizers

ICL is one of the world's largest fertilizer producers. The Israeli-headquartered company provides farmers, growers and distributors on five continents with a wide protfolio of high-performance plant nutrition products, including: potash, *Polysulphate*, phosphate fertilizers, phosphoric acid, specialty fertilizers, phosphate rock and tailor-made compound fertilizers.

ICL operates two European NPK production plants located in Amsterdam in the Netherlands and Ludwigshafen in Germany. Combined, both sites provide the company with 850,000 t/a of NPK production capacity within the EU market.

ICL's Amsterdam site has a total nameplate capacity of 550,000 tonnes for NPK production, divided between 450,000 tonnes of granular and 100,000 tonnes of powder products. The Ludwigshafen plant, although smaller, still has an impressive nameplate capacity of 300,000 tonnes.

ICL is able to produce over 80 different grades of NPK fertilizers from its Amsterdam and Ludwigshafen facilities. ICL also has two mines in Europe: potash is mined at Súria in Spain, while the Boulby mine in the UK is the world's first and only polyhalite mine.

ICL markets polyhalite, a soluble fertilizer containing sulphur, potassium, magnesium and calcium, through its *Polysulphate®* portfolio of products. These includes *PKpluS®*, a range of polyhalite-containing, granular PK precision fertilizers. These balanced formulations contain phosphorus and potassium, without nitrogen (N), supplemented by a wide range of secondary nutrients, including sulphur, magnesium and calcium.

Grupa Azoty targets Poland and Germany

Grupa Azoty Police, a subsidiary of Grupa Azoty, is Poland's largest manufacturer of phosphoric acid, phosphates and NPK fertilizers, making it a significant European producer. The company is based in Police in the country's southern Lesser Poland province. Its main commercial products include:

- MAP, DAP and NPK fertilizers, incorporating secondary nutrients (sulphur, magnesium) and micronutrients
- A granulated NS fertilizer comprised of ammonium sulphate, urea and magnesite
- Urea
- Liquid ammonia
- White titanium dioxide-based dyes.

Grupa Azoty Police's fertilizer unit is the largest within the company, both in terms of production volumes and revenues. Its NPK and DAP products – *POLIFOSKA®* and *POLIDAP®* – are market-leading brands in Poland. Its fertilizer products are also sold in Europe, South America and Africa. The unit produced just over one million tonnes of compound fertilizers in 2018, accounting for just under 60 percent of company revenues. This was supplemented by 326,418 tonnes of phosphoric acid production.

Grupa Azoty Police expected to complete a $18.5 million (PLN 67 million) upgrade project at its phosphoric acid unit by June last year. This involves replacing the existing DA-HF production process with new technology licensed by Prayon. This change should enhance production efficiency and improve output quality.

Grupa Azoty Police purchases its phosphate rock under contract or on the spot market. These purchases are largely African-sourced and mainly from Arabic countries in the north of the continent. In February last year, the company entered into a two-year contract with Ameropa and Senegalese-based supplier Somiva to supply low-cadmium phosphate rock sourced from Senegal. This contract runs until February 2021.

In April 2018, Grupa Azoty signed a three-year phosphate rock supply agreement with Morocco's OCP in a deal thought to be worth around $103 million (PLN 350 million). This contract runs until December 2020. OCP previously agreed to supply Grupa Azoty with one million tonnes of phosphate rock in 2017 in a similar but shorter-term $35 million (PLN 135 million) deal.

Polish phosphate rock imports have been on the rise in recent years. Trade statistics show the country imported 1.2 million tonnes in 2017, some 56 percent of this supplied by Morocco. Poland imported 674,835 tonnes of Moroccan phosphate rock in 2017, up from 541,279 tonnes in 2016.

Fertiberia adapts to market needs

Fertiberia has eight million tonnes of production capacity for chemical intermediates and end-products. It operates 16 production centres located in four countries – ten in Spain, two in Algeria, three in Portugal and one in France. The company produced just over three million tonnes of products and raw materials in 2018, a rise of more than two percent on the previous year. These included

- 1,062,000 tonnes of nitrates
- 676,000 tonnes of nitric acid
- 531,000 tonnes of ammonia
- 342,000 tonnes of urea
- 282,000 tonnes of nitrogen solutions
- 125,000 tonnes of NPKs

The company manufactures NPK fertilizers at the Huelva plant in Spain. Huelva originally had the capacity to produce:

- 290,000 t/a of complex NPK fertilizers
- 290,000 t/a of diammonium Phosphate (DAP)
- 150,000 t/a of monoammonium Phosphate (MAP)

However, Fertiberia ceased manufacturing DAP and MAP at Huelva in 2013, citing high production costs, having previously ended phosphoric acid production at the site three years previously. The company now sources the phosphoric acid needed for NPK production from international markets. It reported a large annual rise in the cost of this raw material (above 20 percent) in 2018.

The production changes seen at Huelva in recent years were part of a restructuring plan by Fertiberia to make the site a central hub for NPK production.

However, 2018 was a difficult year for the Huelva plant, according to the company: "Production of compound fertilisers fell by 17 percent compared to the previous financial year, affected by operational problems and by a lower than forecast sales volume."

Fertiberia's NPK output has in fact declined by around one-third in the last three to four years, having previously been above the 188,000 tonne production level in 2014 and 2015.

In addition to producing NPKs at Huelva in Spain, Fertiberia's Portugese subsidiary ADP Fertilizantes has the capacity to produce 400,000 t/a of NPKs and 170,000 t/a of superphosphates at its Setúbal plant.

Fertiberia has been diversifying and expanding its product portfolio. The company launched a new line of NPK fertilizers in 2016 as part of the *Fertiberia Advance* product line. The company also introduced a new NPK product *SulfActive* in 2018, part of its *CLASSIC* range. This new low-chloride NPK formulation contains six basic nutrients and is "optimised to activate the absorption of nutrients by plants" according to Fertiberia.

Adapt to survive and thrive

The European phosphates industry has undergone further consolidation and market shifts over the last decade (*Fertilizer International* 443, p45; *Fertilizer International* 485, p43). The industry had been in steady retreat for several decades due to the combination of large-scale, low-cost global competition and the region's reliance on imported phosphate rock.

The trend for consolidation and closures in Europe has continued with Fertiberia notably ending DAP and MAP production at its Huelva plant five years ago.

The need to secure a competitively priced supply of phosphate rock also remains a challenge for non-integrated European producers. Grupa Azoty has, however, been able to address this by entering into long-term supply agreements with OCP and Ameropa.

Looking ahead, the introduction of stringent cadmium limits, as part of the new EU fertilizer regulation, has the potential to disrupt phosphate rock imports into Europe and increase costs, with lower cadmium Russian rock most likely to gain at the expense of higher cadmium rock from North and West Africa. The initial introduction of a higher cadmium limit (60 mg/kg P_2O_5) could be achieved without major disruptions to phosphate rock supply, according to the European Commission, although this is disputed by some suppliers.

Europe's major phosphate producers are increasingly focussed on higher-value segments such as compound NPKs, water-soluble fertilizers and feed phosphates. The shift to NPK production has been a particular popular and successful strategy for European phosphate producers, with EuroChem being the latest company considering a move away from DAP to NPK production.

The switchover from DAP/MAP to NPK production seen in Europe is part of much wider global trend, as margins for the former weaken and demand for the latter grows. Changing their product mix in this way has provided Europe with a strong position in the growing and higher-margin NPK market. Indeed, EU phosphate producers currently account for roughly half of global NPK exports, most of this coming from Belgium, Norway and Finland. ■

Author's note

The European NPK fertilizer operations of Rosier are not covered by this article. These include Rosier's two NPK plants at Moustier in Belgium and Sas Van Gent in the Netherlands. *Fertilizer International* hopes to profile these in a future edition of the magazine.

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Phosphoric acid plants for the 2020s

PHOTO: LONGXIN CONSTRUCTION

James Byrd of JESA Technologies (Worley, formerly Jacobs), Florida, looks at upcoming innovations in di-hydrate (DH) phosphoric acid plants for the 2020s.

> **"The legacy of previous engineers is an amazing wealth of information we can learn from."**

Above: Jacobs (Worley) were contractors/ licensor for the Wa'ad Al-Shamal megaproject in Saudi Arabia.

Technological innovation, by introducing improvements to processes or products, offers new efficient ways of achieving the same or more ambitious production goals. In mature industries, innovations generally serve to bring down the unit cost of products. In a situation where small incremental improvements can cumulatively deliver large returns, it is not surprising that innovations are perpetually under study.

The importance of the process

The product being manufactured in a DH phosphoric acid plant is usually merchant grade acid (MGA). This can be the ultimate end-product or, in a vertically-integrated complex, consumed on-site as an intermediate in the manufacture of phosphate fertilizers. Because MGA is generally produced as a fixed and defined product, it is often the process that becomes the main focus for innovation at phosphoric acid plants.

Innovations can come in many forms. Equipment improvements have certainly changed how phosphoric acid plants are configured. But other more subtle process improvements can also provide dividends. Optimisation is possible at almost any phos acid facility, for example, even when the process is left largely unchanged.

The trick is to build these optimisations into the design phase of a project. This avoids the inefficiencies – in terms of cost or implementation – that invariably occur with retrofits. That is not downplaying the value of retrofits. It is just a recognition that, in engineering, the money is best spent early on.

This article will focus on innovations in di-hydrate (DH) technology for phosphoric acid production, as this process comprises over 80 percent of the market worldwide. Other production technologies, of course, do have merit. Indeed, matching individual technologies with the different production circumstances found across the world allows each process to find a place where it is the best fit.

The article is split into two sections. In Part 1, we look at the current state of the art and previous industry innovations. We then take a look at future innovations and trends that will influence the design of phosphoric acid plants over the next decade in Part 2.

Learning lessons from the past

No look forward is complete without a look back. Interestingly, over the decades, well-respected pioneers in our industry have written articles about future innovations more than once. Previous predictions are valuable as – by revealing how market forces influenced the industry in the past – they can tell us about our own path to the future. After all, the imprint of forces that influenced what our industry looks like today will also partly shape what it will look like tomorrow.

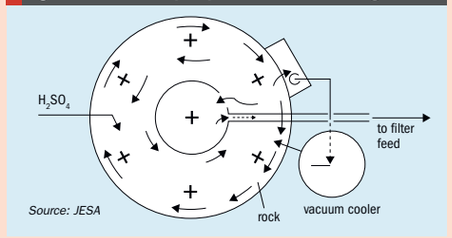
It is important to note that the general approach to improving phosphoric acid plants has been largely the same for many decades. Many significant improvements have been made in the past with undoubtedly more to come in future. In a world where the operating environment is constantly changing, the industry's technology providers must evolve as well. Inevitably, those that stand still will actually lose ground due to the progress of their competitors.

Many talented engineers have made important contributions throughout the history of this mature industry. We owe them a debt as the current state of the industry is built on the lessons of the past. Yet technology has progressed to a point where it is sometimes easy to overlook or forget those past lessons.

Often, supposedly new ideas that are raised and dicussed have actually been thoroughly explored some decades earlier. Sometimes, these ideas may have newfound merit due to changes in the economic climate. Furthermore, no single idea is universally applicable as operators in different parts of the world have different concerns. While many phosphoric acid producers globally have superficial similarities, a deeper dive often reveals that their economic drivers are different.

In certain production situations, even driving down the unit cost per tonne may not be the primary driver. Where revenues and demand are both high, for example, production output may be more valued than production efficiency.

Fig. 1: **1960s Dorrco phosphoric acid reactor design**



Source: JESA

Many decades ago, the need for output over efficiency was recognised as an economic imperative that could be exploited under certain conditions. The danger comes in losing such institutional knowledge when the tide turns and highly efficient operation once again becomes the main objective. The value in using experienced operators and engineers, therefore, cannot be overestimated. The engineering literature states that phosphoric acid plants typically provide a six percent annual net return on annual production. Yet production losses can easily be higher in real operating conditions – a possibility that should be allowed for in plant design by ensuring the right balance is struck between design simplicity and flexibility.

The general point here is that there is a lot of merit in understanding how design principles have come to be applied. This is because a continuation of these principles is often the basis for current innovation and plant optimisation. But it also needs to be understood and appreciated that the same design principles are not always applicable in every circumstance. Indeed, from an engineer's perspective, one of the things that makes this industry so interesting is that a bespoke approach is necessary – as there are few solutions that are universally applicable to every operation. ■

PART 1: Current state of the art

Ball mills

Very few DH phosphoric acid plants across the world can operate efficiently without first reducing the size of the ore they consume. Ball mills have been the traditional method for grinding phosphate rock concentrates for many decades, and are still the favoured method today. While dry grinding was preferred initially, wet grinding has become favoured for DH processes. This is due in large part to the power savings and operational reliability of wet grinding. The switchover from dry to wet grinding which began in the 1970s continues today. There are, however, industry circumstances where dry grinding is still warranted.

Ball mills require a substantial power load. A closed-circuit design improves their efficiency, in terms of both power usage and grinding consistency. It is important to recognise that the size distribution of the feed, and not just its chemistry, affects process parameters in the phosphoric acid reactor. Because phosphate concentrates make inherently unstable feeds, any improvements in grind consistency will therefore improve control of the phosphoric acid reactor.

Savvy operators will sluice phosphate rock in the ball mill with process water. Indeed, many plants have been retrofitted in this way from the 1990s onwards. The process water can come from gypsum stack decant water or from cooling pond water. Regardless of the source, sluice water usually contains P_2O_5 that can be recovered to the process. While there are side effects – acidity, gas evolution, and gas entrainment in the slurry – these can be designed around.

Reactors: feed control, design and heat load

Rock slurry blend systems are used to mitigate variations in feed to the phosphoric acid reactor. This is critical in situations where slurries from different sources are blended together. Due to the water balance, it is desirable to supply the phosphoric acid reactor with a high solids feed. Because of this, rheology modification is one area that may become a focus for innovation in the future.

The use of nuclear density meters to monitor the reactor feed has improved solids control. The accuracy of these meters is unrivalled, allowing the automation of solids feedback loops. Future goals could include online chemical analysis of the rock slurry. Knowing the calcium feed to the reactor, the operator can more precisely add sulphuric acid to optimise reactor control.

Furthermore, while many have attempted online analysis for excess sulphates in the reactor slurry, this is not commercially

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successful at present. Jacobs did develop a method using conductivity meters many years ago. These meters have been used with moderate success, albeit primarily as trend indicators. Other methods have tried using slip streams, with one operator reporting moderate success, but scaling remains an inherent problem.

For reactors, much of our current understanding of internal recirculation properties and the benefits of sulphate control were first established back in the 1970s. At the time, agitation and flow schemes were identified as areas for future improvement in reactor design, as is still the case today. Computational fluid dynamics (CFD) has become accepted as the agitation design tool in modern times. CFD can improve reactor efficiencies and optimise capex and opex.

In the industry's early days, the reactor heat load was controlled by air cooling. Then, in the late 1960s, flash coolers were introduced to control heat loads and increase reactor capacities. Low level flash coolers were subsequently designed and introduced in the early 1980s to improve cooler reliability.

Further improvements in the pumping capacity and direction of the recirculation pumps have been made since then. With increasing pumping capacities, the heat load removal for a given delta T has increased, particularly in the last ten years.

Plant capacity

Another trend was apparent between 1961 and 1978: phosphoric acid plant capacities were increasing (Figure 2).

One of the primary advantages of DH technology is economies of scale. To some degree, this is due to its relative simplicity and stability of operation. It was only natural that plant capacities would rise to keep pace with increasing equipment capacities.

Larger phosphoric acid plants are inherently more forgiving and flexible than smaller plants. The throughput to wetted surface area ratio increases with capacity. This reduces scale formation as there is less area available for scale nucleation per unit of production. With lower relative scale rates, plant run times can be extended between required turnarounds, allowing a higher relative specific reaction volume (SRV) to be realised over time. In turn, higher volumes improve reactor control resulting in higher overall yields and rates on an annualised basis.

Generally, the potential for improving annual production is greater at plants with higher nameplate capacities. Putting a precise figure on this higher annualised production, for project justification purposes, is problematic. Similar to investing in safety, the events that don't occur justify the return on investment.

The trend for larger reactors continued through the 1990s culminating with the design and installation of a 2,650 tonne/day nameplate capacity plant in Paradeep, India, in 2000 (Figure 2). The plant, currently operated by IFFCO, routinely produces 3,000 t/d of phosphoric acid.

The obvious advantage of larger plants is their economies of scale for capex (capital expediture). The positive impact of plant capacity on opex (operational expenditure) is less pronounced. This is because opex is largely driven by raw material consumption and, to a lesser degree, labour and utility costs.

Filter design and operation

One logistical issue encountered with larger reactors has to do with filtration. Managing the return acid and mixing tee(s) is critical. Moderate strength acid is returned from the filter and introduced into the mixing tee alongside high strength sulphuric acid. Relative quantities are adjusted to control the dilution of the acid entering the reactor. The heat of dilution is significant as it provides a major source of heat in the reactor. Dispersing heat homogeneously is paramount to reactor control.

The use of multiple filters per reactor has been another practice that has evolved as plant capacity has increased. The primary goal here is to keep the reactor running. Every time a reactor shuts down mechanical losses occur during start up, shut down and the time it takes for the reactor to return to equilibrium. In addition, oversizing filtration – i.e. providing more filtration area than strictly necessary – by a larger margin than for other plant equipment allows higher relative production rates during routine washing of a filter. As a measure, oversizing also provides a way of mitigating against system upsets. Taken as a whole, these filter working practices should provide additional product tonnes on an annualised basis and help simplify operations.

Filter design has also advanced. The central valve, for example, has become more efficient in preventing entrainment losses and increasing filtration rates. It can even accommodate a dual vacuum system to increase overall control. Duct sizing has been optimised and vacuum pumps are also more efficient. Filtrate pumps can now be self-regulating too. This eliminates the need for filtrate tanks – bringing down the structural costs of the filter building and its elevation.

Another process advance has been in mixing tee placement. CFD has shown that placement makes a difference in how sulphates are dispersed. In an annular reactor, results showed that the position of the tee, relative to an agitator, controls whether the majority of sulphates move forward or backward in the reactor (Figure 3). This discovery can be exploited to improve process conditions, depending on the phosphate rock source. Advances in mixing tee design have also improved operational stability. JESA Technologies (JT) offers a proprietary tee to maximize dissolution and reliability.

Fig. 2: **JESA Technologies: the trend for larger size reactors size over time**

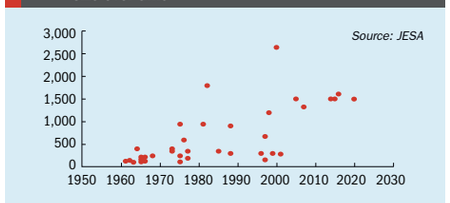
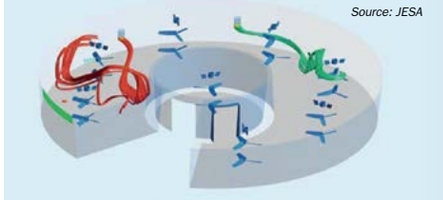


Fig. 3: **Mixing tee differential flow patterns**



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PART 2: Future innovations

Plant capacity and scale

Since 2000, no plant has been designed that approaches the nameplate capacity of the 2,650 t/d IFFCO plant in India. Nevertheless, with technological advances in filter capacities, flash cooler capacities and agitation, there is high confidence that even larger phosphoric acid plants can be designed and built. For example, a 3,000 t/d design with today's technology could comprise of three filters and two flash coolers. This is a mark of progress as twenty years ago such a design would require five filters and three flash coolers.

Even a nameplate capacity of 3,000 t/d capacity should not be considered the upper limit for the size of phosphoric acid plants. Multiple filters, in excess of two, have been proven to operate successfully. It has also been proven that multiple flash coolers, again more than two, can be installed and operated in a single reactor.

In fact, a design exists in the JT archives for a 5,000 t/d plant. Although this was never built, the technical challenges in designing and building a larger scale plant have been overcome. It is likely there will be a time in the future where a 1,500 t/d plant will no longer be considered world-class. Economics dictate that this point will be reached, although precisely when this will occur is open to question. Given that the primary advantage of the DH process is economics and mass production, large-scale plants are an easy prediction, as they allow these advantages to be further exploited.

Gypsum reuse

Gypsum, the by-product of the DH process, has received more attention, particularly as plant sizes have increased. Storage and/or reuse of gypsum has always been an issue because of the large volumes generated during phosphoric acid production. Environmental constraints are also becoming more and more prevalent throughout the world.

Other phosphoric acid technologies produce a slightly purer gypsum than the DH process, and is therefore one of the primary selling points for those technologies. Nevertheless, DH gypsum is being used in certain parts of the world, albeit on a limited basis. Developments enabling the ubiquitous reuse of gypsum look likely in the future. In fact, the inevitable shift to the gypsum reuse was predicted in a 1991 article by Dave Leyshon (see references).

Water balance

The phosphoric acid plant design is driven by the water balance. Any coherent design needs to take all local water constraints into account. Because water is a primary driver, and water concerns differ as much as the rock itself does, phosphoric acid plant designs also differ significantly between various locales.

Off the shelf plant design

Project teams typically want to copy plant designs, taking them off the shelf and then applying them to the next location to save time on the project schedule. While it is true that there is a time saving in quickly getting to the first drop of acid produced, this can be costly subsequently if start-up problems and delays occur in reaching full production potential – in essence there is a failure to realise project economics.

The economics of a plant that achieves its full potential late, versus early, is not something anyone wants to present to management. But it is a real issue nevertheless. It is quite impossible, except in retrospect, to quantify the production tonnes lost, the reductions in yields or the lower efficiencies that result from building and operating a plant with a copied, off the shelf design. Savvy operators will, however, take this point into account in future, so ensuring project economics will reach their full potential. In the overall scheme of things, developing a bespoke design early in the project does not require much additional time or cost.

Global losses

It is also useful to incorporate the concept of global losses into the coherent plant design. These can be significant even if many operators do not even track these. One operator, after seeking help, reported global P_2O_5 losses of 15-20 percent of everything fed to the plant. This compares to 1-5 percent mechanical losses for a well-run plant cited in the literature. (Mechanical losses are equivalent to the global losses less filter losses). Management in a well-run plant will be aware of these losses and will be proactive in minimising them. It is not unusual for losses to exceed 5 percent, and even 10 percent, if mechanical losses are not a focus of operations.

Global losses therefore look set to remain a critical issue, looking ahead, as each operator takes steps to reduce the cost per tonne of product. Certainly, reducing global losses will be a focus of plant design in the future and, being a potential low hanging fruit, will also be the target of efficiency improvements in existing plants.

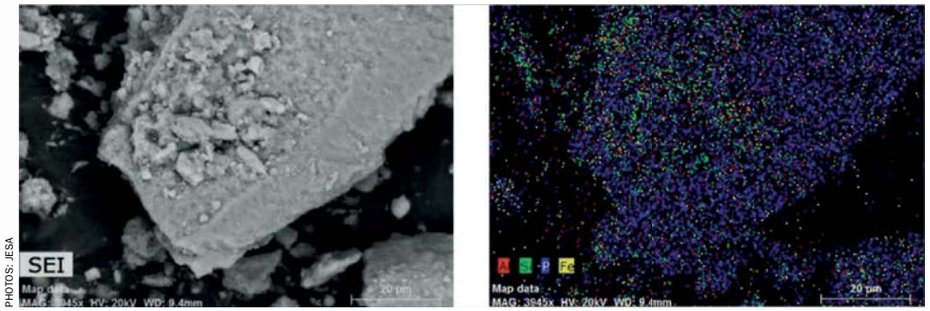
Acid concentration

Improvements in concentrating acid are closely linked to equipment advances. For example, recirculation pumps have become more reliable with higher capacities, while instrumentation and interlocks have also made operation much more reliable and efficient. Concentrator vessel construction has trended larger over the years too, albeit with the same design.

Entrainment separation has played an essential role in concentrator efficiency improvements as well, with several high efficiency designs currently commercially available. With proper design, the separator return can be merged with the product stream, improving throughput by about one percent.

Unit capacities have risen over time, although the heat exchanger bundle is a current limitation. Graphite is commonly used in the industry, but metal heat exchangers are becoming more economic. In monolithic heat exchanger designs, there is a limit on the graphite tube length. Metal heat exchangers, in contrast, could possibly break this barrier and be the basis for even larger unit capacities. Metal exchangers are well known by the phosphate industry in some parts of the world, while in others there is concern about corrosion being a life limiting factor.

Fluorosilicic acid (FSA) can be recovered from the process. Several design options are commercially available depending on the reasons for capturing fluorine and its end-use. Environmental designs that recover low-quality FSA, for example, have a much lower capex than designs that deliver product quality FSA.



PHOTOS: JESA

SEM and corresponding elemental analysis of apatite ore.

JESA Technologies (JT)

JESA recently rebranded its technology arm as JESA Technologies (JT). The renamed company is pursuing a number of specific innovations in response to current industry concerns.

JT has developed a modified flash cooler design. This new integrated flash cooler design is specific to the JESA reactor. The redesign is intended to save capex and minimise the plant footprint. Minor energy savings and improvements in process stability may also be realised. In this concept, the flash cooler sits on top of the reactor's central compartment. Accommodations are also provided for cleaning. The design eliminates the need for an agitator in the central compartment. It does not alter the annulus geometry yet increases the open area of the annulus. A better recirculation ratio is anticipated as CFD has shown that the internal recirculation gains momentum in the open area.

Fluorine sequestration remains problematic for virtually every operator worldwide. JT has developed a new relatively low capex technique for neutralising fluorine. It is also an economically and environmentally attractive solution. Details of this process cannot be disclosed at present as the patent has not been filed as yet. Nevertheless, JT hopes to make the process commercially-available in the near future.

JT offers a patented iron removal technique. This can make some deposits commercially viable by removing iron and improving global losses. The associated equipment, because a slip stream is used, is small relative to the rest of the plant.

Operators are driving down their cost per ton of product produced, with process efficiencies being integral to this trend. JT offers a high yield mode for DH operations termed *DH+*. The goal is to provide an incremental improvement in filter losses. *DH+* is expected to deliver increases in yields in the range of 1-2.5 percent. However, test work is required in all cases, with results being directly dependent on the source of phosphate ore.

JT is pursuing innovations in a number of other areas, including

- Upgrading coarse rejects for producing concentrate
- Flotation recovery for low-grade phosphate
- Refining flotation techniques
- Iodine recovery from phosphoric acid
- Cadmium removal
- Recovering rare earth minerals
- Chromium removal from phosphoric acid
- Sulphur recovery from gypsum.

Many more additional areas of investigation have also been identified. JT's research and development activities are therefore expected to produce more results in the future.

Conclusion

The future is predicated on the past *and* present. Some great engineers and scientists have contributed a lot to this industry in many areas over time. Not recognising their achievements, which form the foundations for our own achievements, would be remiss. Foretelling the future is almost impossible – as can be seen when looking at the present from the past. Nevertheless, the legacy of previous generations of engineers is an amazing wealth of knowledge which we can draw on and learn from.

As we already know what the constraints will be, some forthcoming innovations for the 2020s seem like common sense – including efficiency improvements, cost reductions and advances in technology. These are all changes that have been predicted in the past. But how we execute such changes is likely to be what is different moving forward.

Larger scale phosphoric acid plants certainly seem likely over the next decade or so. In the future, the focus will also be on coherent plant designs. These will need to encompass the maximisation of global recovery, equipment refinements and consumption improvements.

A significant opportunity also exists for the comprehensive reuse of DH gypsum. It will be interesting to see what technology is either revived or developed to turn gypsum waste into a resource.

Only one thing is for sure, the future is coming, and – as a technology and engineering company – if we are not moving forward, we will be watching others overtake. ■

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EcoPhos *ChemBe* plant for Evergrow in Egypt


PHOTO: ECOPHOS

The innovative *ChemBe* process from EcoPhos merges beneficiation with chemical processing to generate high-quality phosphoric acid and dicalcium phosphate products. **Mohamed Takhim**, the CEO and founder of EcoPhos, describes how the *ChemBe* process is being implemented at the Evergrow project in Egypt.

Conventional phosphate production

The production of phosphates is traditionally based on two distinct and separate processes: beneficiation and chemical processing.

Beneficiation aims to remove deleterious components from the phosphate rock raw material – sand, organic matter, magnesium salts etc. – to ensure it is suitable for chemical processing This is generally achieved by grinding, washing, de-sliming, sizing and froth flotation. Calcination is also used occasionally.

This complex beneficiation process consumes large amounts of energy and water and generates substantial volumes of waste and contaminated effluent. The efficiency of beneficiation is also low, typically because of large phosphate losses in waste materials such as pebbles, clay, oversize and tailings. Beneficiation is also becoming increasingly challenging due to the depletion of phosphate resources and the decline in the quality of phosphate rock ore.

After beneficiation, upgraded rock concentrates are transported to the chemical plant where they are reacted with sulphuric acid to produce dilute phosphoric acid. This is then concentrated and purified to obtain merchant grade acid (MGA). The quality of MGA obtained is directly linked to the composition of the phosphate rock used and can still contain heavy metals and other harmful impurities.

This wet phosphoric acid process also generates large quantities of gypsum. This phosphogypsum waste – which may be contaminated with heavy metals and radioactive elements – needs to be stored in stockpiles (stacks) or discharged to the sea. Phosphogypsum, whatever the disposal route, creates a costly environmental problem that needs to be managed.

The EcoPhos *ChemBe* process

The Belgian company EcoPhos was founded by Mohamed Takhim in 1996 with the specific aim of developing solutions to the economic and environmental challenges faced by the phosphate industry. The *ChemBe* process is one of the solutions successfully developed by EcoPhos. This innovative technology merges beneficiation with chemistry to create an optimised chemical beneficiation process.

In a *ChemBe* plant, the raw phosphate ore is gently digested in dilute hydrochloric acid solution. This 'soft' process selectively dissolves the soluble phosphate from the unwanted insoluble part of the ore. This insoluble fraction, which remains as a solid residue under the mildly acidic conditions, is washed and then disposed of or recycled.

The next step in the process is to precipitate the soluble phosphate obtained from acid digestion. This is achieved by adding calcium carbonate (or another source of calcium) to the soluble phosphate solution. This precipitates dicalcium phosphate (DCP) crystals and leaves a calcium chloride solution. The crystallised DCP created is then separated from the calcium chloride mother solution by filtration.

The leftover calcium chloride solution is fully recycled in the process by reacting with sulphuric acid. This results in the formation of hydrochloric acid and a gypsum by product. The gypsum obtained is highly pure as impurities from the phosphate rock were removed in the preceding digestion stage.

The DCP product generated by the *ChemBe* process is an ideal starting material for a wide range of other phosphate products, including:

- Single superphosphate (SSP)
- Triple superphosphate (TSP)
- NPKs
- All grades of phosphoric acid
- Feed-grade DCP and monocalcium phosphate (MCP) etc.

Indeed, the DCP obtained from the ChemBe production route contains much higher phosphate levels than beneficiated ore – typically 40-48 percent P_2O_5 vs 30-39 percent for high-grade rock concentrates. The DCP end-product is also free of carbonate (CO_2) and sand, contains less calcium, and has a low heavy metal content. The yield of the *ChemBe* process (typically 80-95 percent) is also much higher than standard beneficiation technologies (which typically range from 25 percent to 80 percent maximum depending on rock quality).

These significant yield and quality advantages means the *ChemBe* process can make new projects much more economically feasible. Because the process can happily consume much lower quality ore, it can also increase the operational life of a phosphate rock mine by a factor of up to four! Finally, because water is recycled, water consumption in the *ChemBe* process is much lower in comparison to traditional beneficiation.

In summary, the EcoPhos *ChemBe* process, by combining together chemistry with beneficiation, offers a practical, economic solution that overcomes a number of issues encountered when using conventional phosphate production technologies. It key advantages include:

- The efficient and highly flexible processing of phosphate ore
- Rock reserves are increased
- More mining projects are made economically feasible
- Process effluents are drastically reduced
- Higher quality products and co-products are obtained
- Less energy and water are consumed.

Table 1: **Evergrow project: composition of the phosphate rock raw material**

P_2O_5 22.9 wt %	Fe_2O_3 1.6 wt %
CaO 42.0 wt %	Al_2O_3 0.5 wt %
SO_3 3.0 wt %	SiO_2 16.0 wt %
F 2.5 wt %	Cd 9.2 ppm
MgO 0.8 wt %	As 12ppm
	Pb 7 ppm

Source: EcoPhos

The Evergrow project, Egypt

Evergrow is a pioneering Egyptian company that produces speciality fertilizers to meet increasing demand from local and regional agriculture. Evergrow is positioning itself as the future leader in the fertilizer market in Egypt and the Middle East by optimising the value of locally-available resources.

As the company has grown, Evergrow has maintained a high level of operational excellence in fertilizer manufacturing – by investing in innovation and regularly upgrading its plants. This approach to business enables Evergrow to supply its customers with effective, reliable and safe products that meets international quality standards.

Evergrow was founded in 2006 with the opening of a production site in the Abo Rawash industrial zone of Egypt's 6th October City. This is located in Giza Governorate around 32 kilometres from the capital Cairo. Evergow was the first Egyptian company to specialise in the production of water-soluble fertilizers such as potassium sulphate (SOP), monoammonium phosphate (MAP), granular and liquid urea phosphate (UP), solid and liquid NPKs and calcium ammonium nitrate (CAN).

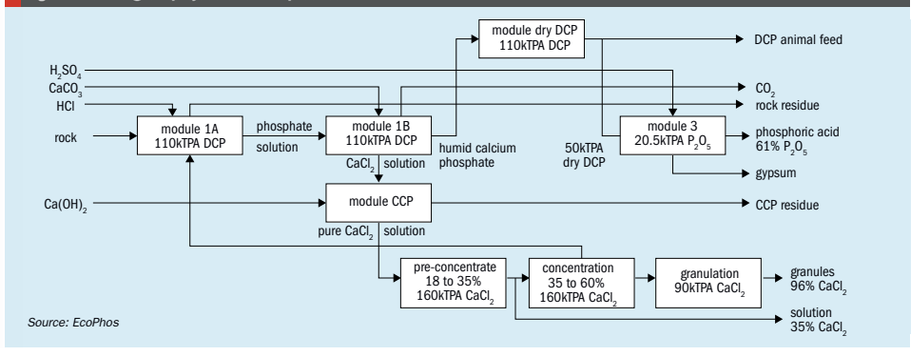
In 2011, to meet increasing demand for its products, Evergrow established two new large-scale production complexes for phosphoric, nitric and sulphuric acid on an 180,000 m² site in the Sadat industrial zone. The site, ideally located in Sadat City, Monufia Governorate, between Alexandria and Cairo, is close to the Egyptian water-soluble fertilizer market.

The new acid production facilities will enable Evergrow to increase SOP capacity and produce $CaCl_2$ for non-agricultural uses. Due to these manufacturing investments, Evergrow's annual production capacity rose from 885,000 tonnes in 2016 to more than one million tonnes in 2017.

EcoPhos implemented a project for Evergrow at the Sadat industrial zone to consume waste hydrochloric acid (HCl) from the new complex. As well as being the best solution for HCl waste, the *ChemBe* process was selected by Evergrow because it was capable of generating high profits from phosphates and phosphoric acid production.

The industrial process developed by Ecophos for Evergrow (Figure 1) converts phosphate rock into dicalcium phosphate (DCP) and calcium chloride ($CaCl_2$). Hydrochloride acid (HCl) and calcium carbonate ($CaCO_3$) are the other main raw materials.

Fig. 1: **The Evergrow project *ChemBe* process**



Source: EcoPhos

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Fig. 2: **Schematic of the Evergrow *ChemBe* plant**

Fig. 3: **The Technophos demonstration plant in Bulgaria**

The DCP from the process is firstly dried. A portion of the dry DCP obtained is sold as final product, while the remainder is converted to purified phosphoric acid (H_3PO_4) and gypsum ($CaSO_4.2H_2O$) using sulphuric acid (H_2SO_4). The $CaCl_2$ solution generated is concentrated to 35 percent. This is partly solidified to obtain a 96 percent pure calcium chloride by-product.

Construction of the €80 million Evergrow project began in 2015 with start-up currently scheduled for June 2020. The large-scale project has involved:

- 12,000 man-hours of process development and tests
- 72,000 man-hours of engineering
- 12,000 man-hours of project management and procurement.

More than 80 Ecophos staff have worked on the Evergrow project since its inception. They have been involved in all aspect of the project, including laboratory work, detailed engineering, process validation, semi-industrial plant tests, project management and procurement.

Project raw materials

Analysis of the Egyptian phosphate rock raw material revealed a low P_2O_5 content and high aluminium, iron and silica contents (Table 1). This composition – although unusable with conventional phosphate production processes – is ideal for Ecophos technology, which is perfectly capable of consuming low-grade phosphate rock.

The *ChemBe* process also consumes HCl, an unwanted by-product of Evergrow's SOP plant. Calcium carbonate used in the process is sourced locally and ground to increase reactivity. The sulphuric acid (96-98%) consumed by the process is also supplied locally.

Semi-industrial scale demonstration tests

The *ChemBe* process for the Evergrow project was validated by EcoPhos at Technophos, the company's semi-industrial demonstration plant in Bulgaria (Figure 3). For validation purposes, this plant was operated continuously for 24 hours over a 10-day period.

The process stability of the following three *ChemBe* modules was validated during the 10-day test run at the Technophos demonstration plant:

Module 1A: digestion of phosphate rock – first refining step

Module 1B: crystallization of DCP – the second refining step

Module 3: Phosphoric acid production using the EcoPhos *TacHem* process.

The phosphoric acid obtained from Module 3 is suitable for production of water-soluble fertilizers. However, an additional purification process developed by EcoPhos – known as *PUMA* (purification using membranes of acids) – is necessary to obtain technical- or food-grade phosphoric acid.

Products and co-products

The *ChemBe* process generates DCP, phosphoric acid and pure gypsum as products and co-products.

The *ChemBe* process, as well as delivering a high phosphate yield from low-grade Egyptian rock, generates DCP with a high P_2O_5 content (around 41 percent), low calcium content (around 26 percent) and low levels of impurities (Table 2). Analysis of the phosphoric acid obtained from the semi-industrial tests confirmed a high-quality product with low impurity levels (Table 3). Finally, the gypsum by-product generated by the *ChemBe* process was also found to be extremely pure (99.8 percent, Table 4).

Table 2: ***ChemBe* process: composition of the DCP product**

P_2O_5	41 wt %
CaO	26.4 wt %
F	0.08 wt %
MgO	210 ppm
Fe_2O_3	472 ppm
Al_2O_3	67 ppm
Cd	<0.5 ppm
As	1.2 ppm
Pb	< 1.0ppm

Source: EcoPhos

Table 3: ***ChemBe* process: composition of the phosphoric acid product**

P_2O_5	62 wt %
CaO	0.02 wt %
SO_3	0.8 wt %
F	<0.02 wt %
MgO	300 ppm
Fe_2O_3	698 ppm
Al_2O_3	102 ppm
Cd	<0.5 ppm
As	<2 ppm
Pb	< 1.0 ppm

Source: EcoPhos

Table 4: ***ChemBe* process: composition of the gypsum product**

$CaSO_4.2H_2O$	>99 wt %
P_2O_5	0.36 wt %
Cl	300 ppm
F	Below detection limits
MgO	13 ppm
Fe_2O_3	<100 ppm
Al_2O_3	<50ppm
Cd	<10 ppm
As	<10 ppm
Pb	<5ppm

Source: EcoPhos

Conclusion

The innovative phosphates technology developed by EcoPhos leads to lower production costs due to its ability to consume low-grade phosphate rock as a raw-materials.

The company's *ChemBe* process consumes phosphate rock, as-mined without any additional beneficiation, and successfully converts this to high-quality DCP. This intermediate product is a stepping stone for the production of phosphoric acid and several other phosphate products such as monosodium phosphate (MSP), TSP and NPKs.

EcoPhos is currently building a modern phosphate production plant in Egypt as a project for Evergrow. This plant will use low-grade Egyptian phosphate rock and hydrochloric acid waste generated by Evergrow's SOP production plant. The Innovative *ChemBe* process developed by EcoPhos will use these raw materials to produce DCP, phosphoric acid and calcium chloride. The low cost of the rock and HCl raw materials, as well as the valorisation of co-products, will keep plant production costs very low and profit margins high. Last but not least, the *ChemBe* process guarantees that the Evergrow plant will operate to high ecological and environmental standards – as it avoids the generation of large quantities of phosphogypsum, and also keeps both energy and water consumption to a minimum.

The *ChemBe* process used in the Evergrow project has been validated by EcoPhos at semi-industrial scale. Demonstration tests carried out at the company's Technophos site in Bulgaria confirmed the stability of the process and its ability to deliver high-quality products.

The Evergrow project is close to completion with start-up of the *ChemBe* plant currently scheduled for June 2020. ■

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PHOTO: MSR PHOSPHATE

Phosphates project listing 2020

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

Phosphate rock projects*

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

KEY FOR BOTH TABLES

FS Feasibility study complete
n.a. not available
PL Planned
UC Under construction
C Project completed
DAP Diammonium phosphate
DCP Dicalcium phosphate
MAP Monoammonium phosphate
PPA Purified phosphoric acid
SSP Single superphosphate
TSP Triple superphosphate

**Excluding China. Standalone, non-integrated projects only. At present, there are tens of junior phosphate mining projects globally. However, only capacity developments with a published feasibility study are listed here. Additionally, expansions by established producers in Russia (PhosAgro at Kola, EuroChem at Kovdor, Acron at Oleniy Ruchey), and new projects in Kazakhstan (EuroChem), should add more than two million tonnes to regional phosphate rock capacity by 2023. Africa is undoubtedly the region with the most potential for phosphate rock expansion – although large uncertainties over individual projects and their timescales remain. OCP Group is, however, pressing on with ambitious plans to increase phosphate rock capacity at Khouribga and Meskala in Morocco. Avenira was looking to sell its Baobab project in Senegal to a consortium of buyers, as of September 2019. Kropz's Elandsfontein project should restart this year, if and when its water permitting issues are resolved. The company recently signed a technical cooperation agreement with PhosAgro.*

Phosphate fertilizer, 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	2022/3
Bled Al-Hedba	Asmidal/Manal Group/Indorama	Oued El Kebrit, Hadjar Soud	Phosphoric acid (P_2O_5)	1,600	PL	2022/3
Bled Al-Hedba	Asmidal/Manal Group/Indorama	Oued El Kebrit, Hadjar Soud	DAP/MAP (3 x 1.3 Mt)	3,900	PL	2022/3
BRAZIL						
Serra do Salitre	Yara	Patrocinio, Minas Gerais	Phosphate rock	1,200	C	2018
Serra do Salitre	Yara	Patrocinio, Minas Gerais	Phosphoric acid (P_2O_5)	250	C	2019
Serra do Salitre	Yara	Patrocinio, Minas Gerais	SSP	650	C	2019
Serra do Salitre	Yara	Patrocinio, Minas Gerais	DAP/MAP	350	C	2019
EGYPT						
Ain Sokhna	NCIC	Suez Ain Sokhna	Phosphoric acid (P_2O_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_2O_5)	500	UC	2021
El Wadi	WAPHCO	Abu Tartur	DAP/MAP	800	UC	2021
El Wadi	WAPHCO	Abu Tartur	TSP	600	UC	2021
ChemBe	Evergrow/EcoPhos	Sadat City	DCP	n.a.	UC	2020
ETHIOPIA						
Dire Dawa	OCP/Ethiopia	Dire Dawa	Finished phosphates	1,500	PL	2023/4
INDIA						
Visakhapatnam	Coromandel International	Visakhapatnam	Phosphoric acid (P_2O_5)	100	UC	2019-21
Sikka expansion	GSFC	Sikka	Phosphoric acid (P_2O_5)	230	UC	2019-21
Sikka expansion	GSFC	Sikka	DAP/NPK (Train 4)	500	UC	2019-21
Orissa expansion	Paradeep Phosphates	Paradeep	Phosphoric acid (P_2O_5)	180	PL	2022/3
Orissa expansion	Paradeep Phosphates	Paradeep	DAP/NPK	400	PL	2022/3
KAZAKHSTAN						
Karatau	EuroChem	Zhambyl	Finished phosphates	1,000	PL	2021
Taraz	Kazphosphate	Taraz	PPA (P_2O_5)	240	PL	2019-21
Taraz	Kazphosphate	Taraz	MAP	460	PL	2019-21
MOROCCO						
Various	OCP Group	Various	Phosphoric acid (P_2O_5)	1,500	UC	2019-21
Various	OCP Group	Various	Finished phosphates	4,350	UC	2019-21
NIGERIA						
Ammonia/ fertilizer complex	OCP/Nigeria	Southeast Nigeria	Fertlilizers	1,000	PL	2023
RUSSIA						
Cherepovets expansion	PhosAgro	Cherepovets	Phosphoric acid (P_2O_5)	170	UC	2019-21
Cherepovets expansion	PhosAgro	Cherepovets	Finished phosphates/NPK	1,130	UC	2019-21
SAUDI ARABIA						
Wa'ad Al Shamal/Umm Wu'al	MWSPC	Wa'ad Al Shamal	Phos acid (P_2O_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	Phosphoric acid (P_2O_5)	1,500	PL	post-2022
Second mega project	MWSPC	Ras al Khair	Finished phosphates	3,260	PL	post-2022
TOGO						
n.a.	Dangote Group	n.a.	Finished phosphates	1,000	PL	n.a.
TUNISIA						
M'dilla II	GCT	M'dilla	Phosphoric acid (P_2O_5)	180	UC	2019/20
M'dilla II	GCT	M'dilla	TSP	500	UC	2019/20
UNITED STATES						
White Springs	Nutrien	Florida	MAP	400	UC	2019

***Excluding China. The International Fertilizer Association (IFA) expects various production investments by OCP Group to collectively add an additional 4,350 t/a to Morocco's finished phosphates capacity out to 2023. Elsewhere in Africa, OCP has also firmed-up joint venture projects in both Nigeria and Ethiopia. The second phosphates mega project announced by Ma'aden and its MWSPC partners should eventually ramp-up product capacity in Saudi Arabia by a further 3,260 t/a. PhosAgro is also expanding phosphate fertilizer and NPK production capacity at its Cherepovets complex by more than one million tonnes, and at the same time enlarging the range of fertilizer grades it produces.*

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Phosphate technology profiles

Prayon Technologies (PRT)

Prayon Technology (PRT) is the technology arm and subsidiary of parent company Prayon s.a. With experience dating back more than 60 years, PRT considers itself the undisputed global leader in phosphoric acid production technology.

Uniquely, Prayon is both a leading commercial manufacturer of phosphoric acid and its derivatives – purified acid, technical- and food-grade phosphates – and a licensor of phosphoric acid production technology. This provides the Belgium-headquartered company with considerable advantages when it comes to understanding the needs of its technology customers.

A major proportion of phosphoric acid production worldwide relies on Prayon's process technology. In fact, Prayon Technologies has designed, developed and helped construct more than 135 phosphoric acid plants in more than 30 different countries globally. These plants consume more than 40 different types of phosphate rock and have P_2O_5 production capacities ranging from 25 tonnes up to 2,000 tonnes per day.

Prayon offers flexible production technologies able to respond optimally to the requirements of phosphoric acid producers, offering:

- Reduced energy consumption
- increased yield
- Lower production costs
- Excellent environmental performance.

Prayon Technologies essentially offers two types of service: technology licensing and consultancy. Its licensing activities cover:

- Phosphoric acid production – including a full range of processes (DH, HH, DA-HF, CPP, PH2) producing hemihydrate or dihydrate calcium sulphate with one or two filtration step(s)
- Phosphoric acid concentration
- Fluorine recovery
- Gas scrubbing systems – for F, dust and H_2S reduction
- Phosphoric acid purification – SO_3, Cd, As, F, Al_2O_3, Fe_2O_3 and MgO reduction technologies
- Phosphogypsum purification
- Uranium recovery from phosphoric acid
- DCP production from low-grade rock and dilute sulphuric acid – the *GetmoreP* process.

Prayon's consultancy activities cover:

- Audits of existing plants with specific objectives
- Phosphate rock evaluations
- Plant operator training. ■

GEA Group

GEA is emerging as a leading technology and equipment provider to the phosphates industry. The Dusseldorf-headquartered group is one of the world's largest production technology and equipment suppliers and employs about 18,500 people across the globe. GEA generates around 70 percent of its revenues from the food and beverages sector – and is the technology leader in this market.

With more than 100 years of experience in crystallisation alone, the company offers a range of production plant technologies able to meet the diverse requirements of the phosphate and fertilizer industries. They include:

- Evaporators
- Crystallisers
- Membrane filtration units
- Centrifugal decanter and separators
- Spray and fluid bed dryers for drying crystals or granulation.

GEA specialises in the production of water-soluble monoammonium phosphate (MAP) from phosphoric acid. The innovative production technology offered by the company is capable of manufacturing high-quality water-soluble MAP from lower-quality merchant grade acid (MGA). This ground-breaking process reduces opex and/or capex costs as it avoids the need to purchase more expensive purified phosphoric acid (PPA), or integrate a purification line within the fertilizer production plant.

GEA's process firstly produces a clarified liquid stream after an initial reaction and filtration step. Dry, pure and highly water-soluble MAP crystals are eventually generated as an end-product, after a series of further crystallisation and purification steps. Waste from the various purification and filtration steps, in the form of sludges or purges, still contains some valuable P_2O_5. This can be captured by further processing – for example, via the fertilizer plant's blending or granulation units.

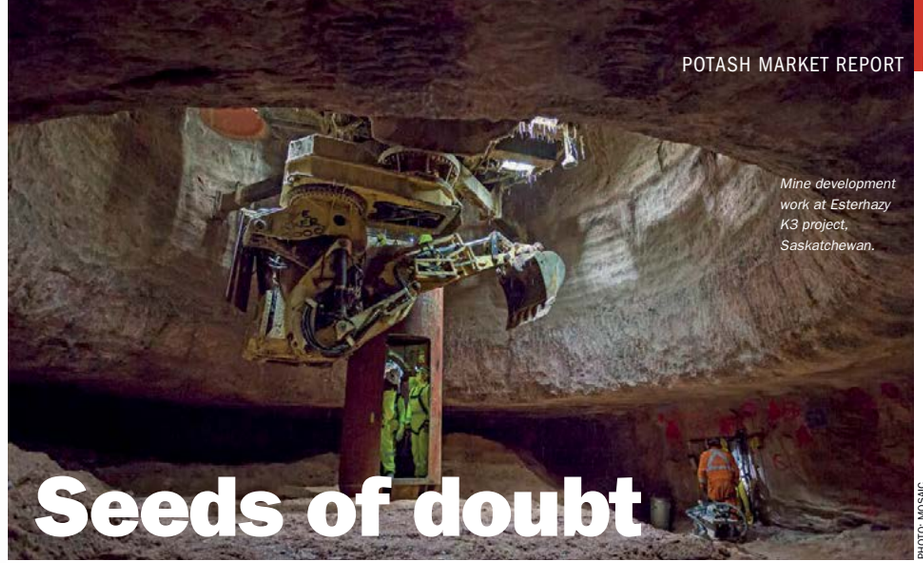
GEA's manufacturing process can typically deliver a yield (i.e. the amount P_2O_5 recovered to the crystalline end-product vs the P_2O_5 contained in the feed acid) of between 50-70 percent. The exact yield depends on the impurity levels in the MGA and the purity/quality requirements (non-soluble content) of the final MAP product.

GEA's production technology for water-soluble MAP has already been successfully implemented by an Eastern European customer. The new plant avoided considerable capital and operational expenditure by allowing non-purified MGA to be used as the phosphoric acid feed, while still delivering a pure MAP fertilizer with a high market value as the end-product. As a fertilizer, the crystalline MAP end-product offers the following key benefits:

PHOTO: GEA

Operational GEA crystalliser at a fertilizer production plant.

- High-quality water-soluble MAP (typically 12-61-0) with a low insoluble content
- Avoids clogging problems on spray systems and pumps
- Suitable for fertigation, foliar applications and the production of fertilizer blends and nutrient solutions
- Low turbidity after dissolution in water
- High-throughput processing
- Free of chlorine, sodium and other deleterious elements
- Moderate solution pH – safer and less corrosive
- Access to excellent laboratory back-up, support and expertise. ■



Mine development work at Esterhazy K3 project, Saskatchewan.

PHOTO: MOSAIC

Seeds of doubt

Andy Hemphill, senior editor for potash at ICIS Fertilizers, takes a deep dive into the potash market. Potash producers are praying that tight capacity control and resurgent demand will curb the current bearish price trend.

After a rocky second-half in 2019, the global potash industry has limped into 2020 hoping that tighter production control – and the potential for resurgent demand – could spur trade and even, perhaps, a price recovery.

Last year ended with the major global producers publicly announcing cuts to muriate of potash (MOP) output – their tried and trusted response to what is traditionally a slower period of demand.

But did they act fast enough to curb production in 2019? Probably not, given the already high inventory levels in Brazil, a key importing nation – a situation compounded by the waiting game being played by Chinese buyers over their next long-term import contract.

Production cutbacks

Last September, Canadian major Nutrien unveiled plans for inventory shutdowns of up to two months at its Allan, Lanigan and Vanscoy potash mines in Saskatchewan. A two-week shutdown at Nutrien's flagship Rocanville mine in the province was also announced subsequently, despite a Canadian Rail strike that caused chaos in mid-November.

On the other side of the Atlantic, German potash producer K+S responded similarly to weak demand by cutting back its 2019 production by up to 300,000 tonnes. This curtailment in MOP output is expected to reduce company earnings (EBITDA) by up to €80 million, according to K+S.

Russian potash producer Uralkali also announced plans to cut production in September. The company planned to reduce its MOP output by 350,000-500,000 tonnes for the remainder of 2019 by temporarily shutting down its production complex for maintenance. Although BPC was more reserved about precise tonnages, the Belarusian producer also confirmed its production would be cut by "around one-third" during 2019's last quarter.

Despite arguably acting too late, the main potash players nonetheless appear confident that, collectively, their combined production cutbacks will support the potash market by tightening availability.

Neither are they ruling out a possible rise in potash prices, provided production discipline continues.

"A lot will depend on the levels of production and demand. I'm not… dropping the scenario of a price increase. If the industry will be wise enough to avoid overproduction, prices can go up dramatically fast," a chief salesperson of one major producer told ICIS.

Of course, a lot of this confidence hinges on the potential for increased fertilizer demand in the first-half of 2020. Exactly when buyers will return to the market is also up for debate.

Long-term potash supplies

The start of negotiations for the next long-term Chinese import contract will be a particularly notable market feature in early 2020. Chinese buyers are expected to approach MOP suppliers in January or February 2020 to begin talks, having opted to stall these in late 2019.

Chinese MOP inventories remain high. Buyers also have flexibility on source of supply – with the choice of domestic production and/or lower-priced imports from Cambodia and Laos – giving them considerable clout in negotiations.

The delay to the Chinese contract forced Indian buyers to settle their own import contract first. India is eventually expected to buy 1.8 million tonnes of MOP between October 2019 and March 2020, the subcontinent's newly-established six-month import period. Overall, India's 2019-2020 purchases are expected to reach 3.8-4.0 million tonnes in total.

At the time of writing, there have been no new Indian contract settlements since early November, when the Arab Potash Company (APC) became the latest producer to sign a supply contract with Indian Potash Limited (IPL). APC did not, however, reveal contract details – either the price agreed or the volumes placed – beyond saying its agreement with IPL was in line with the market level.

The first wave of 2019-2020 supply contracts (Table 1) were agreed in October and early November at $280/t cfr (cost & freight) India – a decrease of $10/t from the previous contract supply period.

Indian long-term contracts are a bell-

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wether for the global MOP trade. Given that a decrease of up to $30/t on the previous year's contract price has been heard in discussions, the initial decrease of just $10/t was seen as the first sign of a recovery in MOP demand and pricing – after months of bearish sentiment and eroding offer levels.

But it later became clear, that IPL's decision to limit settlements to a six-month period means a stronger argument for a higher price cut will be advanced in the first-quarter of 2020.

"The discount wasn't really enough, but the Indians had to get things moving. In the first quarter, the Chinese can push everybody down, looking for $20-30/t less – but that's a problem for then," a source at one MOP producer told ICIS: "For now, the pain is gone. The potash industry will survive. We'll see more demand in Southeast Asia as [crude palm oil] futures are recovering, then there's India. First-quarter and maybe second-half [2020] will be busier."

Table 1: **Contract volumes for IPL, October 2019 to 31 March 2020, $280/t cfr India**

Supplier/Country	Volume (tonnes) – unconfirmed
Belarusian Potash Company (BPC)/Belarus	350,000-400,000
Uralkali/Russia	350,000
ICL/Israel	250,000-275,000

Source: ICIS

Table 2: **Chinese SOP: Top 10 export destinations, January-October 2017-19 (tonnes)**

Country	2017	2018	2019
Iran	480	25	102,260
Myanmar	656	1,557	28,984
South Africa	2,018	0	23,566
Mexico	0	0	23,362
Chile	16	0	19,152
Peru	0	0	12,460
India	0	1,985	11,289
Pakistan	636	0	11,203
Japan	3,323	121	7,611
Australia	2,014	244	5,299
Total	**13,584**	**7,424**	**293,369**

Source: China Customs via TDM

Mergers and management

Another key point to watch in 2020 is the potential for consolidation in the global potash industry.

Uralkali has been getting close to another major player in the Russian market – EuroChem. The pair have been discussing the possibility of "logistics optimisation for shipments into selected southeast Asian markets", a Uralkali source told ICIS.

Although some coordination has been mooted, this is the first overt signal of a potential Uralkali-EuroChem alliance. EuroChem is a relative newcomer to the potash market. It also manufactures a variety of fertilizer products, including urea, ammonium nitrate and urea ammonium nitrate. The company plans to leverage its already trusted EuroChem brand to secure a premium on MOP sales in Brazil.

The potential EuroChem-Uralkali team-up remains possible. This is despite news in January that a joint bid by Uralkali and Uralchem – the major Russian nitrogen producer – to take a controlling stake in Brazil's Fertilizantes Heringer had fallen through. Heringer is currently under bankruptcy protection. It is understood that OCP and Nutrien – who own a 10 percent and 9.5 percent share in Heringer, respectively – have the right of first refusal for the company.

In Canada, meanwhile, questions surround potash major Nutrien's plans for 2020 – following a dismal year in which the US market was characterised by bad weather, low crop prices, and limited demand. Nutrien's CEO Chuck Magro nevertheless remains bullish in the company's latest results announcement: "We believe that agriculture fundamentals are starting to strengthen, and we expect 2020 to be a strong year for crop input demand."

Farmers in many US states have been discussing the need to tighten expenditure since the end of last summer. A large percentage have been storing the fertilizer and crop production products that went unused in 2019 ready for the start of 2020's spring planting season. This could see the US fertilizer retail market suffer a final blowback in early 2020 from last year's historically poor planting season.

A Texas farmer told ICIS "it's getting harder out here", confirming he was holding off from any further fertilizer commitments until the start of spring.

"Crop prices have been not good for a while now, and everything we are buying to put into this, from seed to fertilizer to labour, is costing so much more, and there is less coming in," the Texan farmer said, adding: "I had hoped to take on more land but not now, and not without having more equipment, and because I don't have faith prices will not crash again."

One thing everyone seems to agree on is that a significant upturn in upcoming 2020 corn sowings will help spur a recovery in the US fertilizer market – a development that is generally expected if the weather stays favourable.

SOP outlook

The 2020 outlook for sulphate of potash (SOP) – MOP's low-chloride, premium sister product – is less bearish, albeit still weak overall.

European SOP demand was steady in second-half of 2019, with bids declining slightly in what is the low season. Supply is ample going into 2020, meaning there is little expectation of increased demand until this year's second-quarter.

Although imports are on the increase, Chinese SOP has yet to make large inroads into the traditionally insular European market. There is speculation, however, that Chinese-sourced SOP may find a more receptive audience in Europe, if imports continue to rise at the rate seen in 2019.

It seems very unlikely Beijing will impose SOP export tariffs in 2020, following the increase in volumes traded internationally last year (Table 2), generally regarded as a great success. That said, high freight costs, and the expense of enrolling and complying with the EU's REACH regulations, may deter many potential Chinese SOP producers from exporting to Europe.

In Australia, meanwhile, five junior mining companies are locked in a race and competing to be first in the market to produce SOP from Western Australia's dry lakebeds. None of the five has yet to begin producing SOP in bulk, and all are still at relatively early stages of development – although two companies have a noticeable lead.

Salt Lake Potash has secured a trio of offtake agreements for its low-chloride SOP fertilizer amounting to 170,000 t/a. Similarly, rival prospective producer Kalium Lakes has also secured buy-in from established market players (Table 3). ■

Table 3: **Prospective Western Australian SOP producers**

Company	Claim/Area (km²)	Resources	Offtake agreements
Salt Lake Potash	Goldfields/3,300	290-458 million tonnes	● 50% to Mitsubishi and 50% to China's Sinofert from 50,000 t/a demonstration plant ● Three offtakes with Indagro, Unifery & Fertisur for a total 170,000 t/a.
Kalium Lakes	Beyondie/2,400	180,000 t/a over 30-50 years	75,000 t/a to K+S for a 10-year term
Australian Potash	Lake Wells/1,200	14.7 million tonnes over seven years	MOUs with China's Sino-Agri and Hubei-Agri for up to 200,000 t/a
Agrimin	Lake Mackay/4,370	426,000 t/a over 20 years	None confirmed
Reward Minerals	Lake Disappointment/5,000	9 million tonnes over 25 years	None confirmed

Source: ICIS

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