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INTERNATIONAL Fertilizer

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50 YEARS ANNIVERSARY 1969-2019

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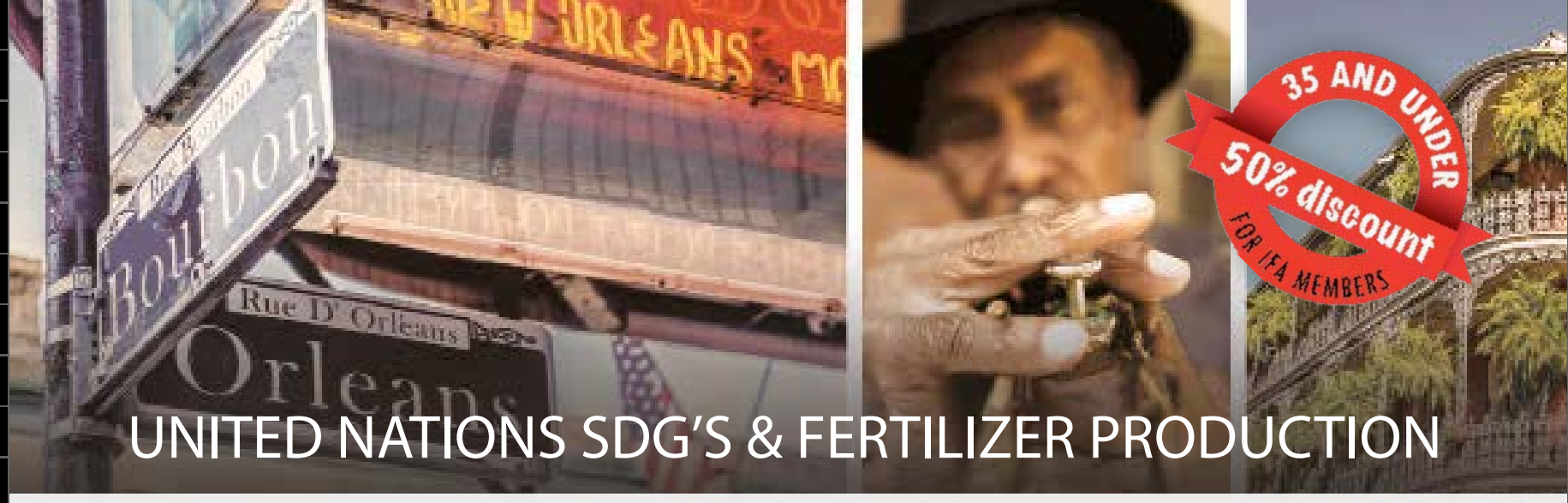
25th AFA Fertilizer Forum, Cairo

The year ahead

Foliar fertilizers

Alternative potash options



UNITED NATIONS SDG'S & FERTILIZER PRODUCTION

ifa
GLOBAL TECHNICAL SYMPOSIUM

8-11 April 2019
Loews Hotel, New Orleans

WHY SHOULD YOU ATTEND?

IFA's biennial Global Technical Symposium has emerged as the fertilizer industry's thought leadership event, leading to more efficient and responsible production over the past decades.

Participation in this event historically comes from the senior leaders from the IFA membership, thus distinguishing it from similar events, which tend to appeal to much broader, more commercial audiences, and which often focus on one fertilizer product or region at a time.

Following a record-breaking Symposium in Madrid in 2018, this event is returning to the U.S. where support has already been ensured from the national association, TFI, as well as local member producers.

Special focus will be given to the United Nations' Sustainable Development Goals and their implications on the future of fertilizer production. Speakers will explore those issues with the most potential to bring about significant change in the fertilizer industry, impacting fertilizer production through the 2030 time horizon.

EVENT HIGHLIGHTS

- Two-day conference with side events and exhibition, plus networking opportunities
- Participation of approximately 200 technical leaders from 40 countries, including the IFA Executive Board and TFI leaders
- Technical visits to IFA members' N- and P-facilities
- Gala Dinner at the legendary House of Blues
- Marketing and PR opportunities with exhibition space and sponsorship

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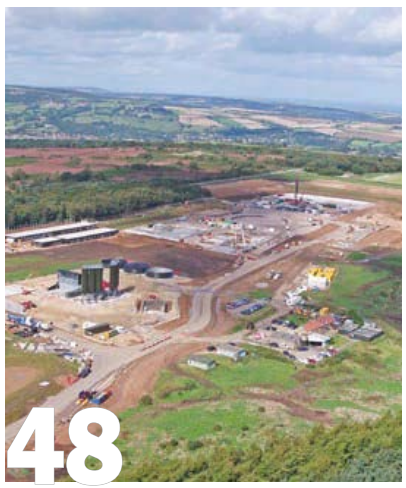
AFA Forum preview



Potash options

Read this issue online at: www.fertilizerinternational.com

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INTERNATIONAL Fertilizer

www.fertilizerinternational.com

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PHOSPHATES AND POTASH INSIGHT

REGULARS

50 YEARS ANNIVERSARY 1969-2019

Happy birthday to you!

Fertilizer International is 50 this year. The title began life as an eight-page magazine first published in July 1969 by The British Sulphur Corporation out of their Upper Brook Street offices in London's Mayfair district.

Auspiciously, *Fertilizer International* first rolled-off the press at the time of the 1969 moon landing, during the very month that Neil Armstrong and Buzz Aldrin successfully touched down in the Sea of Tranquillity in Apollo 11's lunar module.

It was a year of other notable firsts. Robin Knox-Johnston became the first person to sail solo non-stop around the world. And the first episode of Monty Python's Flying Circus was aired on the BBC. 1969 was also the year of Woodstock, the original rock music festival. Richard Nixon was inaugurated US president too.

1969 didn't just mark the end of a decade either. Elsewhere in London that year, less than three miles from Mayfair, the final Beatles album, Abbey Road, was being recorded in St John's Wood.

The last year of the 1960s was also volatile. A quarter of a million people marched on Washington to protest against the Vietnam War. In the UK, it was also a year that was dominated by the start of the 'Troubles' in Northern Ireland.

Yet it was also a time of technological innovation and change with the maiden flight in March of the world's first and only supersonic airliner, Concorde.

In 1969, British Sulphur was still being run by its long-time managing director, the energetic John Lancaster, under the chairmanship of Major-General Godfrey Edward Wildman-Lushington, CBE. The Corporation was certainly well-connected and run with a military swagger in those days. Wildman-Lushington had previously commanded the Royal Marines at the end of World War II, before becoming aide-de-camp to King George VI.

Lancaster and Wildman-Lushington's partnership dated back to 1953 when John joined the Major-General at the Sulphur Exploration Syndicate. Remarkably, almost all of today's UK-based fertilizer consultancies can trace their roots back to this post-war progenitor.

The Syndicate's first *Quarterly Bulletin* in 1953 also launched what was to become, under British Sulphur, the first privately-owned publishing house and information company specialising in fertilizers and fertilizer raw materials.

The late John Lancaster was the prime instigator of all of this. John enjoyed legendary status, thanks to a highly distinguished 50-year career in sulphur and fertilizers. He notably served as managing director of British Sulphur from its inception in 1963, later succeeding Wildman-Lushington as chairman in 1970, before eventually becoming executive director, following the merger with CRU in 1985. John was still playing a leading role as a non-executive director of CRU in the 1990s, only stepping down from the board on his retirement at the end of 1996.

Fertilizer International didn't appear from nowhere. It was preceded between 1966 and 1969 by 36 issues of British Sulphur's monthly *World of NPKs* periodical, which it incorporated. Another British Sulphur title, *Phosphorus and Potassium*, dates back even earlier – it was first published in May 1962. Remarkably, it still survives today as our *Phosphates and Potash Insight* section.

Six issues of *Fertilizer International* were published monthly between July and December 1969. The magazine was put together by a team of six, including the editor-in-chief, Daphne Mermikedes, and our very first editor, Ivan Elek.

> **"Better communications and the availability of accurate and timely information goes a long way..."**

Would Ivan and Daphne still recognise the 2019 version of *Fertilizer International*? I'd like to think they would. We still provide – as they did in that very first issue – an informative mix of company and project news, market analysis and articles on fertilizer technology.

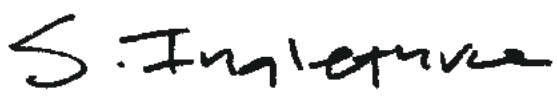
Amazingly, the magazine's very first editorial from July 1969 still holds true today. It highlighted the "great and lasting benefits" that would come from "speedier recognition of… changes in fertilizer technology, market structure, growth, and other fundamental aspects of the industry". What could possibly fulfil this need? Well, the editorial concludes – in what amounted to a mission statement for the new magazine – by calling for: "Better communications and [the] greater availability of accurate and timely information."

Half a century later, *Fertilizer International* still works to 'greatly benefit' our readers by providing insightful, accessible, topical and authoritative in-house editorial content.

The magazine continues to go from strength to strength. This year, for example, *Fertilizer International* will be distributed at a record 14 international conferences, many of these as the official publication and media partner.

The continuing success of the magazine depends not only on our own expertise and acumen. It also relies on the mutually beneficial partnerships forged with the many companies and individuals who have supported us over five decades.

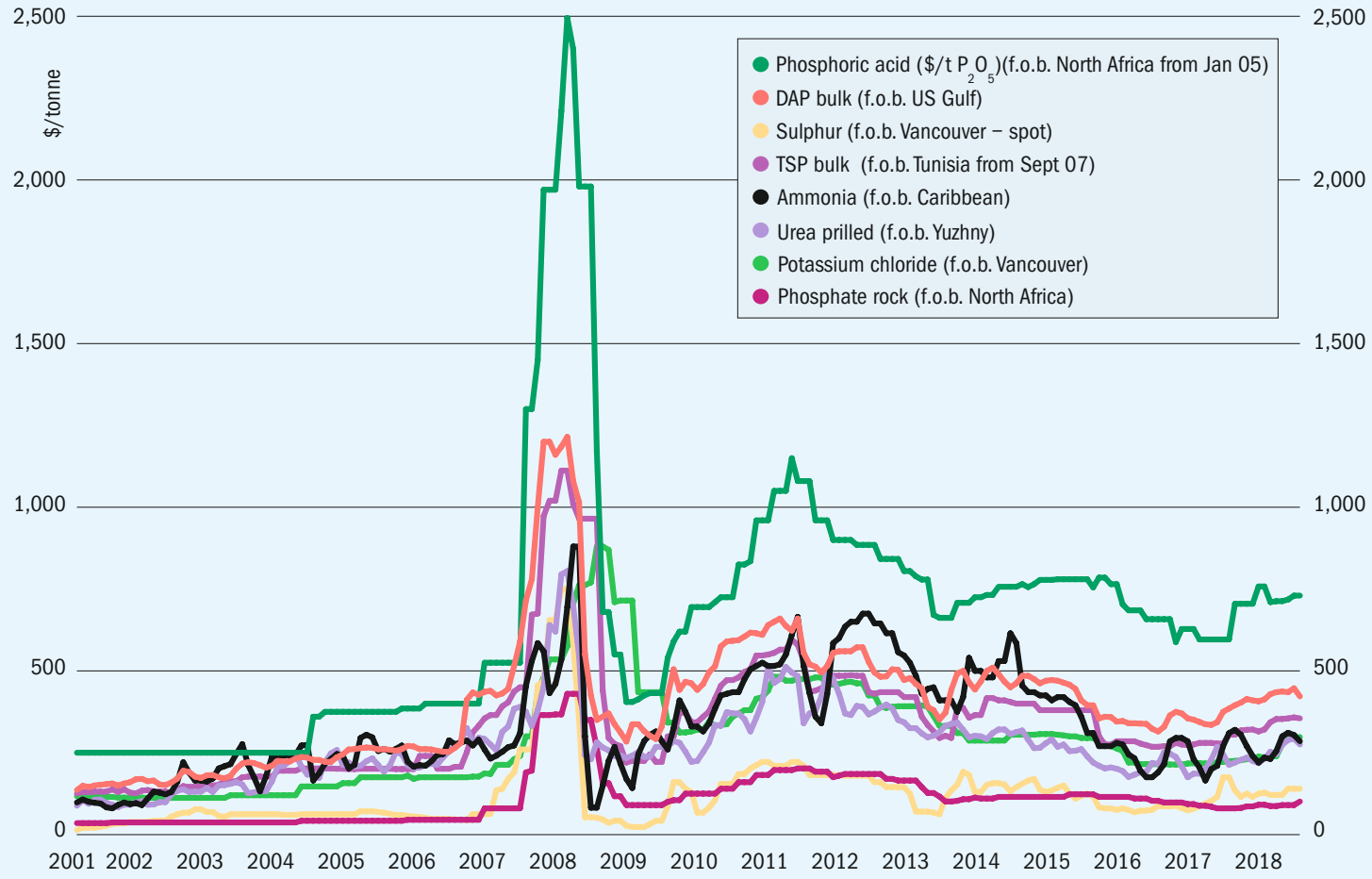
So, in celebrating the 50th anniversary of *Fertilizer International* this year, BCInsight would like to say thank you – to all our readers, contributors and advertisers, then and now. As one thing is certain, we wouldn't be here without you.



Simon Inglethorpe, Editor

Market insight

Historical price trends $/tonne



Source: BCInsight

Market insight courtesy of Integer Research

PRICE TRENDS

Urea: Our worst-case scenario for 2019's fourth quarter became a reality, triggering a downward market correction of just over $70/t between October and January. Two downside risks, in particular, became eventualities with negative consequences for prices: Iran did find a way circumvent new US sanctions, and the mild winter has also allowed China to boost shipments to the international market. Indeed, Iran has continued exporting at around 400,000 tonnes per month. China, by changing certificates of origin and then re-exporting Iranian cargos, is enabling these exports through 'triangular trade'. As well as negative supply-side factors, prices were further undermined by weak demand fundamentals. Dry European weather in the last quarter of 2018 allowed German and French buyers to postpone purchases and wait for the market to bottom out. Turkish consumption also remains moribund.

Ammonia: Fundamentals began to weaken in late October, following a strong showing in last year's third quarter. Ammonia values fell gradually throughout November before a market collapse in December. The Tampa benchmark, for example, fell from an annual high of $355/t cfr for October/November deliveries, to $325/t cfr for December deliveries, and then all the way down to $285/t cfr for January shipments. The collapse was kicked-off by weaker fourth quarter demand and continuing Iranian ammonia exports. The forecast disruption to Iranian exports has not materialised thanks to sanctions waivers granted by the US. Black Sea trade was impeded by shipping delays, resulting in a build-up of stocks. At the same time, European demand for imports weakened due to improved gas economics. Finally, any optimism about direct-application demand in the US has been virtually eliminated, due to the disruption of fieldwork by poor weather.

Phosphate: The market exhibited its typical seasonal slowdown in the fourth quarter of last year, with major benchmarks falling by around $6/t quarter-on-quarter to $410-430/t f.o.b. Chinese demand softened in the fourth quarter, to the extent that DAP offtake ended up some 50 percent down year-on-year. Chinese producers reacted to the weak demand by cutting operating rates. Brazilian MAP demand was also thin, largely due to the negative effects of currency weakness on financing. OCP managed to tighten spot availability by keeping operating rates low at Jorf Lasfar. This has allowed OCP to continue to sell DAP volumes into Europe at a premium.

Potash: Global potash prices stabilised in December, following almost a whole year of upward movement. Standard MOP (Vancouver) increased by $35/t over the year to average $256/t f.o.b. in 2018. Planned and unplanned production outages, strong demand, and the slow ramp-up of new potash mines, combined to keep the potash market tight in 2018. Latin America, Europe and North America all entered a

seasonal slow-down in December. While Southeast Asia typically remains active, the region's tender season has got off to a slow start. Potash buying has faded on the back of falling palm oil prices. Fertilizer purchase decisions by plantations are being delayed, or concluded at lower levels, due to squeezed margins. This has resulted in tenders being awarded at around $15/t cfr below supplier target prices.

Sulphur: Global benchmarks saw a downward correction in November and December 2018. This represented a turning point in the market as more bearish sentiment took hold. Middle East prices fell to the $130s/t f.o.b. in December, a drop of around $40/t in just a few weeks, on the back of lacklustre end-user interest across several markets. Sulphur imports to China between January-October 2018 dropped by around two percent year-on-year. This is a sign of increasing domestic sulphur availability, an emerging factor that is likely to influence the outlook for 2019. In the US, fourth quarter 2018 prices were agreed at $140/t Tampa cfr, compared with $121/t cfr in the previous quarter. Vancouver spot prices, meanwhile, eroded to the $120s/t f.o.b. in December, a consequence of China stepping out of the market.

Market price summary $/tonne – End-December 2018

Nitrogen	**Ammonia**	**Urea**	**Ammonium Sulphate**	**Phosphates**	**DAP**	**TSP**	**Phos Acid**
f.o.b. Caribbean	280-283	-	f.o.b. East Europe	f.o.b. US Gulf	425	-	-
f.o.b. Yuzhny	270-290	270-277	-	f.o.b. N. Africa	435-451	352-359	720-740
f.o.b. Middle East	280-305	280-290**	-	cfr India	411-425	-	768*
Potash	KCl Standard	K_2SO_4	**Sulphuric Acid**		**Sulphur**		
f.o.b. Vancouver	290-305	-	cfr US Gulf	90-110	f.o.b. Vancouver	122-132	-
f.o.b. Middle East	272-320	-	-	-	f.o.b. Arab Gulf	135-155	-
f.o.b. Western Europe	-	500-520	-	-	f.o.b. N. Africa	132-145	-
f.o.b. Baltic	255-333	-	-	-	cfr India	151-157+	-

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.*

MARKET OUTLOOK

- **Urea:** A small price recovery looks likely in the near-term, once spring demand kicks-off. We are expecting strong demand from Europe and Turkey to boost North African values, given the paucity of fourth quarter 2018 pre-buying. This should see f.o.b. Egypt back above $300/t by February. Indian urea inventories remain stubbornly low despite all the recent tender activity. With the Rabi season in full swing, most of the MMTC tender volume should move swiftly inland to be absorbed in the retail chain. This suggests that another tender for 600,000-800,000 tonnes will be needed in coming weeks to cover the remainder of the season, most likely followed by a further tender around February-March time to rebuild end-of-season stocks.
- **Ammonia:** The outlook remains relatively weak for the next two months at least, and probably well into the summer. Bearish sentiment is continuing into the New Year, as shown by the $40/t drop in the latest Tampa settlements for January deliveries. Corn application tends to bring the market back to life in February. But that is likely to provide only momentary price stability before further downwards corrections as we approach 2019's second quarter. The Black Sea market remains long. It is logistically less attractive for spot buyers due to the 15-20-day vessel queues at Dardanelles and Bosporus. New output from EuroChem's Kingisepp plant is now expected to enter the market in the second quarter, due to commissioning delays. But the plant will still put Baltic prices under considerable downwards pressure, once successfully commissioned.
- **Phosphate:** With demand stuttering in the US, Brazil and India, the overall outlook for early 2019 is soft. Plant City's closure in the US has delayed the expected market shift to oversupply. However, the arrival of new Saudi Arabian and Moroccan capacity will be felt at some stage in 2019. We expect the rise in North American imports, following closure of the Redwater plant in Canada, to be hotly contested by Russian, US and Moroccan producers. DAP operating rates in China are likely to remain under pressure, with demand weak in India and Pakistan. The first quarter phosphoric acid price settlement between OCP and its Indian joint venture partners will be the next barometer of Indian pricing. DAP requirements in India remain at a low level. DAP prices globally also look inherently weak.
- **Potash:** Scaled-back output from incumbent producers looks likely to partly offset the extra potash supply from new sources during 2019's first half. Canpotex is sold out until April 2019 and several other key producers also report limited availability. Uralkali is said to be encountering water inflow issues at its 1.2 million t/a Solikamsk-1 mine, and also experienced a fire at its Solikamsk-2 mine in December. Germany's K+S will lose around 600,000 tonnes of MOP and kieserite production capacity in 2019 with the closure of Sigmundshall. The tight global balance suggests prices will remain buoyant in the year's first half. Despite this, the trajectory of demand and inventory levels still pose risks to the potash outlook in 2019, following bumper potash buying in 2017 and 2018.
- **Sulphur:** The start to the New Year has been bearish with buyers staying on the side-lines. Looking ahead, we expect the downward price trend to reach a floor and then stabilise. Spot demand in China should revive during the first quarter, as a flurry of activity is expected in late February when buyers return to the market following the end of the Chinese New Year. However, market stagnation in the weeks prior to this could see further softening. Further falls in sulphur benchmarks could also be prompted by downward pressure from the processed phosphates market. A tight market balance in the first quarter will be supported by stretched sulphur supply out of the Black Sea, owing to the winter closure of the Volga Don waterway.

BELGIUM

EU fertilizer regulation agreed

Agreement has been reached on the EU's new fertilising products regulation.

In a breakthrough moment, the European Commission, the European Council and the European Parliament reached a provisional agreement in Brussels on 20 November. The three EU institutions had been locked in intensive 'trilogue' negotiations since the end of January last year.

Industry trade body Fertilizers Europe broadly welcomed what it called a "compromise agreement" over the regulation. This strikes a balance between setting ambitious products standards, in its view, while also maintaining the fertilizer industry's ability to supply farmers. "We, however, regret that the level of nutrients in mineral fertilizers was reduced – as we want to offer quality products," Fertilizers Europe added.

Jacob Hansen, Fertilizers Europe's director general, said: "Fertilizers Europe would like to congratulate the MEP rapporteurs Mihai Turcanu and Elisabetta Gardini, as well as the shadow rapporteurs and the Austrian Presidency of the EU for concluding an agreement on the new fertilizer regulation. We broadly welcome this agreement as it represents a balance, which allows the mineral fertilizer industry to move forward in supplying quality fertilizer products to European farmers."

Importantly, the regulation will introduce, for the first time, a cadmium limit of 60 mg/kg P_2O_5 on phosphate fertilizers placed on the EU market. The new limit is set be enforced immediately after the regulation is implemented. "The immediate implementation of this limit creates a challenge for the European phosphate industry," said Jacob Hansen. "I would have expected the limit to only take effect after an appropriate transition period allowing EU producers to adapt their sourcing practices and their production processes."

Fertilizers Europe welcomed the fact that crop nutrient products sourced from by-products will fall within the scope of the new regulation, without creating excessive bureaucracy for conventional mineral fertilizers. "We want to continue to be the leading sector for industrial symbiosis and recycling in Europe," said Jacob Hansen. "The original proposal did not allow this. I therefore want to thank Members of the European Parliament, Member States and also the EU Commission for helping to find a solution on this key issue."

The extension of the CE mark to include organic fertilizers and biostimulants, in addition to mineral fertilizers, provoked a mixed reaction from Fertilizers Europe. "We only regret that this… came at the expense of the quality of mineral fertilizers. The minimum nutrient levels are very low and this is a drawback. EU farmers rely on efficient mineral fertilizers to boost their yields and the quality of their crops," said Jacob Hansen.

The trilogue agreement is provisional and the fertilising products regulation needs to overcome one final hurdle – formal adoption by the European Parliament and Council – before becoming EU law.

Fertilizers Europe also wants the European Commission to draw up a guidance document to help the transition to what it calls "new complex rules". ■

Fertilizers Europe launches new strategy

Fertilizers Europe launched 'Feeding Life 2030', its new long-term strategy for the European fertilizer industry at the end of November.

The strategy, released to coincide with the trade association's 30th anniversary, has two entwined 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 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 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 better 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 generation and water electrolysis. thyssenkrupp Industrial Solutions (tkIS), for example, is a global leader in the manufacture of large-scale electrolysis equipment.

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.

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. This emerging market could help Europe's nitrogen industry diversify and become an important and integral part of the EU's emerging low-carbon energy infrastructure.

Anti-dumping duty cut

Fertilizers Europe has criticised European Commission moves to reduce the anti-dumping duty on ammonium nitrate by one-third, from €47/t down to €32/t.

The trade body attacked the decision to cut the duty, proposed in the Commission's interim dumping review, saying this was contrary to the continuing threat posed by Russian ammonium nitrate producers to the EU's nitrogen industry.

Fertilizers Europe did, however, welcome the review's central findings. It supported the Commission's view that circumstances in the Russian gas market, where state-fixed pricing predominates, remain unchanged. Jacob Hansen, Fertilizers Europe's director general, said: "As an industry, we are very concerned with the Commission's decision to reduce by one third the anti-dumping duty on ammonium nitrate originating from Russia despite recognising structural dumping, as it sets a very dangerous precedent which puts at risk high-skilled jobs and competitiveness of European fertilizer industry as a whole."

The Russian ammonium nitrate industry still has millions of tonnes of spare export capacity, Hansen said, adding: "The Russian industry remains a powerful export industry with exports reaching over 3.5 million tonnes in 2017. In comparison, the EU ammonium nitrate market is estimated between 6.4-7.5 million tonnes annually. No amount of EU industry re-structuring or improved efficiencies can compensate for the massive gap between Russia's typical state fixed price of $2.50/MMBtu [vs] the EU's wholesale gas price of nearly $10.00/MMBtu."

INDIA

Casale wins nitrate plant order

Casale has won a contract for a new technical ammonium nitrate complex in India.

The contract was awarded by Smartchem Technologies Limited (STL), a fully-owned subsidiary of Deepak Fertilisers and Petrochemicals Corporation Limited (DFPCL). Under the terms of the contract, Casale will supply process licenses, know-how, basic design and proprietary equipment to the complex, together with on-site assistance.

The planned complex includes the following three production units:

- 900 t/d nitric acid plant based on Casale's proprietary *NA2000* dual-pressure process
- 1,143 t/d ammonium nitrate solution plant incorporating Casale's *AN2000* pipe reactor technology
- 970 t/d prilling unit able to produce either high density ammonium nitrate (HDAN), based on Casale technology, or low density ammonium nitrate (LDAN), based on newly-acquired ORICA technology.

The project will fully-utilise equipment mothballed, but never used, from another project in a different region.

CHINA

China scraps fertilizer export tariffs

The Chinese government removed export taxes on fertilizers at the end of December.

Export taxes on all fertilizer products –including finished phosphates, nitrogen fertilizers, MOP, SOP, NOP and NPKs – have been

revised down to zero. The changes were announced as part of a major revision of tariffs for 2019 affecting a wide variety of Chinese goods.

Previously, MOP/SOP and NPK fertilizer exports were taxed at flat rates of 600 yuan/t ($87/t) and 100 yuan/t ($15/t), respectively, in 2018, while NOP and PK fertilizers were subject to a five percent export tax levy. Exports of other potassium-containing fertilizers incurred a 30 percent tax rate in 2018.

The export tax on phosphate rock is also now zero, down from 10 percent in 2018.

Import tariffs, in contrast, remain largely unchanged. Imports of urea, NPKs, DAP and sulphur will still be subject to a one percent tax rate. Imports of phosphate rock and ammonia will attract a zero percent import tax, also unchanged from 2018.

Value-added tax on imports in 2019 has, however, been reduced, and will be charged at a 10 percent rate for most fertilizers, and at 16 percent rate for sulphur and ammonia.

The tariff changes for 2019 affect over 700 different Chinese products, and are designed to boost the Chinese economy and grow its import and export trade. Export duties on 94 items such as mineral fertilizers, apatite, iron ore, slag, coal tar and wood pulp have all been cancelled. Tax rates on wheat and eight other commodities have been left unchanged.

ALGERIA

$6 billion phosphate megaproject unveiled

China and Algeria have agreed to collaborate on developing a $6 billion phosphate megaproject.

Algerian state-owned oil and gas giant Sonatrach signed an agreement with China's Citic Group in November for the construction of an integrated phosphates project at Bled El-Hadba in the eastern Tebessa region of Algeria. The project is designed to exploit and commercialise the area's phosphate and natural gas deposits. It could create up to 3,000 jobs and is scheduled to begin production as early as 2022.

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

The partners behind the joint venture include Algerian state firms Sonatrach, Manal and Asmidal (51%) and China's state-owned Citic Group (49%)

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

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

Although Algeria has the third largest phosphate reserves in the world, after Morocco and China, deposits have yet to be developed to the same extent as in neighbouring Arab countries. Algeria has, however, adopted an ambitious strategy to increase its national phosphate production from two million tonnes annually to 30 million tonnes by 2030. Following in the footsteps of Morocco and Saudi Arabia, Algeria is seeking to diversify its economy, and lessen reliance on oil and gas exports, by turning itself into one of the world's largest exporters of phosphate fertilizers.

UNITED STATES

Mosaic to begin Ona mining operations

The Mosaic Company is ready to commence mining at the Ona phosphate project in Hardee County, Florida, having now obtained all the necessary permissions.

Mosaic announced that it had acquired its final remaining permit for Ona – a US Army Corps of Engineers 404 permit – in December. As a consequence, the company now expects the project to start mining operations by March time.

The Ona project adds 160 million tonnes to Mosaic's phosphate rock reserves and is spread across 16,000 acres. Mosaic previously secured the other necessary mining permits for the project from the State of Florida in 2015 and from local government in July 2018.

"This is the largest new mine Mosaic has permitted since the creation of the company in 2004," said Russell Schweiss, the company's mining and land management vice president. "The most significant thing is the size of the phosphate reserves – 160 million tonnes. It's a very significant mine."

Importantly, Ona will extend the life of two existing Mosaic phosphate rock mines that are running out of reserves, Schweiss said.

Initial mining operations on the western side of Ona will extend the life of the Four Corners Mine for another 14 years. The eastern half of Ona will also eventually extend the life of the South Pasture Mine in north Hardee, just across the Polk County border, once it reopens. Mosaic idled South Pasture in August 2018, saying it had sufficient rock from its other mines to meet current production requirements.

"This important project helps secure the continued operation of our Florida manufacturing facilities," said Mosaic president and CEO Joc O'Rourke. "It will deliver tremendous value to the local community, our employees and our investors well into the future."

CANADA

Arianne secures second offtake

Arianne Phosphate has entered into a second offtake agreement for its under-development Lac à Paul project.

The agreement covers the purchase and marketing of high-purity phosphate rock concentrate. Although both the terms of the offtake and the name of the customer remain confidential, Arianne said that the deal was with "an industry leading global trader of fertilizer products, including phosphate concentrate and phosphoric acid".

The latest offtake agreement follows a previous offtake deal announced last September.

"This agreement is yet another validation of Arianne's Lac à Paul project," said Brian Ostroff, CEO of Arianne Phosphate. "By entering into this relationship, Arianne's product will now have an even greater global reach by leveraging on the operations and relationships of long-established, well respected international fertilizer traders."

The Arianne project is located around 200 kilometres north of the Saguenay/Lac St Jean area of Quebec. The project is aiming to produce high-quality concentrates (39% P_2O_5) from igneous phosphate deposits in the region.

AUSTRALIA

Centrex prioritises Ardmore project

Centrex Metals has taken a strategic decision to 'switch out' of iron ore mining and enter the fertilizer market.

The company is rapidly developing its flagship Ardmore phosphate rock project in Northwest Queensland, using the AUD 1.4 million proceeds from the sale of its Port Spencer landholding in South Australia.

Centrex says Ardmore is now "fast approaching" production. The company is planning to start-up operations in mid-2019 and produce 30,000 tonnes of phosphate rock concentrate initially. The company will use this to supply priority customers with 5,000-6,000 tonne trial shipments.

Queensland's Department of Environment and Science granted Ardmore an environmental permit for the start-up of mining and processing operation in December.

Centrex also released a definitive feasibility study for the Ardmore project in October 2018. The maiden ore reserve estimate of 10 million tonnes (30.2% P_2O_5) is enough for a 10 year mine life at a production output for phosphate rock concentrate of 800,000 tonnes annually.

Karratha urea project gathers pace

Perdaman Chemicals and Fertilisers has signed a binding heads of agreement with SNC-Lavalin for engineering, procurement and construction (EPC) work at its Karratha urea project in Western Australia.

Perdaman is planning to build a two million tonne capacity urea plant on the Burrup Peninsula, some 20 kilometres north-west of Karratha on the northwest coastline of Western Australia (WA). The AUD four billion project will use local natural gas as a feedstock for fertilizer production, using innovative and low-emissions technologies.

Chris Brown, SNC Lavalin's president for oil & gas, said the company was pleased to be part of this important Australian project. "Our vast experience in delivering major projects that involve constructing state of the art technology will be vital in bringing this project to completion over the next four years," he said.

Perdaman has selected Haldor Topsoe's new *SynCOR*™ technology for Karratha's ammonia plant. This will make the project the first in the world to use Topsoe's state-of-the-art technology for large-scale ammonia production. Stamicarbon's *LAUNCH MELT*™ pool condenser design has also been selected for urea production.

"We are very happy to be partnering with SNC-Lavalin who are a world class engineering and construction management company," said Vikas Rambal, chairman and managing director of Perdaman. "With a proven track record delivering projects across multiple sectors in Australia – oil and gas, mining and metallurgy, clean power and infrastructure – we are confident that their knowledge and client-focused solutions are the best fit for this project."

Mr Rambal added: "Signing the agreement marks a significant step forward for the Karratha urea project. We are now full steam ahead on this project, working with WA government departments for the various approvals regarding this project."

Karratha has been awarded 'Project of State Significance' status by the WA State Government. Project construction is conditional on environmental approval but is expected to start at the end of 2019 or early in 2020.

Casale buys Orica's LDAN technology

Casale has acquired Orica's complete know-how for low density ammonium nitrate (LDAN) production.

The move strengthens Casale's technical and commercial capability in the solid nitrates field. The new ability to offer LDAN technology complements Casale's existing and well-proven high density ammonium nitrate (HDAN) fertilizer technology, previously acquired from GPN. Casale says the acquisition is in keeping with its long-term growth strategy.

The deal also includes the right to use Orica's well-known proprietary additive, *Sapphyr*, in new and revamped LDAN prilling plants, on commercial terms yet to be agreed. In addition, Orica will provide assistance to Casale during the transfer of its LDAN technology. This includes access to Orica LDAN plants.

CHILE

Nutrien sells SQM shares to Tianqi Lithium

Canada's Nutrien Ltd successfully sold its remaining shares in Chile's SQM (Sociedad Química y Minera de Chile SA) to China's Tianqi Lithium Corporation at the beginning of December.

An open auction on the Santiago Stock Exchange netted Nutrien gross proceeds of around $4.1 billion.

The sale of SQM shares marks the completion of a number of divestments requested by competition authorities in China and India. These sales were a condition of regulatory clearances that allowed Agrium and PotashCorp to merge and form Nutrien at the beginning of 2018.

Nutrien estimates that net proceeds from the sale of all its equity investments in 2018 will amount to approximately $5 billion.

"Closing the sale of our investment in SQM marks the conclusion of a major deliverable for Nutrien," said Chuck Magro, Nutrien's president and CEO. "The receipt of $4.1 billion in gross proceeds provides an opportunity to deploy the cash to generate significant shareholder value."

These receipts have substantially reduced Nutrien's net debt levels and will allow the company to increase returns to shareholders, and/or make further strategic investments.

Magro commented: "With the sale of our investments in Arab Potash Company and SQM in the fourth quarter, along with significant seasonal cash flow generated from our retail business, we expect our net debt-to-earnings [EBITDA] ratio to decline below two by the end of 2018. As a result, Nutrien has ample flexibility to both return capital to shareholders and grow the business with a disciplined investment approach."

RUSSIA

TOAZ selects Casale for third urea plant

TogliattiAzot (TOAZ) has awarded Casale a contract for the supply of a new 2,200 t/d urea plant.

This will be the third urea line at TOAZ's Togliatti site in Russia's Samara region. Casale will provide TOAZ with proprietary know-how, all of the project engineering, and the supply of offshore equipment and materials.

The ground-breaking ceremony for the plant's construction was held in October. The new line will be constructed alongside the two existing plants and will increase total urea production at the site by 70 percent. Casale's sister company, Prague-based Casale Project AS, will supply all the onshore equipment and be responsible for on-site construction.

Completion of the new urea line for TOAZ is expected in the second quarter of 2021. It is Casale's third Russian plant order in two years.

Russia's first UAS plant starts

EuroChem commenced production at Russia's first urea ammonium sulphate (UAS) unit in December.

The RUB 5.4 billion ($84 million) unit is located at EuroChem's Novomoskovskiy Azot complex, about 200 kilometres south of Moscow. The new 600 t/d unit was designed and built in partnership with Stamicarbon.

UAS production started at the site on 5 December, following the commissioning of granulation equipment, under the supervision of Stamicarbon engineers. The start-up went very smoothly, according to Stamicarbon, with the first UAS granules now rolling off the production line.

Stamicarbon's UAS process allows a very wide range of ammonium sulphate concentrations (0-50 weight %) to be handled, without modifying the granulation plant, or affecting the quality of the UAS granules produced.

The plant's opening ceremony was attended by Igor Nechaev, general director of EuroChem's Russian subsidiary MCC EuroChem, Henri Smolenaers, Stamicarbon's project manager and Semen Evreinov, the head of Stamicarbon's Russian office.

"Novomoskovskiy Azot has always been an innovation leader," said Mr Nechaev. "This is where granulated urea, calcium ammonium nitrate, and low-density ammonium nitrate were first produced in Russia and now, in another first, we have launched the country's only urea ammonium sulphate facility. This new fertilizer will meet the growing needs of Russian and European farmers."

UAS production will add to EuroChem's existing sulphur-enriched fertilizer portfolio, which already includes ammonium sulphate and ammonium sulphate-nitrate.

Maire Tecnimont wins Volgafert urea contact

Volgafert LLC has awarded Tecnimont S.p.A. an engineering, procurement and construction (EPC) contract for a granulated urea plant.

The new 540,000 t/a capacity urea plant, sited at the Kuibyshevazot industrial complex, Tolyatti, in Russia's Samara region, will use Stamicarbon technology.

Under the terms of the €200 million contract, Tecnimont will provide engineering services, equipment and materials, and construction services to the project. It will be responsible for all project activities up to commissioning and start-up, and will also perform a final test run at the granulated urea plant.

Volgafert will produce and market high-quality urea for the domestic and export market. The company is mainly owned by Russian fertilizer producer Kuibyshevazot. METDEV1, a company owned by Maire Tecnimont, also has a minority stake in Volgafert. Simest S.p.A., part of Italian investment bank CDP Group, is another participant.

To finance the whole project, a credit line of €160 million from international banks is currently being finalised. This will be guaranteed by Italian export credit agency SACE, also part CDP Group.

Pierroberto Folgiero, Maire Tecnimont Group's CEO said: "We are eager to strategically cooperate with a prestigious industry leader such as KuibyshevAzot in one of our core business areas, fertilizers. With this new collaboration we confirm the reliability of our Group's value proposition covering the whole value chain, from project development, to licensing to complete EPC execution."

Acron launches new urea unit

Acron Group commissioned a new 600 t/d urea unit at its Veliky Novgorod site in November.

Known as Urea-600, this is Acron's sixth urea production unit at the site. Acron upgraded its five other production units in parallel with the construction of Urea-600. An advanced integrated wastewater treatment plant was also successfully commissioned at the Novgorod site as part of the Urea-600 project.

The successful commissioning of Urea-600 increases urea production capacity at Veliky Novgorod to 3,800 t/d, equivalent to an annual production capacity of 1.3 million tonnes.

The new RUB two billion production unit is based on NIIK's patented *URECON® 2006* technology. This is the first time a new urea unit has been commissioned based on this technology, according to NIIK.

The *URECON® 2006* process incorporates improved liquid recycle technology. It has been successfully used for revamping low capacity units previously. The process offers highly efficient heat and mass transfer. One of the most important features of the technology, according to NIIK, is the single high-pressure vessel used as a urea synthesis reactor.

Alexander Popov, the chairman of Acron's board of directors, said: "The implementation of the Urea-600 project is an important step in the Group's new strategy adopted in 2017. The investment programme through 2025 is based on increasing capacity and output by implementing projects with a short timeline and high rate of return. Ammonia-4, the highest-capacity facility in Europe, which Acron commissioned in 2016, provides additional feedstock output for manufacturing urea, and demand for this product has been steadily growing. We use some of the output in-house to produce UAN liquid fertilizer, urea-formaldehyde resins and high-quality technical-grade urea for *AdBlue®*."

Acron produced over 950,000 tonnes of urea in total in 2017. Production output is used directly as fertilizer and as feedstock for the production of urea ammonium nitrate (UAN) and urea-formaldehyde resins.

In November, Acron also awarded Stamicarbon a licensing and equipment supply contract for a new 2,000 t/d urea granulation plant at Velikiy Novgorod. The plant will use the latest proprietary granulation technology offered by Stamicarbon.

"Acron has decided to expand its product portfolio by including granulated urea which is popular among clients. Cooperation with Stamicarbon, the technology leader in the industry, ensures us advanced technologies for manufacturing top-quality product," said Acron's chairman, Alexander Popov.

INDONESIA

Bedeschi secures shiploader contract

Indonesian engineering company Barata has awarded Italy's Bedeschi a contract to supply a 1,000 t/h capacity shiploader.

The new *SHL 25/1400* shiploader will be installed at Demarga Jetty, Gresik, Indonesia. It will be used by PT Petrokimia Gresik to load NPK and NPS fertilizers onto ships of up to 30,000 DWT. Barata will manage the structural steelwork required for the shiploader's installation.

This is Bedeschi's second order with PT Petrokimia Gresik. It was previously chosen to supply a circular storage and a longitudinal storage system with a *PAL PD* portal reclaimer.

SOUTH AFRICA

Sasolburg plant to start-up in March

Omnia's nitrophosphate plant in Sasolburg is on-track to start-up in March and ramp-up to full production capacity during 2019.

The ZAR 695 million ($50 million) plant will enable Omnia to switch production at Sasolburg away from monoammonium phosphate (MAP) production to nitrophosphate (dry and liquid *Nitrophos*) and calcium nitrate production instead.

The new plant will be "game changing", according to Omnia, due to its ability to consume phosphate rock instead of more expensive phosphoric acid. This will improve Omnia's supply options by enabling the company to source phosphate rock from international markets, as a substitute for domestically-produced phosphoric acid. This should reduce costs and improve the competitiveness of the company's fertilizer operations.

Switching from MAP to nitrophosphate production at Sasolburg should also mean the site will no longer produce large quantities of gypsum waste. It will also improve utilisation of Omnia's nitric acid plant which has been operating below the company's target level of 90 percent capacity.

The new 500 t/d nitrophosphate plant has been designed with expansion in mind, enabling Omnia to add an identical capacity production train in future, if it wishes.

SAUDI ARABIA

Ma'aden uses thyssenkrupp technology again

The Saudi Arabian Mining Company (Ma'aden) has chosen thyssenkrupp Industrial Solutions (tkIS) ammonia technology for its new 'Phosphate 3' megaproject.

thyssenkrupp's dual-pressure ammonia process will be used at a new Ma'aden ammonia plant at the Ras al Khair complex on the Arabian Gulf coast. tkIS will supply the process license together with engineering, supply and monitoring services for the 3,000 t/a plant, acting as a subcontractor to South Korea's Daelim Industrial Co Ltd. The new plant is scheduled for completion in early 2022.

thyssenkrupp's dual-pressure ammonia process is already used in Ma'aden's two existing ammonia plants at Ras al Khair. Combined, the three ammonia plants will provide Ma'aden with around 3.5 million t/a of production capacity.

"This third contract to build a new ammonia plant intensifies the already outstanding collaboration and great trust between Ma'aden and thyssenkrupp Industrial Solutions. It reflects our position as a technology leader for super-size ammonia plants and confirms thyssenkrupp's reputation in the industrial sector," said Ralf Richmann, CEO of the fertilizer technologies business unit at tkIS. ■

ERRATUM

A correction to the article on fertilizer swaps, 'Managing risks in a volatile market', published in our November/December 2018 issue (*Fertilizer International* 487, p34): we wish to make it clear that fertilizer swap contracts offered by Freight Investor Services (FIS) are settled against a monthly index price using information provided by Profercy and ICIS – and not on pricing information provided by CRU, Fertecon and Argus, as the article suggested. We apologise to FIS for this factual error. The online version of the article is being corrected and updated to reflect this change.

People

Acron Group has announced several changes to its management board, including the appointment of **Dmitry Balandin** as vice president for finance. The Group's newly-approved management board now comprises of:

- Dmitry Balandin, vice president for finance
- Vladimir Kunitsky, CEO and president
- Alexander Lebedev, vice president for domestic business
- Alexei Milenkov, finance director
- Irina Raber, vice president for human resources and special projects
- Dmitry Khabrat, vice president overseas.

Dmitry Balandin and **Alexander Lebedev** are both new to Acron's management board. Mr Balandin is a graduate of Kurgan State University, and holds a PhD in economics from the Higher School of Management at St Petersburg State University. He has been with Acron since 2013 as director for corporate finance. Previously, he held several management positions in Gazprom Neftekhim Salavat. Mr Lebedev graduated from Vladimir State University with a degree in marketing. He has worked at Acron since 2011, serving in several roles, most recently as head of the sales department.

Ivan Antonov has now left the management board but will remain with Acron as an advisor to the CEO. **Oscar Valters** has retired, leaving both the board and the company. "The new managing board is aligned with the Group's new strategy, which includes investments in developing our production capacity and our sales network in Russia and abroad," commented Alexander Popov, the chair of Acron's board of directors. "On behalf of our Group, I would like to express our deep gratitude to Mr Valters, who has been with Acron for over 20 years and decided to retire from his position as senior vice president. Mr Valters has made an invaluable contribution to the Group's business development, built an effective system of finance management and ensured sustainability of our production facilities."

Fran Malecha stepped down as president, CEO and board member of Compass Minerals in November, by mutual agreement. Lead independent director **Dick Grant** has taken his place, serving as chairman of the board and interim CEO until a permanent replacement is found.

"Over the last several years, we have made progress toward building a balanced company for the future," said Dick Grant, chairman and interim CEO of Compass Minerals. "The board remains committed to achieving best-in-class operational efficiency in our salt business to maximize its cash generating capabilities and investing in our higher-growth, global plant nutrition business. We are now moving forward with a keen focus on execution in order to ensure we can drive value from these investments and deliver sustainable, long-term value creation for our shareholders."

A search committee, formed of independent directors, has been tasked with finding a permanent new president and CEO for Compass Minerals, assisted by an executive search firm. Both internal and external candidates will be considered. Dick Grant will become non-executive chairman of the board, once a new president and CEO is installed.

Dmitry Konyaev, Uralchem's deputy chairman, was elected to the executive board of the International Fertilizer Association (IFA) in November, becoming one of only five board members. The decision was taken at a meeting of IFA's board of directors during last year's annual Strategic Forum, held in Beijing, China, in mid-November. The board also extended Dmitry's term as chairman of IFA's Communications & Public Affairs Committee until IFA's Annual Conference in Montreal in mid-June. ■

Calendar 2019

JANUARY

28-30

Fertilizer Latino Americano,
MEXICO CITY, Mexico
Contact: CRU Events
Tel: +44 (0)20 7903 2444
Email: conferences@crugroup

FEBRUARY

12-14

25th AFA Annual Fertilizer Forum & Exhibition, CAIRO, Egypt
Contact: Arab Fertilizer Association
Tel: +20 2 23054464
Email: afa@arabfertilizer.org

26-27

Value Added Fertilizer Summit Asia 2019, BANGKOK, Thailand
Contact: George Ade-onojobi, Integer Research
Email: gao@integer-research.com
Tel: +44 (0)20 7503 1265

MARCH 2019

4-7

Nitrogen+Syngas 2019 Conference, BERLIN, Germany
Contact: CRU Events
Chancery House, 53-64 Chancery Lane, London WC2A 1QS, UK
Tel: +44 (0)20 7903 2444
Email: conferences@crugroup

6-7

IFA Production & International Trade Conference, LONDON, UK
Contact: IFA Conference Service
Tel: +33 1 53 93 05 00
Email: ifa@fertilizer.org

25-27

Phosphates 2019 Conference, ORLANDO, Florida, USA
Contact: CRU Events
Tel: +44 (0)20 7903 2444
Email: conferences@crugroup

25-27

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

APRIL

8-11

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

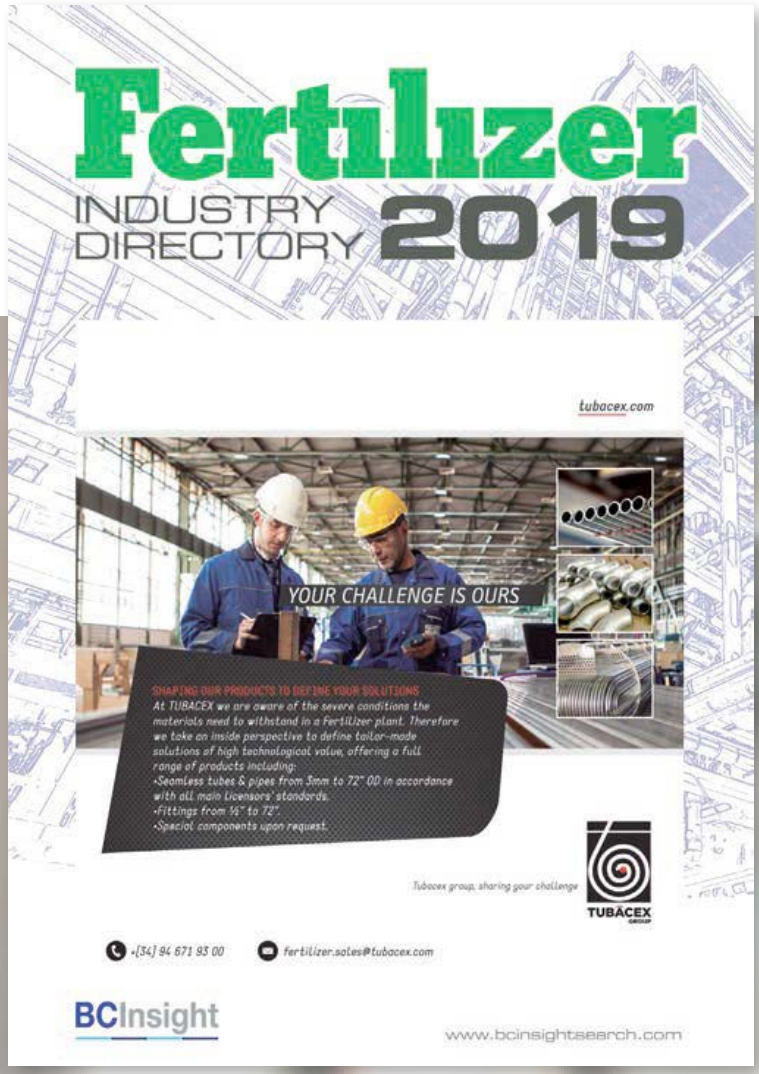
JUNE

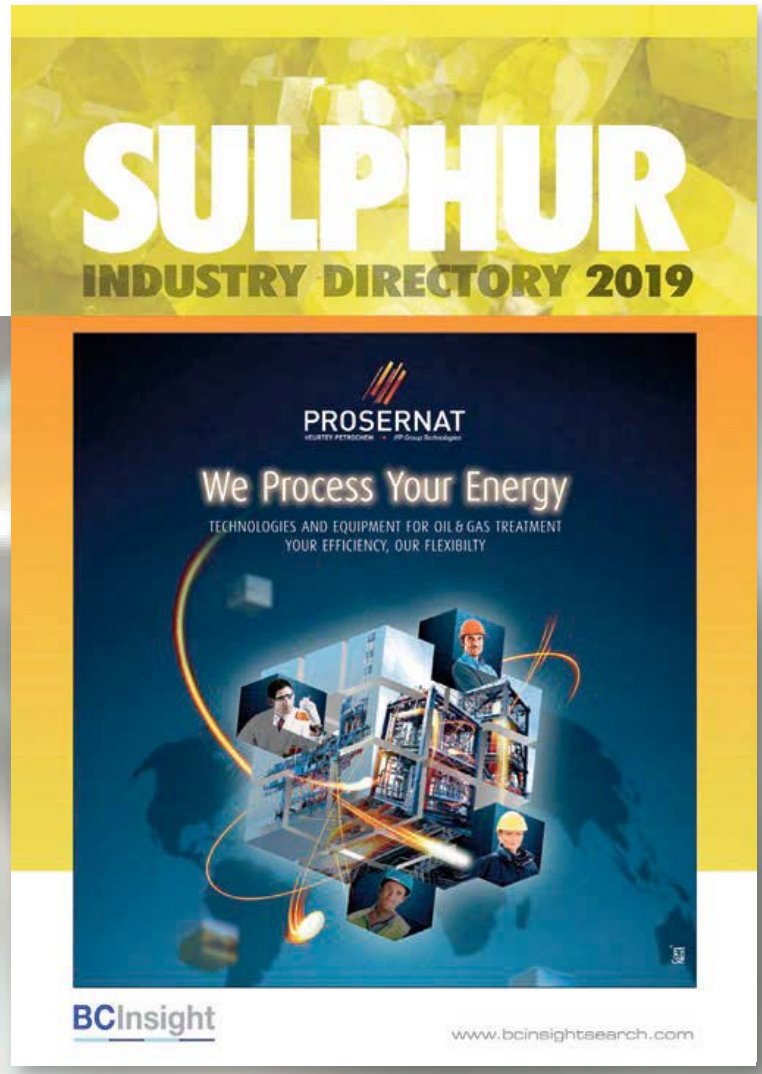
7-8

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

11-13

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





PICTURE THIS...

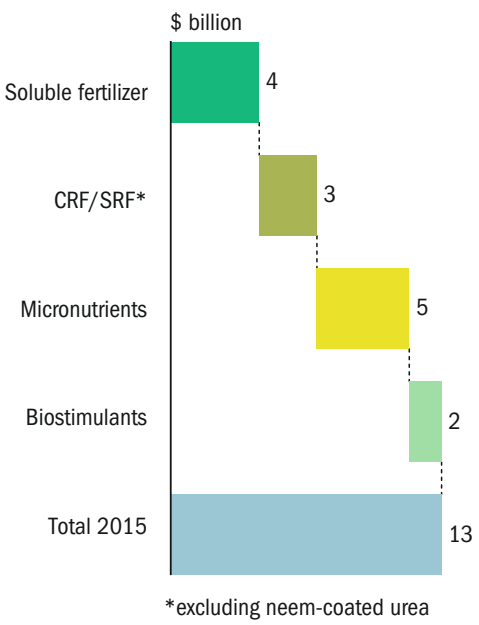
Asia's speciality boom

The global market for speciality fertilizers has been valued at around $13 billion and is growing strongly at around 5-7 percent p.a. Important market segments include water-soluble fertilizers (WSF), slow- and controlled-release fertilizers (SRFs and CRFs), micronutrient products and biostimulants. Market growth is being driven by factors such as the shift to high-value cash crops, the rise of drip irrigation, the need for better water and nutrient use efficiency, and the push for ever higher crop yields. Global market growth for specialities is expected to accelerate into double-digits beyond 2020.

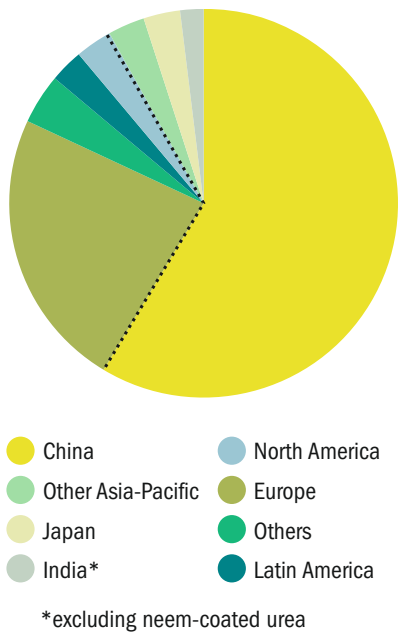
The market for SRFs and CRFs is particularly well-developed in China, Japan and other Asia-Pacific countries. China is the dominant global market for speciality products. The country produced and consumed around four million tonnes of WSFs and 3.6 million tonnes of SRFs/CRFs in 2017. The Chinese market for specialities is expected to grow by circa 10 percent p.a. over the next five years. The WSF and SRF/CRF segments will see particularly rapid growth of 16 percent and nine percent p.a., respectively, over this period. India's speciality product market has been growing above eight percent in recent years, a rate that is expected to rise to 12 percent p.a. out to 2020. India has huge growth potential for WSFs in particular. Although a small market currently (150,000 t/a), there is a great potential for fertigation in India. Only 20 percent of the county's irrigation systems currently incorporate fertigation, compared to global averages of up to 50 percent. Japan is a CRF market pioneer with a history of polymer-coated fertilizer production dating back to the 1970s. The country's speciality market is relatively mature and largely self-sufficient. Over one-fifth of Japan's farmers use CRFs, with rice being the primary crop market. Much of SRF/CRF demand in Southeast Asia (less than 200,000 t/a) is driven by usage on oil palm plantations, particularly in Malaysia and Indonesia.

Sources: Integer Research/Fertilizer Association of India/CNCIC

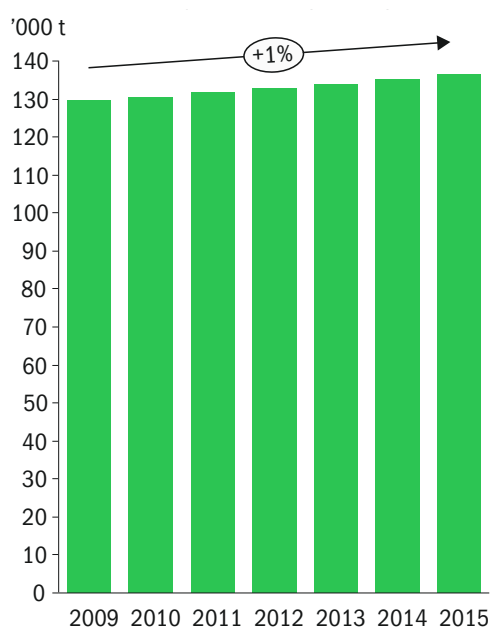
THE GLOBAL SPECIALITY MARKET



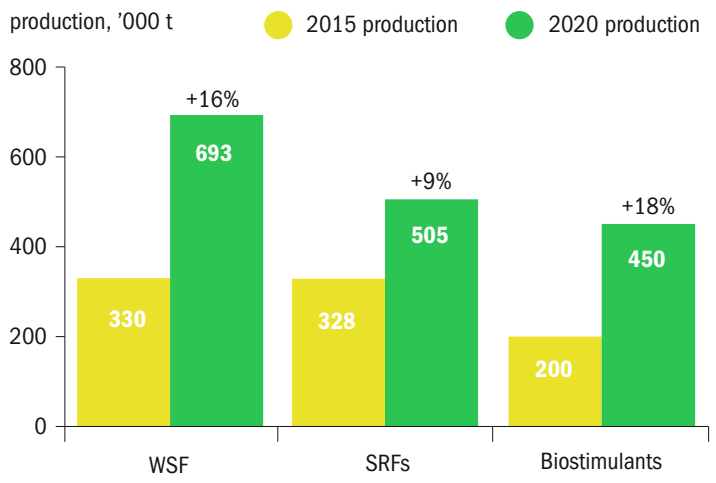
GLOBAL SRF & CRF CONSUMPTION



JAPAN'S SPECIALITY MARKET



CHINA'S SPECIALITY MARKET



INDIA'S SPECIALITY MARKET

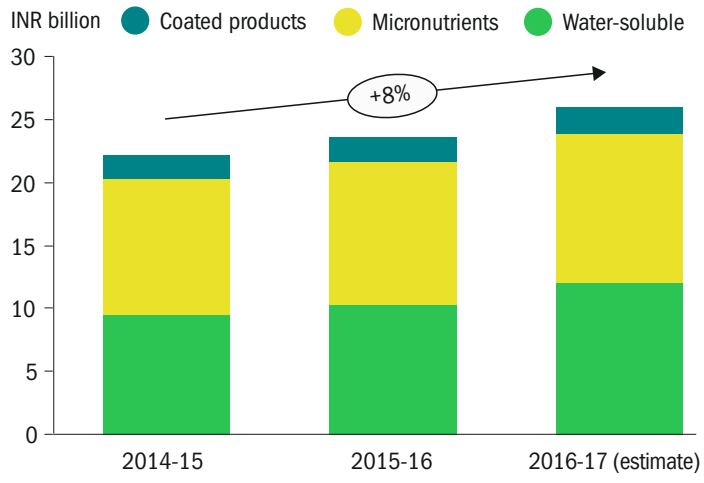


PHOTO: ISTOCKPHOTO.COM / LEONID ANDRONOV

The AFA welcomes you to Cairo

The theme of the 25th Arab Fertilizer Association Annual Fertilizer Forum & Exhibition is ‘Our Journey of Excellence’. This year’s Forum will be held at the Ritz Carlton Hotel, Cairo, 12-14 February 2019. AFA Secretary General, **Mohamed Zain**, provides a preview of what is the Arab region’s showcase annual fertilizer event.

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 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. Mohamed Zain, AFA Secretary General, is looking forward to welcoming delegates to Egypt in February:

“The Arab Fertilizer Association (AFA) would like to invite you to participate with more than 500 leaders in the 25th Annual Fertilizer Forum and Exhibition titled ‘Our Journey of Excellence’. 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.

“The Forum is considered the pre-eminent fertilizer industry economic event in the Middle East and Arab region. Attendance this year is expected to reach 500 participants from more than 33 countries worldwide. These include the chairs of Arab and international fertilizer companies, heads of relevant international associations and organization, experts, executives and general managers representing more than 133 companies and industry bodies.

“The Forum, since its launch in 1995, with the support of the Government of Egypt and Egyptian fertilizer production companies, has become an annual fixture and a must-attend fertilizer industry event.

“Behind the Arab fertilizer sector’s growing status in international markets is the region’s abundant and world-class natural gas, phosphate rock and potash resources. The remarkable returns generated by the fertilizer industry, through the production and export of fertilizers and associated raw materials, are also of great economic significance to Arab countries, and undoubtedly contribute to the region’s economic and social development.”

Forum programme

The AFA’s Forum programme for 2019 includes three days of plenary sessions starting on Tuesday 12th February. This year, the Forum’s main themes address:

- Arab region fertilizer policies
- Key factors shaping the fertilizer industry
- The supply and demand outlook
- Oil & gas markets and their impact on fertilizer production
- Fertilizer use efficiency
- The African fertilizer market
- Fertilizer industry sustainability
- Helping achieve world food security
- Environmental protection
- Fertilizer industry insurance
- Updates on the dry bulk freight market.

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, 2016-2017

	Production ('000 t)		Share of world total, 2017 (%)	Exports ('000 t)		Share of world trade, 2017 (%)
Product	**2016**	**2017**		**2016**	**2017**	
Ammonia	16,920	18,685	11	3,692	4,490	25
Urea	22,399	23,200	14	19,265	19,757	41
Ammonium nitrate	1,175	1,365	10	55	59	-
Phosphate rock	49,267	59,402	28	17,475	21,852	71
Phosphoric acid (P_2O_5)	7,357	8,228	17	2,261	2,436	81
TSP	1,695	1,854	72	1,727	1,815	49
DAP	8,088	11,639	37	8,382	9,913	70
Potash	2,030	2,320	4	1,842	2,166	4
Sulphur	10,176	10,185	18	9,138	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 2016 the region's exports accounted for around:

- 81 percent of world phosphoric acid trade
- 71 percent of world phosphate rock trade
- 70 percent of world DAP trade
- 49 percent of world TSP trade
- 41 percent of the world urea 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 28 percent of regional production, followed by Egypt (22%), Qatar (20%), Algeria (9%) and Oman (7%). Arab producers exported 4.5 million tonnes of ammonia in 2017. The main ammonia exporter is Saudi Arabia with a 43 percent share of regional exports, followed by Algeria (32%), Qatar (12%), Egypt (5%), Oman (3%), Bahrain (2%) and Libya (2%).

Arab countries have a 14 percent share of total world **urea** production and a 41 percent share of world trade. Production is concentrated in Egypt with a 26 percent share of regional production, followed by Qatar (25%), Saudi Arabia (18%), Oman (9%) and UAE (8%). Urea production is highly export-oriented. Qatar, notably QAFCO, is the leading regional urea exporter. Its urea exports of 5.4 million tonnes in 2017 accounted for 27 percent of total Arab region urea exports. Arab urea producers shipped a total of around 20 million tonnes in 2017.

Arab **phosphate rock** producers have a 28 percent share of world production and a 71 percent share of world trade. Morocco's OCP is the regional leader with a 59 percent slice of total Arab region production. Jordan (15%), Egypt (10%), Saudi Arabia (7%) and Tunisia (7%) are also major regional producers. OCP, the world's largest exporter of phosphate rock, has a 50 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 17 percent share of world production and an 81 percent share of world trade. Morocco again predominates in this sector, with a 69 percent share of regional production. The other main regional producers are Saudi Arabia (16%), 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 72 percent of world production and 49 percent of world trade. OCP is again the market leader, supplying 62 percent of regional TSP output, together with Tunisia (16%) and Lebanon (14%).

In the diammonium phosphate (DAP) market, Arab countries contribute 37 percent to world production and 70 percent to world trade. Morocco's OCP is once again the leading regional producer (53%) followed by Saudi Arabia (37%) and supplemented by production from Jordan (5%) and Tunisia (5%). Saudi Arabia is emerging as a major player in the world DAP market, being responsible for 29 percent of Arab regional exports, versus 59 percent for Morocco.

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 17 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 (29%), Qatar (9%) and Kuwait (9%). 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 world trade. 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.

Fertilizer INTERNATIONAL index 2018

A complete listing of all articles and news items featured in *Fertilizer International* during 2018.

PHOTO: CANPOTEX

Canpotex: Canada's export colossus (Sep/Oct, p64).

PHOTO: LONGXIN CONSTRUCTION GROUP

Saudi Arabia's phosphate megaproject (Mar/Apr, p44).

The year ahead: expect turbulence

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 2019.

Demand turning bearish in 2018/19?

PHOTO: DARIA RYBAKOVA / SHUTTERSTOCK.COM

Prospects for the world fertilizer market over the next five years remain relatively modest. Expectations of robust demand growth in Latin America and Sub-Saharan Africa are likely to be tempered by the impacts of market contraction in China and fertilizer subsidy reforms in India. In global agriculture, the prices of many agricultural commodities are also projected to grow slowly over the medium-term.

Trading turbulence

This paints a stable picture. Yet 2018 has been a turbulent year marred by the escalating US-China trade war and widespread currency devaluations. Political uncertainties have also been multiplying. The world's long-standing rules-based system of international trade and financial cooperation – which dates back to the post-war Bretton-Woods Agreement – has looked increasingly precarious.

The resulting turbulence in trading conditions is already affecting the fertilizer market, as the International Fertilizer Association reports[1]:

"World fertilizer demand remained relatively subdued in 2018. Global fertilizer market conditions were marked by depressed or near stagnant crop prices and rising energy prices in a global context of escalating trade tensions and weakening currencies in some large fertilizer consuming countries. These conditions impacted fertilizer affordability and nutrient demand prospects throughout the year."

Below, we look ahead at fertilizer industry prospects for 2019, and highlight some of the key demand and supply influences that will shape the market over the next year or so.

Growth steady but risks abound

The International Monetary Fund (IMF) is forecasting a steady expansion of the world economy this year, continuing the pattern of growth seen since mid-2016. Global growth is projected at 3.7 percent p.a. for both 2018 and 2019 – the same growth level as in 2017. Growth rates for

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.

both years have, however, been downgraded slightly since the IMF's previous forecast last spring.

Although fiscal stimulus is driving the US economy strongly upwards, the country's 2019 growth prospects have been revised downwards due to recently-announced trade barriers imposed by China. These included $200 billion of tariffs on US imports. The 2019 growth prospects of the UK and Eurozone countries have also been marked down.

In contrast, growth prospects for many energy-exporting countries have risen on higher oil prices. Elsewhere, growth forecasts for Argentina, Brazil, Iran, and Turkey have all been corrected downwards – a reflection of tighter financial conditions, geopolitical tensions, higher oil import bills and a range of country-specific factors. The IMF has sharply marked down Iran's prospects, in particular, following the reinstatement of US sanctions.

The IMF also expects China, and some other Asian economies, to experience "somewhat weaker growth" in 2019, as measures linked to the US-China trade dispute start to bite. "Since April 2018, protectionist rhetoric has increasingly turned into action," comments the IMF.

The Fund also warns of softening growth and growing downside risks to the global economy over the medium term, counter to its steadily rising growth projection for this year.

"Risks to global growth skew to the downside… [due to] elevated policy uncertainty," the IMF comments. "Several of the downside risks highlighted in April 2018 – such as rising trade barriers and a reversal of capital flows to emerging market economies with weaker fundamentals and higher political risk – have become more pronounced or have partially materialized."

Oil prices are projected to average $68.76 a barrel in 2019, a very slight fall on 2018's per barrel average of $69.38 – reflecting an expectation that global oil supply will gradually increase. With the exception of food, the IMF is also projecting falls in the prices of non-fuel commodities in 2019 of around 1.5-3.6 percent.

Food prices fall

As 2018 drew to a close, the FAO's food price index, at 160.8 points in November, was down almost 15 points (1.3 percent) year-on-year. The annual fall in the index was largely driven by price declines for vegetable oils, meat, dairy and sugar prices over the last 12 months. These falls more than offset a general rally in cereal prices in 2018.

> **Global food price stability will be under threat from trade wars, disease and El Niño in 2019.**

The decline in the vegetable oil price index has been particularly marked. It fell to a twelve-year low of 125.3 points in November, after ten consecutive monthly falls. The decline reflected weakening prices across the sector. Mainly to blame were high palm oil inventories, abundant US and EU soy oil supplies, and positive sunflower oil production prospects in the Black Sea region.

The cereal price index, in contrast, has remained buoyant. Its 164 point average in November was 11 points up (7.1 percent) from a year ago. The sugar price index has also rallied in recent months. It rose by 7.7 points (4.4 percent) to reach 183.1 points in November, the third consecutive monthly gain. These increases mostly reflect anticipated production falls in Brazil, where a 27 percent decrease in annual sugar output from the Centre-South region is being forecast.

Ag commodity outlook: a melting pot of risks

Looking ahead, global food price stability will be under threat from trade wars, disease and El Niño in 2019, warns agribusiness specialists Rabobank.

Stefan Vogel, head of agri commodity markets at Rabobank, said: "The agri commodity price environment may be relatively stable currently, but it's difficult to remember a time there were so many threats to food commodity prices on so many fronts, from trade wars to currency movements to weather threats and livestock disease."

Rabobank expects the trade war between the US and China, a dispute that shaped the 2018 market, to continue altering global trade flows in 2019. Soybeans are the agricultural commodity most affected by this. Rabobank forecasts that soybean demand in China – which currently imports 60 per cent of the world's soybeans – will fall below 90 million tonnes in 2018/19 due to import restrictions.

The resulting change in soybean trade patterns will be a long-lasting feature, warns Rabobank.

"The largest threat for farmers is the US-China trade war. Depending on whether the superpowers can reconcile, we're likely to see commodities like US soybeans continue to take a real hit as China snubs them. [Although] China might partly switch back to buying from the US, if and when the dispute is resolved, a full recovery of this trade flow seems unlikely," comments Stefan Vogel.

With China buying soybean from elsewhere, US farmers face an oversupply. This is likely to result in a doubling of US stocks to record levels by the end of 2018/19. The US dollar is also currently at an 18-month high and, consequently, US agricultural exports will continue to suffer from a lack of competitiveness abroad – yet another factor affecting US farm profitability.

While the US faces trade wars and currency headwinds, Brazil, the world's second largest soybean producer, stands to gain. The country's soybean farmers look set to be the main beneficiaries of both the US-China trade dispute and higher crop prices. Currency weakness in Brazil, linked to long-standing domestic political uncertainties, has also helped keep sugar and coffee exports competitive.

Weather could also significantly disrupt ag commodity markets in 2019 – given the 80 percent chance of an El Niño event being declared before winter ends in the northern hemisphere. Wetter weather in the US Southern Plains could mean an uplift in wheat production, for example. Palm oil, sugar and *Robusta* coffee yields, in contrast, are all likely to take a hit, if an El Niño emerges in 2019.

Fertilizer demand turns bearish?

The International Fertilizer Association (IFA) expects the world fertilizer market to turn bearish in 2018/19, particularly for nitrogen and phosphate[1].

Growth in global fertilizer consumption (+1.3%) was near to the medium-term average last year (2017/18) rising to 187 million nutrient tonnes[1]. Demand growth for phosphate and potash was firm but slow for nitrogen (Table 1). In contrast, the fertilizer market looks set to shift to below-aver-

age growth moving into the current year.

This more bearish outlook for 2018/19 reflects forecast contractions in the fertilizer markets of three countries: Australia, due to drought conditions; and in Pakistan and Turkey due to the effects of currency depreciations[1]. Nitrogen and phosphate fertilizer use in China – a key global marketplace – has also reached a tipping point, in IFA's view, and is likely to plateau or decline going forwards. Crop prices, a key demand driver, are also likely to remain relatively depressed.

Consequently, world nutrient demand this year (2018/19) is projected to expand by just 0.7 percent to reach 188.3 million tonnes (Table 1). This expansion largely depends on increased consumption in Brazil, India, the US, Indonesia and Argentina[1]. IFA's outlook also assumes no major unexpected weather, geopolitical and economic shocks. Of the three main nutrients, potash demand is forecast to increase most firmly in 2018/19, being especially strong in Asian countries.

More positively, IFA expects world fertilizer demand to pick up pace going into next year (2019/20) and increase by 1.6 percent to 191.4 million nutrient tonnes (Table 1). This rebound in consumption – above the medium-term trend – is linked to improving grain prices, firming nitrogen demand and market growth in India and Brazil. Latin America and South Asia combined are expected to account for 55 percent of the expected 6.7 million tonne net expansion in global nutrient demand between 2016/17 and 2019/20[1].

These latest forecasts do come with a health warning, however, with IFA warning of the downside risks dominating the outlook, particularly in 2019/20. Significantly, the Association has also corrected downwards its 2016/17 baseline figure, scaling-back it previous world fertilizer demand estimate by 0.8 million tonnes to 184.6 million nutrient tonnes (Table 1). This means that the fertilizer market actually grew more strongly in 2017/18 (1.3 percent) than previously estimated (*Fertilizer International* 382, p20).

In summary, the following fertilizer market demand trends are likely over the three year period 2016/17 to 2019/20:

- Sizable contractions in consumption in China, EU, Turkey, Pakistan, Germany and Spain
- Strong market rebounds in India and the US, following falls in 2016/17
- Robust market growth in Brazil, Ukraine, Indonesia and Russia supported by good ag export prospects
- Government-led demand boosts in Nigeria, Ethiopia and Bangladesh.

Global supply and trade

Global sales of primary fertilizer raw materials (ammonia, phosphate rock and primary potash products) are expected to grow by 1.4 percent to 192 million nutrients tonnes in 2019[1].

Fertilizer production capacity continues to grow strongly. Major investment decisions made five to eight years ago under more bullish market conditions are now reaching fruition. Consequently, the large incremental capacity increases of 2018 are set to be followed by further large-scale expansions into 2019.

In total, IFA expects 60 new ammonia, phosphoric acid and potash production units and expansion projects to come on-stream in 2018 and 2019, adding 10 million tonnes of additional nutrient capacity to world supply[1]. However, the market impact of these capacity additions – particularly the potential for production surpluses – will be mitigated by slippages in project completion dates and supply constraints, according to IFA.

World urea capacity is projected to grow by three percent in 2018 and 2019 to reach 224 million tonnes. The bulk of the six million tonne incremental increase is expected to occur in the final 12 months. New urea production plants should come on-stream in India, Nigeria, Mexico, Azerbaijan and Russia. Global urea exports, equivalent to around 28 percent of world sales (169 million tonnes), fell back slightly (-1%) to 47.7 million tonnes in 2018. A further export decline to 45.2 million tonnes is forecast in 2019, with urea imports to the US and India down by more than one-fifth year-on-year[1].

Finished phosphates capacity is forecast to rise by seven percent during 2018 and 2019 to reach 105 million tonnes. Capacity increases will mainly occur in Morocco, Saudi Arabia and Egypt[1].

Global production in finished phosphates was largely static last year (71 million tonnes) with almost half of volumes (34 million tonnes) traded globally. Diammonium phosphate (DAP) exports remained firm in 2018, with extra export tonnages emerging from Morocco, Saudi Arabia and Russia, contrasting with stable monoammonium phosphate (MAP) export levels. China's DAP exports in 2018 were up five percent year-on-year, while its MAP exports fell 20 percent[1].

World DAP production is expected to be stable in 2019 (36 million tonnes), with slight growth in global export sales (+1% to 18-19 million tonnes), mainly to South Asia and Southeast Asia. MAP exports should exceed 13 million tonnes in 2019, thanks to higher sales to Latin America and Africa[1].

World potash capacity is set to rise by 4.8 percent (4.7 million tonnes) during 2018 and 2019 to reach 103.3 million tonnes. The total rise in production capacity of 6.3 million tonnes over this period will be partly offset by plant closures and mothballing in Canada (-2.0 million tonnes) and Europe (-1.0 million tonnes). Russian projects alone will add an extra 4.6 million tonnes of potash capacity to the market[1].

Global muriate of potash (MOP) production rose significantly in 2018 (+3% to 72 million tonnes), driven by firm exports.

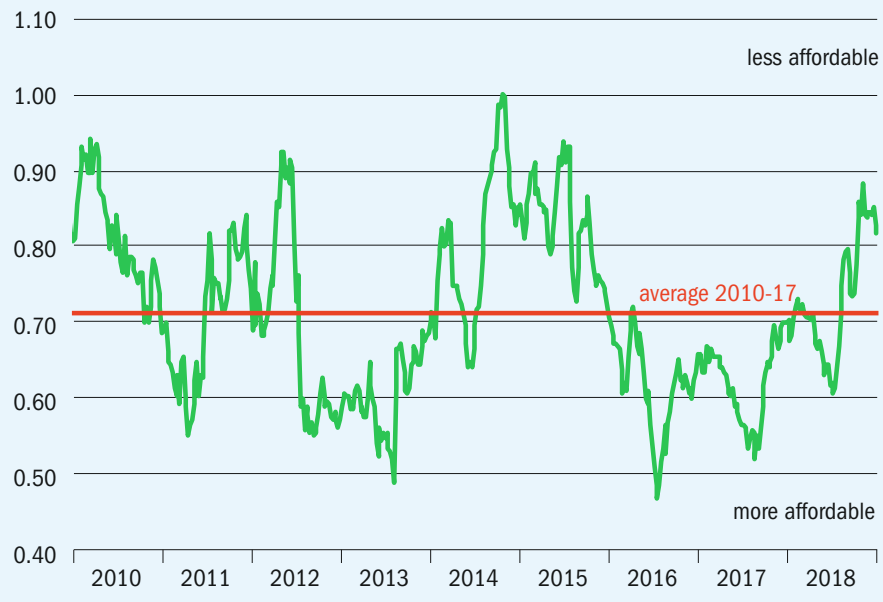
Table 1: **Global fertilizer demand forecast, million nutrient tonnes***

Nutrient	2019/20f (million tonnes)	2018/19f (million tonnes)	2017/18e (million tonnes)	2016/17 (million tonnes)	2015/2016 (million tonnes)
N	107.4 (+1.4%)	105.9 (+0.3%)	105.6 (+0.8%)	104.7	104.0
P_2O_5	46.3 (+1.8%)	45.4 (+0.8%)	45.1 (+2.0%)	44.2	43.5
K_2O	37.7 (+2.1%)	36.9 (+1.8%)	36.3 (+1.7%)	35.7	34.9
Total	191.4 (+1.6)	188.3 (+0.7%)	187.0 (+1.3%)	184.6	182.4

** Year-on-year percentage increase in parentheses*
e = estimate f = forecast

Source: IFA (2018)

Fig. 1: **Fertilizer crop-to-price ratio, 2010-2018**



Source: The Mosaic Company

Global MOP exports amounted to 54 million tonnes last year, around four-fifths of total sales. Global trade in MOP looks set to expand further in 2019 (+2% to 54.5-55.0 million tonnes), on the back of firming demand in Southeast Asia and Brazil[1].

Synthesis

Despite the continuing strength of the world economy – with global growth of 3.7 percent forecast for 2019 – the IMF is warning of softening growth and growing downside risks over the medium-term.

IFA also warns of escalating risks in its latest outlook[1]: "Not only would an escalation of trade tensions adversely impact global economic growth. But an uncooperative environment could manifest itself dramatically if a coordinated world response to a potential major economic or financial crisis were required."

In its 2019 outlook, Rabobank highlights a worrying "melting pot of risks" threatening global food price stability. These include the US-China trade war, currency movements, livestock disease and the high probability of an El Niño event.

The dramatic currency declines seen in Argentina, Turkey, Russia, Brazil and India in 2018 – over 50 percent in the case of Argentina – will have mixed effects. While boosting the competitiveness of agricultural commodity exports, and generating higher revenues from international sales, currency slides also increase the cost of fertilizer imports and make these less affordable.

Agricultural commodity prices have followed a diverging trend. Cereal prices have been strengthening throughout 2018, for example, reflecting tighter supplies. The vegetable oil price index, in contrast, fell to a twelve-year low towards the end of last year, after ten consecutive monthly falls. The declines reflected high palm oil inventories, abundant US and EU soy oil supplies, and positive sunflower oil production prospects. Soybean prices also suffered in 2018 from a combination of record production, high stock levels and the US-China trade war.

This trade war is undoubtedly casting a shadow on global agriculture, and causing possibly permanent shifts in trade flows. US farm sector confidence has taken a major hit and is also facing headwinds from a rising currency. Brazil, in contrast, the world's second largest soybean producer, look set to be the main beneficiary of Washington's current trade dispute with Beijing. Also, while the dollar's strength has harmed the competiveness of US farm exports, Brazil's sugar and coffee exports have received a boost from its currency weakness.

Summarising the agricultural outlook, IFA says it is "cautiously optimistic for cereals, rapeseed and cotton, but not for soybeans, sugar and palm oil".

Fertilizers have undoubtedly became more expensive in 2018. Mosaic's fertilizer-to-crop price ratio, a key measure of affordability, strongly appreciated last year, having risen above the 2010-18 long-term average (0.71) in the last six months (Figure 1). "Plant nutrients today are more expensive than the good buys of the last two years," confirms Mosaic. "But they remain affordable."

IFA expects world fertilizer demand to fall back to below the medium-term average in 2018/19, and remain particularly bearish for nitrogen and phosphate products. A downturn in consumption is expected in three markets: Australia, Pakistan and Turkey. Nitrogen and phosphate fertilizer consumption in China – a key global marketplace – has also reached a tipping point, and is likely to plateau or decline going forwards. More positively, world demand should rebound in 2019/20, led by rising consumption in India and Brazil.

There has long been speculation that the global fertilizer market could be about to enter a slower growth era. What is certain is that, without China, the fertilizer industry will becoming increasingly reliant on fast-growing but smaller and more fragmented markets as the main engines of future demand. The waning of China's influence will also deepen the industry's dependency on India's heavily-subsidised fertilizer market – which at some future point will inevitably face deregulation and rebalancing.

On the supply-side, large additions of new low-cost fertilizer production capacity will continue this year – although supply constraints and project delays should lessen the potential for growing supply surpluses. Trade prospects in 2019 look mixed. The global trade in finished phosphates and potash products is set to expand year-on-year, helping offset a slight contraction in urea trading.

The key take-home message from IFA's latest outlook is to expect turbulence:

"The global trade environment has not seen such turbulence in decades. A flurry of trade measures – a notable escalation of tariffs and defensive trade measures, import bans and barriers – has been emerging in the fertilizer business, affecting various regions and products."

So fasten those seatbelts – as 2019 could be a bumpy ride. ■

References

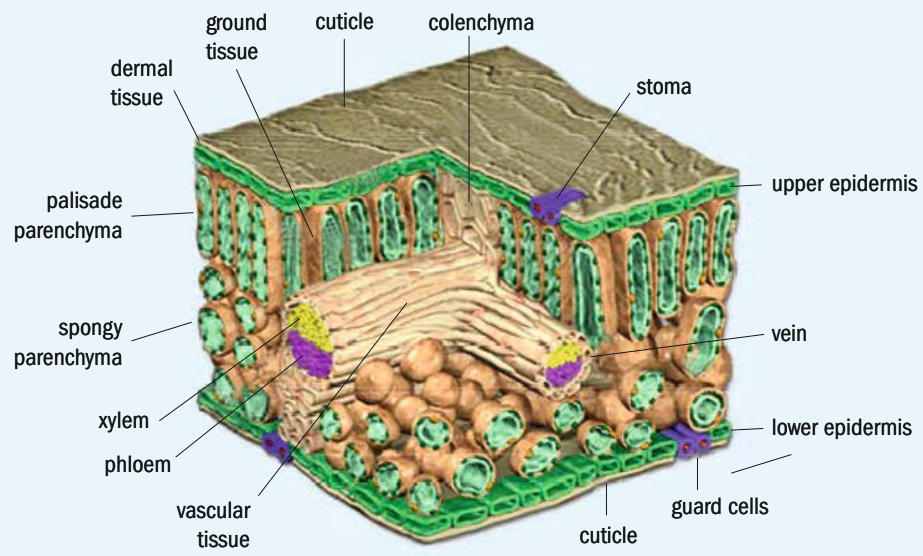
1. IFA, 2018. Short-Term Fertilizer Outlook 2018-2019. *IFA Strategic Forum*, 13-14 November 2018. Beijing. International Fertilizer Association (IFA).

Feeding with foliar fertilizers

PHOTO: VALENTYN VOLKOV / SHUTTERSTOCK.COM

Foliar fertilization offers a number of specific advantages over soil application. The range of tailor-made fertigation products on the market is expanding to meet growing agricultural demand.

Fig. 1: **Leaf tissue anatomy**



Source: Ronen (2008)

Foliar fertilization supplies plants with nutrients by directly applying a liquid fertilizer to their leaves. Plant leaves are able to absorb nutrients through their outer layer (cuticle/epidermis) and microscopic pores in their surface (stomata) (Figure 1). Although stomata offer a rapid pathway for nutrient take-up, absorption through the epidermis can be just as significant[1].

Foliar feeding is an effective fertilization method for correcting nutrient deficiencies and overcoming the inability of soils to transfer nutrients to plants. For some fruit crops – tomatoes, for example – foliar feeding during flower set can dramatically increase fruit production and yields.

In certain circumstances, foliar fertilization can be up to 8-10 times more effective than soil applications. It can also supply plants with nutrients very rapidly. Up to 90 percent of foliar-fed nutrients can be found in the roots of a plant within one hour of application[1].

When is foliar fertilization recommended?

Foliar applications are worthwhile and cost effective – as a complement to soil-applied fertilizers or fertigation – when:

- Plant nutrient deficiencies need correcting quickly at critical growth stages
- Root uptake of nutrients is prevented by disease
- Soil fertilization is inadequate
- Soil conditions are poor, due to low soil temperature, poor aeration and water logging, for example.

Leaves are designed primarily for photosynthesis, however, not for nutrient absorption. Foliar-applied liquid fertilizers need to be able to penetrate the leaf, through stomata openings or directly through the cuticle, before they dry out (Figure 1). However, the structure of leaves prevents plants from absorbing nutrients in large amounts. Consequently, attempting to correct major nutrient deficiencies via foliar fertilization is usually impractical.

While foliar feeding is particularly useful for supplying plants with micronutrients – and for rapid 'emergency' correction of other nutrient deficiencies – it does have limitations. Foliar application of major nutrients, for example, is usually only capable of supplying a fraction of a plant's total needs. Foliar applications, although they

take effect quickly – typically within one to three days – are not long-lasting and have much less residual value compared to soil applications[1].

Foliar fertilization is therefore generally used to supplement soil applications of N, P and K. Although foliar NPK sprays have been shown to 'green up' leaves in numerous trials, significant yield improvements are less readily apparent, especially in situations where enough NPK is already being supplied via the soil. Indeed, if the soil is still delivering plenty of NPK nutrients additional concentrations in foliar sprays can cause leaf damage, and even kill plants in extreme cases.

In summary, foliar spraying is generally recommended as a flexible and supplementary method of fertilization – one that is able to optimise crop yield and quality by rapidly supplying nutrients at critical growth stages. It is also capable of fertilizing plants with those nutrients (such as zinc and iron) that may not be readily-available for root uptake. Foliar sprays can also be used to deliver pesticides, plant hormones and biostimulants.

Benefits of foliar fertilization

Crops generally experience periods of high nutrient demand during critical stages of the growing season. These episodes are associated with an upsurge in nutrient uptake. The following plant growth stages are most likely to benefit from additional foliar fertilization, according to agronomists:

- **Rapid seedling growth** in annual crops after germination
- **Shoot emergence and grain filling** in cereals
- Early spring **shoot growth** in all perennial crops
- **Flowering and fruit-set** in deciduous crops – when there is increased demand for boron and copper for pollen-tube development and growth
- **Rapid fruit growth** in many types of fruit crops
- The fast **bulking-up** stage in bulb and tuber crops
- **Lint production initiation** in lint crops.

Nutrient uptake at these critical growth stages is important as it will determine the yield and quality of produce. However, the supply of nutrients from soil can be limited due to:

- Waterlogging inhibiting the respiration and functioning of roots
- Low temperature limiting root nutrient uptake
- Competition for nutrients from uncontrolled weeds
- Internal bottlenecks within the plant.

Foliar feeding can ensure an adequate nutrient supply in such adverse circumstances. Foliar applications can also be used to help plants recover from transplant shock, hail damage or from weather extremes.

A key advantage of foliar over soil-applied fertilizers is their ability to quickly address nutrient deficiencies. This makes foliar treatments ideal for the prevention or correction of plant nutrient shortfalls. The application of liquid fertilizers to the leaf provides nutrients with a quicker and more direct route to deficient parts of the plants. Soils, in contrast, can act as a nutrient barrier or buffer due to their complex chemical, physical and biological properties.

Inspired by
The School of Athens, Raffaello Sanzio 1509-1511
Vatican Museums. Photo Scala Archives

AMMONIA

NITRATES & PHOSPHATES

UREA

MELAMINE

METHANOL

SYNGAS

Foliar sprays give growers the ability to:

- Immediately apply nutrients as soon as deficiency symptoms are recognised
- Adjust the concentration and frequency of applications to address and correct the deficiency

The nutrients applied can be tank-mixed and applied together with other inputs, such as pesticides and biostimulants, in a single spray, saving on costs.

While foliar fertilization is widely used on a variety of crop types, the economic benefits are generally greater for horticultural crops. These are typically of higher value – and their nutrient status is usually monitored more frequently.

Success factors

Foliar fertilization involves the diffusion of dissolved nutrients. For rapid absorption, nutrients need to be water-soluble and/or present as non-polar compounds such as chelates. Finely-ground insoluble suspensions, such as magnesium hydroxide or elemental sulphur, in contrast, are not well-suited to foliar use.

The diffusion of nutrients into the plant requires a moist leaf surface. Spraying is therefore ideally carried out in the evening, as this helps prevent the sprayed film from drying out on the leaf surface. Nocturnal dew formation also ensures foliar spraying is effective, and enhances nutrient absorption, by keeping leaves moist. Evening dew can re-dissolve dried-out spray, enabling diffusion into the leaf to resume.

The addition of wetting agents can also enhance and optimise leaf surface conditions. These are often included in plant protection formulations. Manufacture recommendations on concentration and miscibility need to be followed when foliar fertilizers are applied alongside fungicides or insecticides.

Adherence to the following guidelines should ensure that foliar fertilization is efficient and avoids crop damage:

- Avoid leaf burn by using very dilute nutrient solutions and avoiding excessively large doses of highly concentrated sprays
- Keep the pH of spray solutions in the near-neutral range (pH 5.5-8.5)
- Apply solutions as a finely atomised spray
- Increase absorption by ensuring sprays reach and coat the underside of leaves where most stomata are located
- Delay foliar fertilization until the temperature falls to below 27°C (80°F), as stomata are closed above this temperature leading to very poor absorption
- Adding a surfactant can increase absorption by lowering the surface tension of the spray solution on the leaf.

Application technologies such as electrostatic sprayers can also improves efficacy. These impart a charge to help spray droplets adhere more strongly to leaves.

Limitations

Foliar fertilization is a powerful application method capable of tackling a range of crop problems. But it does have a number of limitations, including:

- Low penetration rates, particularly in leaves with thick wax/cuticles
- Nutrient run-off from hydrophobic surfaces and nutrient wash-off by rain
- Rapid drying of spray solutions, preventing nutrient penetration
- A single foliar application can only supply limited quantities of dissolved nutrients
- Poor translocation rates for certain nutrients
- Possible leaf damage (necrosis and burning).

Cotton and soybean

Potassium deficiency is a widespread problem in the US Cotton Belt. Cotton is one of several crops which are relatively inefficient at removing potassium from soils through their root systems. In particular, root activity decreases as the boll load develops. Unfortunately, this is the growth stage at which the plant's demand for potassium peaks. Potassium deficiency is also associated with modern cotton varieties which are early-maturing, higher-yielding and faster fruiting.

An average cotton crop in the United States has a total potassium demand of 100-220 kg/ha. Foliar applications are a useful way of supplementing soil-applied potassium at critical growth stages. Cotton also lends itself to foliar fertilization due to the large number of spray applications already required for pest control. Four weekly potassium applications (4.5 kg/ha), beginning at early flowering, are typically necessary to maximise cotton yields.

Foliar fertilization of soybean is recommended for fields with low soil nutrient levels, due to insufficient pre-plant fertilization, and where soil or climate factors limit nutrient uptake in late spring and early summer. Spraying small doses of nutrients on soybean foliage at the seed development stage can be effective. Plants show a sharp decline in root activity during late seed development, and large-scale movements of nutrients (translocation) also occurs from leaves into the pods at this stage. Foliar applications during early growth stages can also supplement pre-plant fertilization and increase nutrient supply at a time when roots and nitrogen-fixing nodules are not well-developed.

Foliar products and manufacturers

Leading Brazilian fertilizer manufacturer **Produquímica**, part of Compass Minerals, produces and markets the *ProAqua Pulse*, *Elevate* and *Restore* range of speciality plant nutrients. The company's *ProAcqua* portfolio combines high-quality nutrients with proprietary enhancers (adjuvants). These products are marketed on solubility, compatibility and their ability to secure an attractive return on investment.

Pulse products are Ideal for foliar feeding. They help mitigate the stress on pulses and legumes resulting from herbicide applications, and also extend the life of nitrogen-fixing nodules in legume crops. *Elevate* products deliver molybdenum, chelated cobalt and chelated nickel to crops as part of a balanced fertilization programme. The correct balance of potassium, magnesium and chelated copper in *Restore* products helps to keep plants healthy and fight off biotic stress.

ProAcqua foliar products are completely water-soluble and provide uniform leaf coverage and fast leaf penetration. They are highly compatible with phosphate-based fertilizers, herbicides and most crop protectants. The range includes:

- *Restore* (0-42-26 + Mg, S and Cu): a potassium, magnesium and copper formulation that helps mitigate biotic and abiotic stress
- *Restore CA* (0-42-26 + Mg, S and Cu): a phosphorous, potassium, magnesium and copper formulation that helps mitigate biotic and abiotic stress
- *Elevate* and *Elevate Ni*: molybdenum, chelated cobalt and chelated nickel formulations that increase nitrogen use efficiency and the formation of amino acids
- *Pulse* and *Pulse Ni* (0-6-4 + Mg, S, Co, Mo, Ni and Zn): formulations for pulse

and legume crops that extend the life of nitrogen-fixing nodules

- *Flow* (5-10-20 + Mg, S and B): a macro- and micro-nutrient formulation with adjuvants, designed for high-yielding crop systems, to help transport sugars during the last stages of fruit development
- *K-Micro* (0-0-10 + Mg, S, B, Cu, Mn and Zn): a potassium-rich macro- and micro-nutrient formulation with adjuvants, designed to prolong leaf health and improve crop quality and yield
- *N-Micro* (12-0-3 + S, Cu, Fe, Mn, Mo and Zn): a nitrogen-, manganese- and zinc-rich formulation with adjuvants, that helps mitigate biotic and abiotic stress, and promotes vegetative growth through increased root formation and nitrogen assimilation.

Speciality fertilizer producer **Compo Expert** (now owned by Grupa Azoty) markets the *Fetrilon* range of water-soluble foliar fertilizers. These carefully formulated micronutrient mixtures are fully chelated by EDTA to protect against soil fixation. Chelation also results in rapid leaf penetration and nutrient uptake and better nutrient transport (translocation) within the plant. The range includes three notable products:

- *Fetrilon Combi 1* is a concentrated multi-micronutrient fertilizer with magnesium and sulphur
- *Fetrilon Combi 2* is a concentrated multi-micronutrient fertilizer with magnesium, sulphur and higher boron and zinc content
- *Fetrilon 13* is a concentrated iron fertilizer containing 13 percent iron in chelated form.

Fetrilon Combi products offer growers a "high quality, cost effective solution for safeguarding and optimizing both yield and quality of crops", according to Compo. One to three applications are recommended during critical growth stages in apples and grapevines.

Fetrilon Combi has been shown to improve winter wheat yields by an average of 200 kg/ha, based on the results of 83 trials in Germany over a 13-year period. Other German crop trials with *Fetrilon Combi* have demonstrated yield increases of five percent for potatoes (eight trials) and 10 percent for Riesling grapes (four trials).

Foliar fertilizers offered by **ICL Specialty Fertilizers** incorporate two proprietary technologies, *M-77* and *FertiVant*. Patented *M-77* technology improves delivery of the spray solution, leaf nutrient uptake and the translocation of nutrients within plants. *M-77* is incorporated in ICL's *Agroleaf Power* foliar products and includes:

- Compounds that extend the effectiveness of chelates delivered by the foliar spray
- Vitamins that increase the metabolic activity of the tissues absorbing the spray
- Functional compounds that boost nutrient utilisation
- Stress-reducing compounds that maintain productive capacity by improving crop resistance to abiotic stress.

FertiVant, in contrast, uses a proprietary enhancer (adjuvant) to help foliar solutions break through the leaf cuticle and achieve higher penetration rates. The technology also enables the continuous release of nutrients for up to four weeks after spraying, an effect ICL calls 'long lasting performance' (LLP). Essentially,

FertiVant acts as continuous nutrient delivery system that:

- Allows nutrients and biostimulants to pass through the leaf cuticle
- Ensures the even spreading of spray droplets on the leaf surface
- Firmly attaches active ingredients to the leaf surface
- Delays evaporation.

FertiVant is incorporated into ICL's *NutriVant* water-soluble foliar range to help guarantee the fast and efficient uptake of nutrients and biostimulants. The technology dramatically increases the effectiveness of foliar sprays, according to ICL, improving crop quality, yield and grower revenues.

ICL's *NutriVant* foliar range is available in formulations for maize, cereals, grapes, potato, cotton and fruit trees. These fully water-soluble products are designed to prevent nutrient deficiencies and contain a tailor-made mixture of major, secondary and micro nutrients. *NutriVant* products work at a low spray dosage, reducing the nutrient cost per hectare. They are chloride-free, fully water-soluble and suitable for all fertilization programmes.

ICL also offers a portfolio of liquid foliar fertilizers for arable, fruit and vegetable crops marketed under the *Agroleaf Liquid* brand. These incorporate *F3* surfactant technology to improve the efficiency of foliar sprays.

> **Foliar sprays give growers the ability to immediately apply nutrients as soon as deficiency symptoms are recognised.**

UK-headquartered **Omex** is a large international liquid fertilizer producer, with manufacturing sites in the UK, US and Canada. The company offers a comprehensive and market-leading range of high-performance liquid foliar fertilizers:

- *Bio 20* is a unique package of nutrients, biostimulants and micronutrients optimised for foliar application
- *Folex B* is a high concentration liquid boron product (15.0% B) for correcting deficiencies in most crops, including sugar beet, oilseed rape, brassicas and carrots
- *High N* is a highly-concentrated, fast-acting foliar nitrogen product, with extra magnesium and a range of micronutrients, suitable for correcting deficiencies in most crops, including cereals, oilseed rape and potatoes
- *K50* is a highly-concentrated liquid potassium product (50% K_2O) suitable for correcting deficiencies in a wide range of crops, including cereals, potatoes, maize, lettuce and leafy salad vegetables
- *Magnesium Plus* is a liquid formulation of magnesium, manganese, nitrogen and sulphur suitable for correcting deficiencies in most crops, including cereals, oilseed rape and potatoes, sugar beet, legumes and grassland
- *Micromex* is a water-soluble suspension that provides a balanced combination of micronutrients, magnesium and sulphur to promote crop yield and quality in most agricultural and horticultural crops
- *Quad 14* is a concentrated suspension of four nutrients (nitrogen, phosphorus as phosphite, potassium and calcium) used to alleviate calcium deficiency and strengthen cell walls in potatoes and a variety of leafy crops.

Omex has reformulated its foliar product range to incorporate *Enhanced Bio-Availability* (EBA) technology to optimise foliar uptake and nutrient assimilation. A silicon based non-ionic wetting and spreading agent, *SW7*, can also be used to improve the foliar uptake of nutrients, particularly for those crops where it is difficult to achieve good coverage because of waxy or tight layers of leaves or dense canopies.

Omex offers *Kickstart* as a foliar product for improving crop establishment and root growth. Formulated with nitrogen and potassium, it also incorporates a phosphite-based rooting stimulator to promote early root growth in young plants. Foliar applications improved cereal yields by 0.5 t/ha in randomised trials.

The range of liquid *Crop Vitality* fertilizers from **Tessenderlo Kerley International** (*Thio-Sul, KTS, K-Row 23, CaTs, MagThio* and *N-Sure*) are all readily-available through leaf tissue. The company's slow-release liquid fertilizer *N-Sure*, for example, can be used as a foliar product, as an alternative to injection through irrigation systems, or soil application. The product provides superior coverage and nitrogen absorption on the leaf tissue and is compatible with many fertilizer solutions.

When applied as a foliar spray, *N-Sure* acts like a humectant, keeping the leave surface moist for a longer period of time, allowing nitrogen and other applied nutrients to be absorbed. The product's patented Tri-azone technology slowly releases nitrogen in a non-phytotoxic form with no leaf burn, even at a highly concentrated dose.

Haifa Group notably offers the *Haifa Bonus* and *Poly-Feed* range of premium foliar fertilizers. Products include:

- *Haifa Bonus* (13-2-44): a crystalline, fully water-soluble, phosphate-enhanced, high-potassium foliar fertilizer based on Haifa's *Multi-K* potassium nitrate
- *Poly-Feed Foliar*: a fully water-soluble, high-quality NPK fertilizer for foliar application
- *Poly-Feed MAR*: a variety of *Poly-Feed* enriched with either 0.5 percent or one percent seaweed extracts.

Haifa also supports growers with its *FoliMatch* mobile app, a convenient and easy-to-use nutrient calculator for precise foliar feeding. *FoliMatch* is a useful crop nutrition tool that provides growers with foliar fertilization data for the growth stages of ten individual crops.

Conclusions – the case for foliar feeding

Foliar fertilization allows growers to circumvent soil-applied fertilizer applications when these are performing poorly. Fertilization via the leaf avoids the major limitations associated with soil application – such as leaching, fertilizer precipitation, nutrient antagonisms, and the soil fixation of phosphorus and potassium. Unlike soil application, which can lose nutrients to weeds, foliar spraying allows nutrients to be precisely targeted at the crop[2].

Foliar feeding also avoids the problems of low nutrient absorption by roots, usually caused by low or high soil temperature (<10°C, >40°C), a lack of oxygen in water-saturated soils, nematode damage, or low root activity during certain growth stages[2].

Foliar feeding is undoubtedly the fastest way to correct nutrient deficiencies and boost crop performance during critical plant growth stages. Spraying chemically-compatible foliar fertilizers as a single solution with pesticides also saves on costs[2]. ■

References

1. Channarayappa, C., & Biradar, D., 2018. *Soil Basics, Management and Rhizosphere Engineering for Sustainable Agriculture*. 1st Edition. Boca Raton, FL: CRC Press.
2. Ronen, E., 2008. Foliar feeding: another successful way of feeding plants. *Practical Hydroponics and Greenhouses*.

Green ammonia technology

Casale's proprietary partial oxidation (POX) reactor.

PHOTO: CASALE

The shift to 'green' ammonia production will be integral to the transition to a low-carbon economy. We report on the carbon-free ammonia technologies being developed by Casale, JGC, Proton Ventures, thyssenkrupp, Topsoe and others.

A low-carbon future?

Carbon-free ammonia production took centre stage last year. In November, trade association Fertilizers Europe launched 'Feeding Life 2030', its new long-term strategy for the European fertilizer industry.

This set out a vision for Europe in which around 10 percent of ammonia production by 2030 will come from hydrogen generated by water electrolysis. The strategy also proposes a valuable role for ammonia as a liquid energy storage medium, to help level-out the fluctuations in intermittent renewable electricity generation.

"Ammonia production units of the future are likely to be flexible, able to use different sources of hydrogen, and to function as energy storage units and back-up energy producers," the strategy said

"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, president of Fertilizers Europe and Fertiberia's CEO.

A number of other concrete steps were taken last year to help bring about this clean energy transition. In August, for example, Morocco's **OCP Group** and Germany's **Fraunhofer Institute** announced their new collaboration on 'green' fertilizer production technology.

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

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 energy 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."

Germany's **thyssenkrupp Industrial Solutions (tkIS)** also launched a new modular technology for industrial-scale water electrolysis last June. This makes large-scale hydrogen production from renewable energy economically attractive.

Electrolysis modules developed by thyssenkrupp are capable of producing hydrogen at scale. These combine a large active cell area (2.7 m^2) with 'zero-gap' electrolysis technology to deliver an efficiency of more than 82 percent.

Sami Pelkonen, CEO of the electrolysis and polymers technologies business unit at tkIS 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

Fig. 1: **The hybrid plant solution**

Source: Topsoe

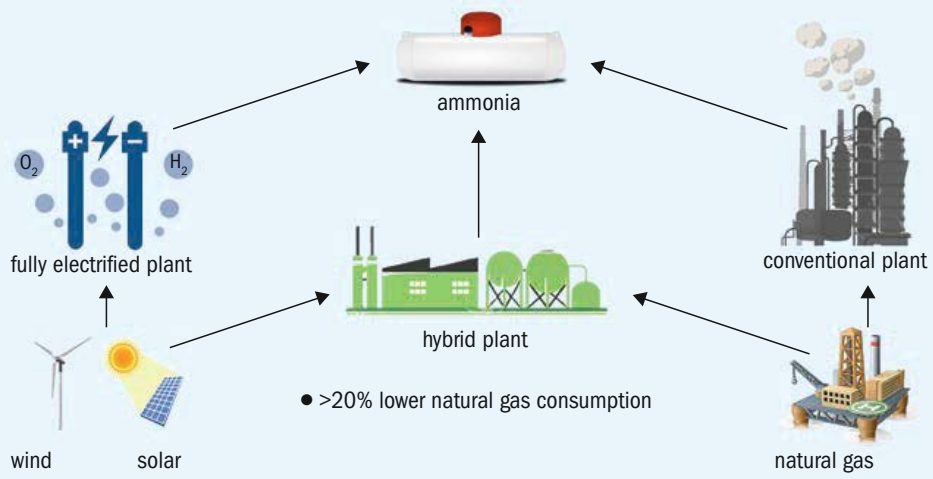
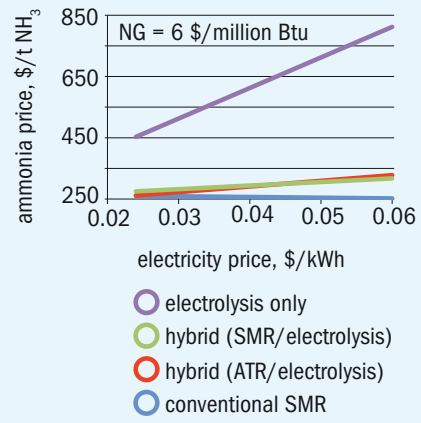


Fig. 2: **Ammonia production price versus electricity cost**



Source: Topsoe

ways: for energy storage, mobility, and the production of sustainable chemicals."

Roland Käppner, head of energy storage and hydrogen at thyssenkrupp Uhde Chlorine Engineers, added: "Based on decades of experience in developing and building electrolysis plants, we have designed our product to meet our client's most important demands: easy to deliver and install, highly efficient, with minimized investment and operation cost. And we have an industrial-scale supply chain of 600 MW per year already in place."

Importantly, this electrolysis technology is modular. The pre-fabricated skid-mounted modules can be easily integrated into existing plants. Projects can be scaled-up by combining multiple modules together, potentially delivering hundreds of megawatts of capacity in a single array. 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 manufacturing.

The above examples typify a wider industry trend. Almost all of the leading technology providers to the global ammonia industry are pressing ahead and rapidly-developing their own green ammonia plant concepts. We review the latest developments in green ammonia technology from Topsoe, tkIS, Proton Ventures, Casale and JGC Corporation below.

Topsoe: practical, viable technology

As a world leader in catalysis and the ammonia process, Denmark's Haldor Topsoe is well positioned to become a leading technology provider for the emerging green fertilizer production and energy storage markets. It is currently investing in and developing technologies for:

- The production of ammonia from renewable energy, water and air
- Ammonia as an energy storage medium for the power sector
- Cost competitive production of sustainable ammonia – both at world-scale and small-scale capacities
- Sustainable ammonia to feed and power the world.

The transition from conventional to carbon-free ammonia production will only happen in stages, in Topsoe's view, and therefore requires a stepwise approach. With this in mind, the company is developing and marketing hybrid technologies as a practical pathway to a more sustainable ammonia industry.

Topsoe's green ammonia plant concept combines hydrogen generated from a small-scale water electrolysis unit with nitrogen generated by an air separation unit (ASU). The company has already constructed demonstration plants to test and prove the concept.

Topsoe is offering small-scale electrolysis units as a hybrid solution for ammonia production (Figure 1). These units can be incorporated into new-build plants, or added to operational ammonia plants during revamping. Both of these options provide a practical way of starting the transition to sustainable ammonia production. Topsoe has demonstrated that hybrid ammonia plants, which partly substitute fossil energy sources which small electrolysis units, can be cost competitive as they retain economies of scale. Hybrid plants are generally economically viable if renewable sources contribute up to 25 percent to their energy mix.

Topsoe has analysed the costs of electrolysis-based green ammonia production versus ammonia production based on conventional steam methane reforming (SMR). A conventional world-scale ammonia plant offers the lowest per tonne production cost for ammonia, assuming a natural gas (NG) price of $6/million Btu. An equivalent large-scale green ammonia plant – based on AEM (alkaline exchange membrane) electrolysis – will find it hard to compete, currently, as their production costs are approximately double. In contrast, hybrid plants (revamp or new-build) can compete with conventional SMR when the electricity price is below $0.03/kWh (Figure 2). Renewable generation would begin to breakeven at a significantly higher electricity price if a carbon tax was introduced, even at modest levels.

Topsoe has longer-term ambitions to replace water electrolysis with more energy efficient steam electrolysis technology.

Fuel cells also have potential as renewable electricity sources in ammonia production. But the current capacity of solid oxide electrolyser cells (SOEC) is small-scale and needs to be increased incrementally, from the kW into the MW and ultimately the GW capacity range. Learning how to scale-up such fuel cells will involve a gradual development process, in Topsoe's view.

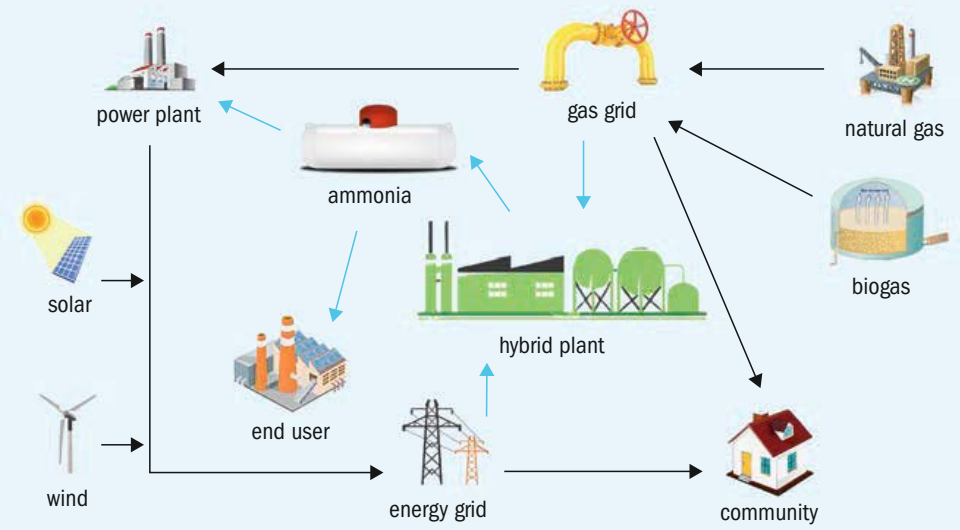
Topsoe plans to complete an SOEC ammonia demonstration plant by 2025. This will demonstrate how syngas can be produced from H_2 and N_2, in the right molar ratio, without an air separation unit (ASU), and at the highest overall efficiency. The knowledge and experience gained from this demonstration plant can then be used to help commercialise an efficient, sus-

tainable and cost competitive SOEC-based ammonia production process.

Interest is also growing in the use of ammonia as a fuel in power production, due to its ability to store renewable energy and release this when it is most needed. Valuably, ammonia's properties as an energy carrier allow it to be used for both energy storage and long distance energy transportation.

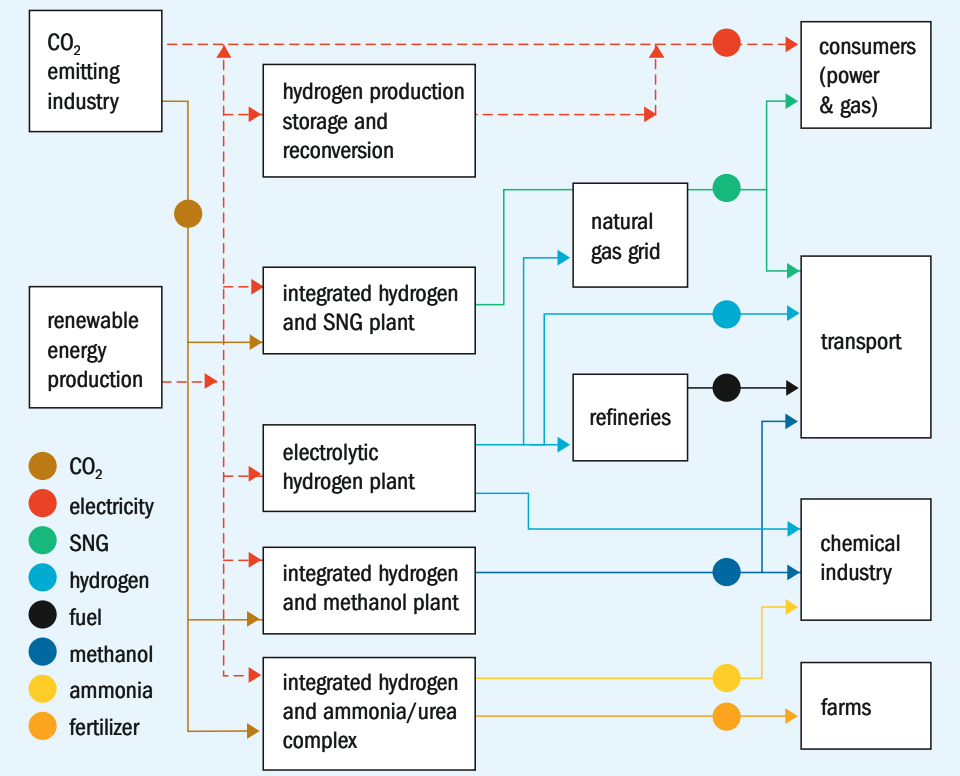
Topsoe would very much like to see hybrid ammonia plants placed at the centre of the power grid in future (Figure 3). In this way, ammonia – wholly or partly generated from renewable electricity – can continue to be used in fertilizer production, as it is today, or instead be used as a fuel to produce power for the grid. Integrating ammonia into the power grid, and using it for fuel and energy storage purposes, helps overcome the intermittency problems associated with wind and solar power. Ammonia's ability to store and release energy can smooth out power supply variations – especially useful on days when either excess or insufficient renewable electricity is available. The adoption of ammonia as a fuel in the power market has dual benefits: not only would it require the construction of more ammonia production plants, it would also enable more renewable energy capacity to be installed.

Fig. 3: **Ammonia as a fuel for power**



Source: Topsoe

Fig. 4: **Hydrogen value chains by thyssenkrupp**



Source: tkIS

thyssenkrupp's green ammonia plant concept

thyssenkrupp Industrial Solutions AG (tkIS) is a leading provider of state-of-the art technology to the global fertilizer industry. The German engineering giant is well known for its *uhde*® ammonia process technology and its engineering, procurement and construction expertise. tkIS is also a leading electrolysis technology supplier, and has played a major role in the emergence of the electrolysis market.

tkIS has developed alkaline-water-electrolysis (AWE) as an environmental-friendly process for the energy, chemical and agricultural industries. Its AWE technology is able to provide hydrogen at scale to a range of downstream processes.

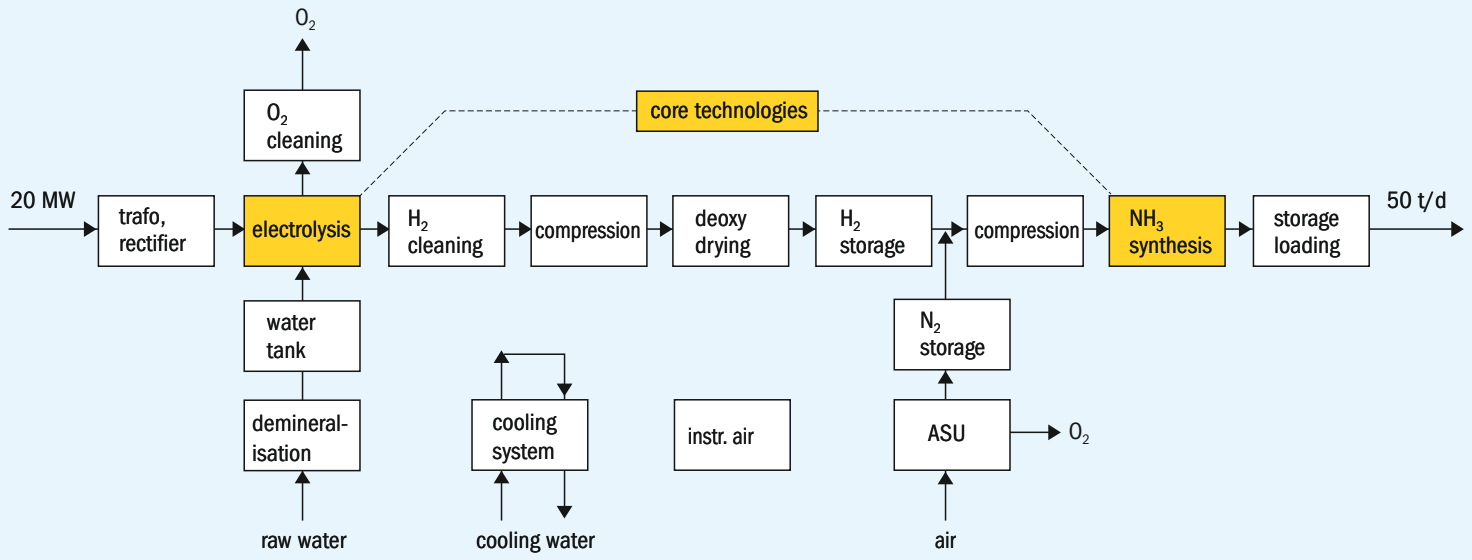
Importantly, by generating hydrogen, AWE allows renewable energy to be stored in a variety of ways, such as 'green' hydrogen, methanol, ammonia and synthetic natural gas (SNG). The ability to store energy in this way overcomes the intermittency and fluctuations associated with renewable electricity, the major drawback and limiting factor associated with both solar and wind power.

AWE generates hydrogen from the electrolysis of water, while the nitrogen required for ammonia synthesis is generated by an air separation unit (ASU). Ammonia can be processed further, if requred, and converted into downstream nitrogen products or DeNOx fluids. AWE can also be integrated with a range of other environmentally-friendly technologies to create value chains based on hydrogen (Figure 4).

Modularisation and standardisation have been key to the development and feasibility of tkIS's green ammonia plant concept (Figure 5). While the AWE and ASU were already fully modularised, tkIS also needed to successfully modularise the ammonia synthesis section. This has allowed the company to offer the concept to customers as a complete technology package from one provider.

tkIS's initial green ammonia plant concept was smaller scale (50 t/d) and

Fig. 5: **Process concept of thyssenkrupp's green ammonia production**



Source: tkIS

required a 20 MW power input from an onshore or offshore wind farm (100 % availability). The company has also developed a second larger scale concept (300 t/d) requiring 120 MW of power input. Because of its industrial scale, tkIS believes this plant concept could be offered as a revamp option for existing ammonia plants. This should allow green ammonia units to be installed at currently operational plants to partly substitute for conventional ammonia production.

The *NFUEL*® mini-ammonia plant

Netherlands-based Proton Ventures is the developer of the *NFUEL*® mini-ammonia plant. Proton's goal is to become a global leader in sustainable, decentralised and small-scale ammonia technology. Installation of local small-scale *NFUEL*® units eliminates transport costs and insulates customers from ammonia price volatility. Natural gas, associated gas, flare gas, hydrogen or biogas can all be used as feedstocks (Figure 7). Widespread deployment of the technology could also reduce the global CO_2 footprint of the ammonia industry.

NFUEL® mini-ammonia plants are based on the Haber Bosch process and are available in three different capacities: 1,000 t/a, 4,000 t/a and 20,000 t/a (Table 1). The units can use renewable electricity (wind, solar and tidal energy) as a power source. This makes it possible to produce decentralised green ammonia for use as a:

Alkaline water electrolysis

Alkaline water electrolysis (AWE) is based on proven chlor-alkali electrode technology developed by thyssenkrupp Uhde Chlorine Engineers. With more than 600 plants built and more than 10 GW capacity installed, tkIS is the number one electrolysis technology provider in the market. tkIS's electrolysis units uses proven zero-gap technology with high efficiency cathode and anode designs and coatings, and optimised high-performance separators and diaphragms.

Raw water is demineralised prior to feeding the AWE. Oxygen and hydrogen are the main outputs and both need to be cleaned. The oxygen is available for other downstream processes as it is not required for green ammonia production. The hydrogen generated by AWE is compressed, deoxygenated and dried before being fed to the ammonia synthesis section. Nitrogen is produced in a cryogenic air separation unit (ASU). It is then added to hydrogen in the correct stoichiometric proportions prior to supplying the synthesis gas compressor.

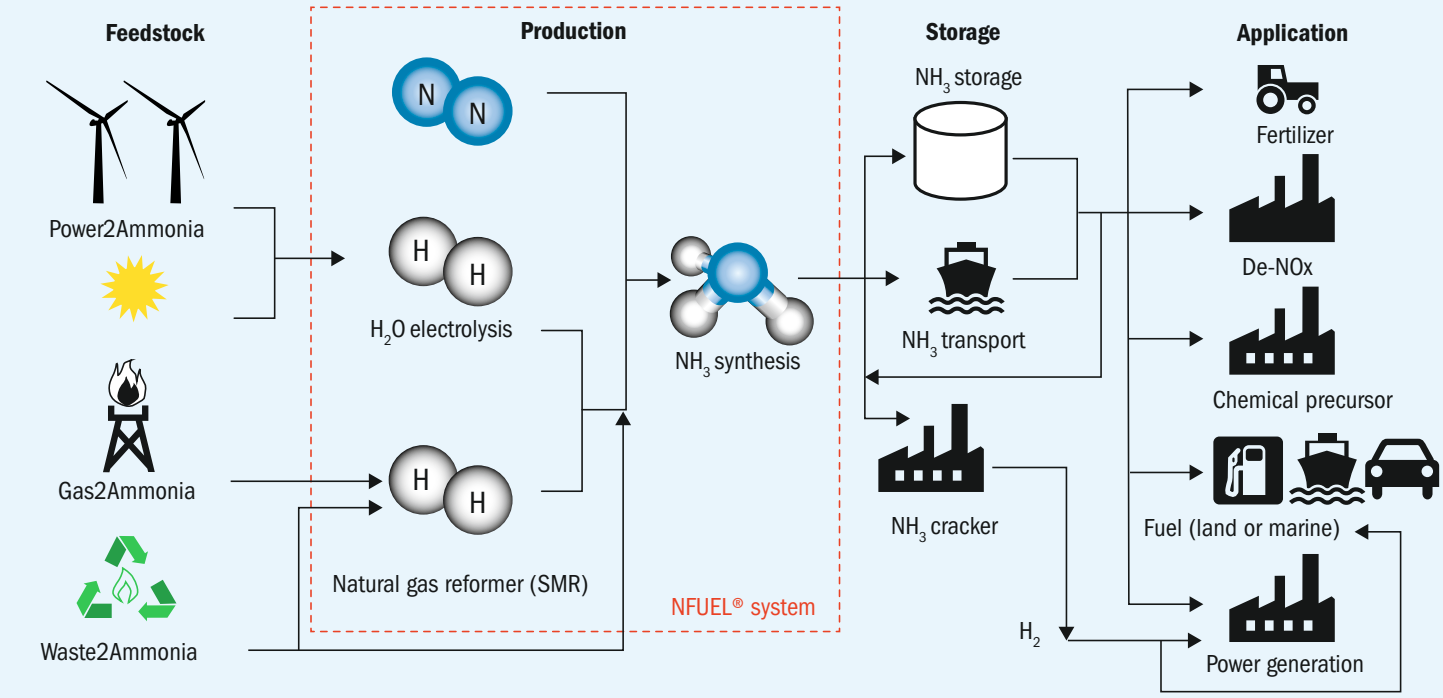
AWE is a flexible technology that is well-suited to the operating conditions of a green ammonia plant, which can suffer from a lack of power due to the fluctuating supply of renewable energy. The AWE can be started-up within minutes and follows load variations within seconds. In the ammonia synthesis section, the problem of intermittency is overcome by storing hydrogen upstream of the synthesis gas compressor unit. Hydrogen storage is designed to allow ammonia synthesis to run continuously. Storage size can be adjusted to compensate for power availability.

Fig. 6: **3D model of 5 MW electrolysis skid**

Source: tkIS

Each of tkIS's highly modular, standardised 5 MW-size AWE units are mounted on prefabricated skids (Figure 6). Their modular design, by minimising engineering/construction costs, reduces overall project cost. The installation of prefabricated skids is also relatively fast and simplifies project execution. ■

Fig. 7: ***NFUEL®* overview**



Source: Proton Ventures

- Nitrogen carrier (fertilizer)
- Hydrogen carrier
- Energy storage
- Chemical precursor, e.g. for urea, nitric acid, ammonium nitrate
- Maritime or agricultural fuel
- DeNOx feedstock
- Feedstock for fuel cells.

Table 1: **NFUEL® mini ammonia plants**

	NFUEL® 1	NFUEL® 4	NFUEL® 20
Capacity, t/a (t/d)	1,000 (3)	4,000 (10)	20,000 (60)
Power consumption, MW	1.5	5-6	25-30

Source: Proton Ventures

Table 2: **NFUEL® system key consumables**

Natural gas, Nm^3/tonne NH_3	835
Hydrogen, Nm^3/tonne NH_3	2,080
Electricity (when H_2 from NG), kWh/tonne NH_3	800-1,000
Electricity (when H_2 from H_2O), kWh/tonne NH_3	10,000-11,000

Source: Proton Ventures

Energy storage is a promising potential market as the units – by producing ammonia as an energy carrier – can be used to compensate for fluctuations in renewable energy supply and demand.

The standardised design of the *NFUEL®* units also helps to minimise their capex and opex. These mini ammonia units are modular, fully transportable, skid-mounted and can be installed in various locations with minimal installation costs. The consumable requirements of *NFUEL®* units are summarised in Table 2.

NFUEL® technology is flexible and can operate in SMR mode (gas-to-ammonia concept). However, unlike large-scale plants, *NFUEL®* units can run on biogas from landfill or anaerobic digestion, from stranded or associated gas from oil wells, and natural gas from small fields. Creating value-added products by capturing previously unusable gas feedstocks helps cut CO_2 emissions.

But running *NFUEL®* units on gas is generally only economic if there are no large-scale ammonia plants nearby, or if the units are installed at locations where the feedstock is essentially free. One example is the 180 million Nm^3 of high-purity associated gas being flared in the Bakken shale play, North Dakota, USA. Associated gas, which would otherwise be flared, can be accessed here at close to zero cost, allowing ammonia to be produced at a competitive market price.

NFUEL® units can also capture renewable energy from solar, wind, tidal or geothermal sources to power electrolysers (power-to-ammonia concept). The ammonia obtained can efficiently store energy in liquid form, effectively creating a carbon-free fuel. *NFUEL®* units can also run on flared hydrogen or by-product hydrogen from industrial processes (waste-to-ammonia concept).

Proton Ventures has industrial references (all 20,000 t/a NH_3 capacity) for four *NFUEL®* units: two in China, one in Argentina and one in Switzerland. Proton has also carried out feasibility studies for mini ammonia plants (4,000-20,000 t/a capacity) for companies in the US, Canada, Germany and Angola, and for bodies funded by the Dutch government.

Economic evaluation

tkIS has carried out a preliminary economic evaluation of small-scale green ammonia production. This examined the viability of the concept based on five main considerations:

- Capex
- The availability and cost of renewable electricity
- Ammonia transport costs and restrictions
- Restrictions on CO_2 emissions
- Carbon taxes.

The capex of small-scale green ammonia plants is broadly similar to their conventional small-scale natural gas-based counterparts. High material costs are the main disadvantage for all small-scale plants. The use of modular design can therefore be highly advantageous due to its ability to slash construction costs.

Unsurprisingly, economies of scale favour the conventional SMR process over the green ammonia process at higher production capacities. This is because no significant cost reductions are achieved in the electrolysis section, when multiple cells are added to deliver the required capacity. This means that green ammonia production is unable to compete with conventional production at a large-scale – although this was never actually the aim of the small-scale plant concept.

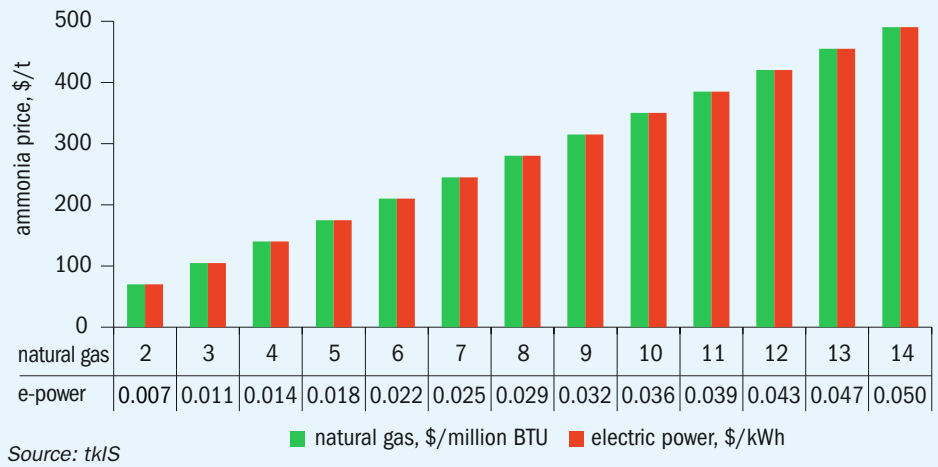
tkIS has estimated the breakeven points for ammonia production by both green and conventional process routes (Figure 8). Operational expenditure (opex) for the former is mainly down to the cost of electricity, while the opex of the latter is linked to natural gas costs.

tkIS has calculated that green ammonia production is economically feasible if the electricity cost is kept below $0.035/kWh, based on an ammonia market price of around $330/t. For conventional ammonia production based on natural gas, the same breakeven point is delivered at about $9.50/million Btu (LHV). These values are only rough estimates as no other opex factors were considered.

Ammonia transport costs can be high in landlocked regions and for locations where transport restrictions have been imposed. In both situations, the cost of transport to site ($100-200/t) can increase the final cost to the customer to around $500-600/t. Such high transportation costs dramatically improve the viability of small-scale local production, and shift the breakeven point for green ammonia plants to $0.055/kWh. Carbon taxation and restrictions placed on CO_2 emissions can also improve the economic case and make green ammonia plants more feasible.

In summary, tkIS's economic evaluation suggests that green ammonia plants might be a viable option for the fertilizer or chemical industry in some landlocked locations with access to low-cost electricity. Additionally, the use of ammonia to store and carry renewable energy could create an even more sizable market, suggests tkIS, which could ultimately bring about a complete transformation of the ammonia industry.

Fig. 8: **Break even points for NH_3 production (from natural gas and electricity) vs ammonia price**



Source: tkIS

Casale's leading role

Switzerland's Casale is a world leader in ammonia synthesis. It has delivered more than 200 ammonia synthesis loops in recent years, with capacities ranging from 50 t/d to more than 2,000 t/d.

The Lugano-headquartered company is playing a leading role in the development of sustainable ammonia production technologies. The economic production of ammonia from renewable feedstocks such as biomethane is likely to require smaller, simplified and decentralised plants.

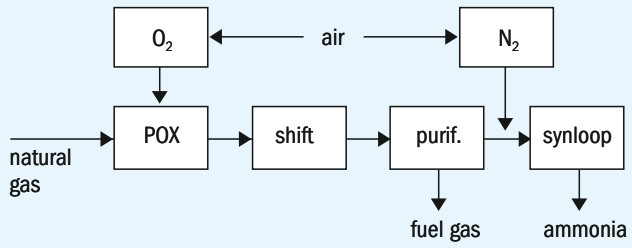
Two small-scale design concepts from Casale offer a convenient production route for converting renewable feedstocks to syngas. The smallest *A60*™ design is for ammonia plants with capacities of up to 100 t/d, while the larger *A600*™ design is for plants in the 300 t/d to 1,000 t/d capacity range. Although originally designed with natural gas in mind, both concepts are well suited to biomethane. They can also run on green hydrogen produced from renewable electricity via water electrolysis.

The main goal in the *A60*™ concept is to minimise the number of equipment items (Figure 9). Feedstock is converted using Casale's proprietary partial oxidation (POX) reactor. This reactor and its advanced burner technology is capable of operating soot-free at very low steam-to-carbon ratios. The POX can also cope with very low turndown ratios, with stable operation possible down to 20 percent of the nominal load. The advantageous features of POX enable plant size to be minimised, while also ensuring high levels of reliability and efficiency, and a long burner life.

The *A60*™ concept also simplifies the production process by adopting a single shift step at high temperature prior to syngas purification. The latter is carried out by a highly-automated pressure swing adsorption (PSA) unit. Advantageously, the need for a refrigeration section is also avoided by running the synthesis loop at high pressure (above 200 bar). This produces highly concentrated ammonia that can be easily condensed via water-cooling (or even air-cooling).

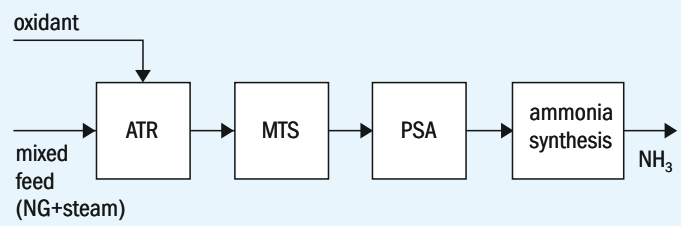
The *A600*™ concept, in contrast, is based on low-pressure ammonia synthesis (Figure 10). The general aim of this concept is to simplify the plant as much as possible, while retaining centrifugal compressors to maximise reliability. A low-pressure synthesis loop, by increasing the

Fig. 9: **Casale *A60*™ ammonia plant block flow diagram**



Source: Casale

Fig. 10: **Casale *A600*™ ammonia plant block flow diagram**



Source: Casale

volumetric flow of synthesis gas, enables more reliable centrifugal compressors to be used.

The feedstock is reformed in the *A600*™ concept in single autothermal reforming (ATR) step (Figure 10). This generates syngas using heat captured from the partial combustion of feed gas in a patented burner. The use of ATR greatly simplifies process design by avoiding the need for a steam methane reformer (SMR). Valuably, reformer stack flue gas emissions – a continual source of atmospheric pollution in conventional plants – are also avoided.

Shift conversion in the *A600*™ concept is performed in a single step – similar to the *A60*™ concept – in this case using a medium temperature shift (MTS) converter. This operates safely at much lower steam-to-carbon ratios than are conventionally permissible. Gas purification is subsequently performed via a PSA step. This avoids solvent washing to remove carbon dioxide. The syngas generated is also immediately suitable for ammonia synthesis, without the need for methanation.

Ammonia production from green hydrogen is also possible by configuring Casale's 'back end' ammonia technology (*A600*™ or *A60*™) with a 'front-end' based on water electrolysis. A (catalytic) purification step is usually necessary to remove residual oxygen from the hydrogen prior to ammonia synthesis. Nitrogen is supplied from either a PSA or from cryogenic separation. It is then mixed with hydrogen and compressed to the correct pressure for ammonia synthesis.

As mentioned above, plant design can be adjusted to accommodate the production capacity desired. High-pressure ammonia synthesis is recommended for very small-scale plants, for example, while low-pressure synthesis pressure is permissible for ammonia plants with a capacity above 300 t/d.

However – because renewable electricity from wind and solar generation is highly variable – the most demanding design feature for ammonia plants based on water electrolysis is the ability to handle variations in load.

Continual fluctuations in plant load during operation can harm the ammonia synthesis loop. When ammonia plants operate at a much lower load than nameplate capacity – and at full pressure in the synthesis loop – the excess volume of catalyst in the ammonia converter shifts the reaction toward equilibrium. This can damage synthesis loop equipment by raising the temperature of the product gas above the design limit.

> **The use of ammonia to store renewable energy could completely transform the global industry.**

The usual way of avoiding overheating in the ammonia converter, when operating at partial load, is to reduce the operating pressure of the synthesis loop. However, in conventional ammonia plants load variation only occurs infrequently, unlike the frequent load variations in ammonia plants based on water electrolysis. The resulting stress fatigue in synthesis loop equipment may eventually lead to ruptures.

To overcome these operational challenges, Casale has patented a method for protecting the ammonia synthesis loop from load variations. This works by cutting the purge flow rate to increase the inert content of the synthesis loop, when the plant runs at reduced loads. This lowers the partial pressure of reagents in the converter, depressing ammonia conversion and avoiding overheating.

JGC at the vanguard

Japan's JGC Corporation is also pursuing ammonia synthesis from CO_2-free hydrogen. The company has developed a new high-performance ruthenium catalyst supported on rare earth oxide. This allows ammonia synthesis at lower temperature and pressure than the conventional Haber-Bosch process. This breakthrough should enable CO_2-free ammonia to be efficiently produced from hydrogen obtained using renewable energy.

To demonstrate the newly-developed catalyst, JGC designed and constructed an ammonia synthesis pilot plant (20 kg/day capacity) at the Fukushima Renewable Energy Institute (FREA), National Institute of Advanced Industrial Science and Technology (AIST). The performance of the new ruthenium catalyst was evaluated during trials at the pilot plant last year.

Encouragingly, the catalyst met its performance goals. Trials demonstrated that hydrogen conversion above 24 percent was achievable, at a reaction temperature of <400°C, a reaction pressure of 5 MPaG, and a GHSV of 6,000/hr. About one tonne of CO_2-free ammonia was produced in total over the course of 12 demonstration test runs. The catalyst maintained its performance throughout, and was not affected by short-term load fluctuations.

In August last year, JGC successfully demonstrated the use CO_2-free ammonia as a fuel in power production. Ammonia was produced using hydrogen from solar-powered water electrolysis units installed at the FREA. Liquid ammonia produced in this pilot plant was then used as a fuel for direct combustion in a gas turbine. Some 45kW of electrical power was successfully generated during stable operations.

JGC believes this is the first time globally that a completely CO_2-free ammonia value chain has been successful demonstrated, from production to utilisation. ■

Bedeschi: innovative equipment and skilled project management

Example of a Bedeschi shiploader for fertilizers.

PHOTO: BEDESCHI

Venice-headquartered Bedeschi has a long track record as a global leader in the bulk handling of fertilizers and chemicals. The company recently delivered a successful shiploader project for Borealis in Rouen, France.

PHOTO: BEDESCHI

Bedeschi's headquarters near Venice.

Environmental protection and conservation has become a paramount concern for many industries globally. Shipping is no exception. Nowadays, pollution prevention is a primary objective for ports worldwide. This is especially true when it comes to the import/export of dry bulk cargoes such as fertilizers.

For fertilizers and fertilizer raw materials, the risk of spillage and dust generation and its prevention are extremely critical. The release of dust to the environment can occur during fertilizer loading, discharge operations, and during port-side storage. The use of 'eco-friendly' bulk handling equipment is therefore a practical and necessary first step for protecting the environment and reducing dust emissions from dry cargoes at ports.

Global leader and innovator

Venice-headquartered Bedeschi (left) has a long track record as a global leader in the bulk handling of fertilizers and chemicals across the world. The company has built an enviable reputation for equipment innovation, thanks to substantial research and development (R&D) investment in 'green' technology.

Bedeschi has the necessary know-how and in-house capability to design and manufacture innovative bulk handling equipment. These are fitted with sophisticated environmental-protection measures, and are capable of meeting the highest and most exacting environmental standards.

Ambitious project for Borealis

Bedeschi recently carried out a highly-ambitious bulk handling equipment project for Borealis Group, one of Europe's leading fertilizers producers. Borealis supplies over five million tonnes of fertilizers and technical nitrogen products each year, via its Borealis LAT distribution network.

Table 1: **Borealis shiploader project: specification and data**

Material	CAN
Bulk density	0.95-1.03 t/m^3
Grain size	10 mm
Capacity	400 t/h

Source: Bedeschi

Bedeschi secured a contract from Borealis to install a new shiploading system in the industrial area of Rouen in northern France. The contract also included the installation of associated conveyors to transport materials from the Borealis-owned production plant to the port. The project presented Bedeschi with a number of daunting challenges, most notably:

- The product being handled – calcium ammonium nitrate (CAN) – is extremely aggressive in terms of corrosion
- A special rubber tyre mounted machine was necessary, because of the limited space available on the dock for the shiploader
- Project management, particularly health and safety, was also a major concern, as the shiploader would need to be installed with the production plant in operation, over the entire life of the project
- Finally, the time available for delivery, installation and commissioning of the equipment was extremely short.

Project specifications are summarised in Table 1.

Delivering the Borealis project

Bedeschi's wide experience of handling corrosive materials, gained over more than 100 years, allowed the project team to develop a suitable *ad-hoc* totally stainless steel shiploader system for Borealis. The use of stainless steel extended to all of the conveyor components too. This ensured that all of the project equipment provided was of the highest durability and efficiency.

Project management was also carried out to the highest standards. Sophisticated 'lean' management methods and up-to-date management tools were used at each stage of the project. This enabled Bedeschi to supply and install the 400 t/h capacity shiploader, and all of the associated plant, in about 10 months.

Tailor-made solutions

The successful delivery of the Borealis project shows that Bedeschi – despite the growing size of its business – still proudly offers tailor-made solutions to its customers. Highly standardised components manufactured in the company's Italian workshop are combined with the very best engineering to optimise the customer's return on investment. The end result is well-designed installations and a wide range of innovative machinery offering a variety of mechanical solutions.

Bedeschi has the capability to cover every step of project execution – from the basic design phase to equipment assembly, installation and start-up, to post-commissioning services.

Automatic loading systems

Bedeschi's R&D department is always looking for new challenges. Its latest innovation is an automatic shiploading system. Operating shiploaders in fully automatic mode increases operational efficiency, by allowing higher overall loading rates, and also reduces manpower.

During the loading of bulk carriers, Bedeschi's latest shiploading system provides:

- Automation/operator assistance
- Machine safety features
- Lower maintenance costs
- Higher turnaround.

The system is suitable for both manned and unmanned shiploader operation.

The system incorporates highly-innovative 3D-laser and 2D-radar sensors, mounted at the end of the boom and near the chute. Data from these sensors allows the system to create a model of the ship prior to loading operations. The model clearly delineates vessel structures, hatch layouts and hatch sizes. Additional sensors near to the boom also prevent the shiploader from colliding with the vessel's structure.

Fully-automated shiploading systems are probably the future, when it comes to investing in eco-friendly, innovative equipment at modern ports. Bedeschi is able to offer clients compact, functional, and eco-friendly machines. These are capable of dealing with all the pollution concerns associated with dry bulk handling, and also guarantee the perfect filling of vessel cargo holds. These are important considerations, given that ports have limited available space, and the expense of port-side infrastructure and land. ■

Young professionals

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

To support IFA's new initiative, *Fertilizer International* magazine is running a series of profiles featuring industry young professionals. These highlight the wide range of attractive and rewarding career options available to young people in the fertilizer sector. In this issue, Pote Jarupanich of Thailand's Charoen Pokphand Produce (CPP), talks to us about his career.

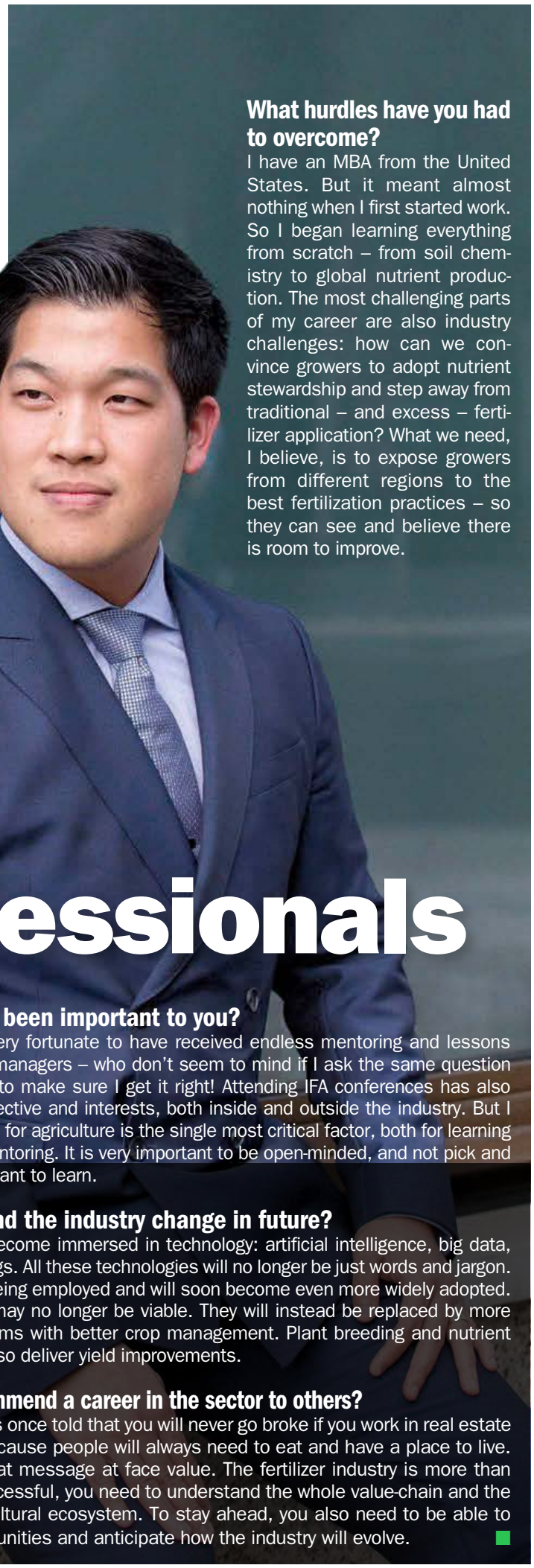


PHOTO: IFA

Pote Jarupanich, 34, vice president, CPP

How did your career in the industry start?

I joined CPP in 2014. Before that I worked in rice trading. My job was developing the export market, mainly for Myanmar, and we also successfully completed our very first shipment to Africa. Once rice export volumes were growing steadily, I began to look for a new challenge in my career. Eventually, I landed a role in the purchasing team of CPP's fertilizer business, after an international purchasing position opened up.

What achievement are you most proud of?

As a team, our biggest achievement has been establishing a direct business relationship with prominent fertilizer manufacturers. Not only has this seen our volumes expand exponentially – from 40,000 tonnes to 260,000 tonnes in four years – it has also helped us deepen our knowledge of the industry. Achieving these advances, however, did require us to tackle thousands of pain points as a team! What we did learn, though, was that effective supply chain management is the key to solving 60 percent of the issues we face.

What hurdles have you had to overcome?

I have an MBA from the United States. But it meant almost nothing when I first started work. So I began learning everything from scratch – from soil chemistry to global nutrient production. The most challenging parts of my career are also industry challenges: how can we convince growers to adopt nutrient stewardship and step away from traditional – and excess – fertilizer application? What we need, I believe, is to expose growers from different regions to the best fertilization practices – so they can see and believe there is room to improve.

What do you find most rewarding about your job?

That's easy: the people and the opportunity! This job and this industry never cease to amaze me. For instance, in 2017 I had a chance to attend Agritechnica in Hannover, Germany. While there, I realised that agriculture and agribusiness – not only fertilizers – have infinite room to grow and improve. Meeting people always gives me new lessons, both in the fertilizer industry and in best business practices.

How do you get the best from yourself and colleagues?

Our team's motto is 'one voice'. Mutual understanding of common goals helps our team function efficiently, both together and as individuals. I find that regular dialogue and prompt communication – whether to argue or agree – ensures that nothing important goes unnoticed. Getting to know my team members, professionally and outside the office, also helps me understand colleagues and myself.

Has mentoring been important to you?

Absolutely. I am very fortunate to have received endless mentoring and lessons from experienced managers – who don't seem to mind if I ask the same question for the tenth time to make sure I get it right! Attending IFA conferences has also widened my perspective and interests, both inside and outside the industry. But I believe my passion for agriculture is the single most critical factor, both for learning and successful mentoring. It is very important to be open-minded, and not pick and choose what you want to learn.

Will your job and the industry change in future?

The industry will become immersed in technology: artificial intelligence, big data, the internet of things. All these technologies will no longer be just words and jargon. They are already being employed and will soon become even more widely adopted. Traditional farms may no longer be viable. They will instead be replaced by more efficient, larger farms with better crop management. Plant breeding and nutrient stewardship will also deliver yield improvements.

Would you recommend a career in the sector to others?

Yes. After all, I was once told that you will never go broke if you work in real estate or agriculture – because people will always need to eat and have a place to live. Just don't take that message at face value. The fertilizer industry is more than trading. To be successful, you need to understand the whole value-chain and the surrounding agricultural ecosystem. To stay ahead, you also need to be able to see growth opportunities and anticipate how the industry will evolve. ■

January-February 2019

phosphates & potash INSIGHT

Salitre project profile

Brazil is facing a growing phosphate supply deficit, spurred by rising demand from soybean farmers. Yara Brazil's Salitre project in Minas Gerais is leading the charge to fill this deficit by producing 1.5 million tonnes of finished phosphate fertilizers annually.

Brazil consumes more than 16 million tonnes of nutrients each year. This makes the country the world's fourth largest fertilizer market, ranked behind China, India and the US. The country currently accounts for an impressive nine percent of global fertilizer consumption.

Brazil's emergence as a global agricultural powerhouse also means that fertilizer demand is continuing to grow. Total fertilizer product deliveries reached 34.4 million tonnes in 2017, a 356,000 tonne increase on the previous year. And the latest fertilizer statistics show that demand is accelerating, with an uptick of more than one million tonnes expected in 2018. ANDA reports Brazilian fertilizer consumption running at 29,916,186 tonnes for January-October last year, compared to 28,793,004 tonnes for the same period in 2017.

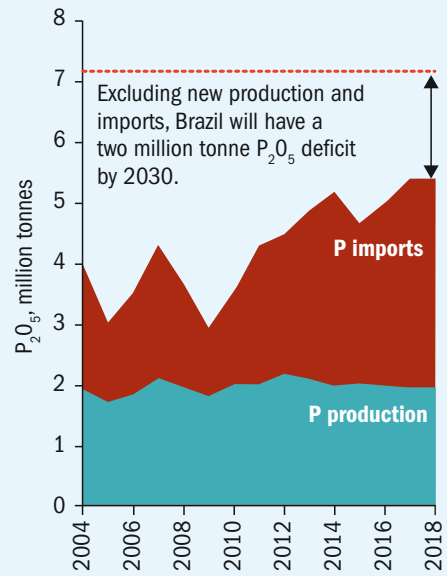
Growing import demand

Brazil's fertilizer market remains heavily import-reliant with around 80 percent of total demand being met by imports. In terms of individual nutrients, imports supply more than 95 percent of domestic potash consumption and account for roughly 83 percent of the country's nitrogen use. While Brazil is less import reliant for phosphate – having access to substantial domestic production capacity – the country still looks to the international market to supply around 60 percent of its domestic phosphate needs.

Brazil's combined imports of phosphate products amounted to 4.9 million tonnes in 2016, representing one-fifth of the country's total fertilizer imports of 24.5 million tonnes. Brazil imported the following product volumes that year:

- 2,950,000 tonnes of monoammonium phosphate (MAP): 72 percent of total consumption
- 726,000 tonnes of triple superphosphate (TSP): 46 percent of total consumption
- 718,000 tonnes of single superphosphate (SSP): 13 percent of total consumption
- 482,000 tonnes of diammonium phosphate (DAP): 100 percent of total consumption

Fig. 1: **Brazil's projected phosphate supply/demand gap**



Source: Yara/ANDA

The US, Morocco, China, Egypt and Israel are all major suppliers of phosphate fertilizers to the country.

Phosphate hungry soybean

Soybean is Brazil's most widely grown agricultural commodity. Large-scale cultivation of this potash- and phosphate-hungry crop is responsible for more than two-fifths of domestic fertilizer consumption.

The predominance of soybean farming distorts Brazil's fertilizer consumption. The country consumes much larger amounts of potash and phosphate, for example, relative to nitrogen, compared to averages in other world markets. Phosphorus (P_2O_5) is the most widely-applied nutrient in Brazil (39%), followed closely by potassium (K_2O, 35%) while – highly unusually – nitrogen (N) use is left trailing in third place (26%).

Future growth in Brazilian phosphate consumption, spurred on by rising fertilizer requirements from soybean, could result in an additional two million tonnes of annual (P_2O_5) demand by 2030, according to projections by ANDA and Yara (Figure 1). They predict that soybean fertilization requirements will eventually capture a 50 percent share of the Brazilian fertilizer market. Demand will mainly come from large soybean farms in central regions, particularly Mato Grosso, and from soybean-growing cooperatives in Brazil's south.

Serra do Salitre

Brazil's growing phosphates supply/demand deficit over the next decade will have to be met by more imports and/or increases in domestic production capacity. The latter is set to receive a substantial boost from the scheduled completion of the Serra do Salitre project in 2019.

The flagship project is ranked as Brazil's foremost investment in greenfield fertilizer capacity, due to its scale and imminent start-up. Serra do Salitre is also ideally located in Minas Gerais state, close to key fertilizer-consuming markets.

The project was originally a joint venture between Yara International and Brazilian producer Galvani. However it is now 100 percent Yara-owned, following Yara's complete acquisition of Galvani last October (see box).

Serra do Salitre is divided into two phases. The initial phase, which came onstream in 2018, involved the completion of a 1.2 million tonne capacity phosphate rock mine. A one million tonne capacity production plant for finished phosphate products is due to be completed this year, as part of the project's second phase.

Yara completes Galvani ownership

Yara International first took a 60 percent stake in major Brazilian fertilizer produce Galvani (Galvani Indústria, Comércio e Serviços) in 2014. The company subsequently completed its purchase of the Brazilian phosphates fertilizer producer in October 2018, buying-out the remaining family stake for $70 million. This transaction is expected to close in the first quarter of 2019.

Galvani's main business is phosphate rock mining, single superphosphate (SSP) production and fertilizer distribution. The company employs around 1,250 staff and generated revenues of $220 million in 2017 from fertilizer sales of one million tonnes. It markets powdered and granulated SSP in Brazil, with incorporated micronutrients, under the *Phosgrao* brand. Galvani also sells fertilizer blends under the *Phosmix* moniker and granulated NPKs.

Prior to the recent buy-out and division of assets, Galvani operated a total of around one million tonnes of SSP production capacity through its Paulínia, Sao Paulo, and Luis Eduardo Magalhães, Bahia, plants. Both plants sourced phosphate rock from two company-owned mines, Lagamar in Minas Gerais and Angico dos Dias in Bahia, and the leased Irecê mine.

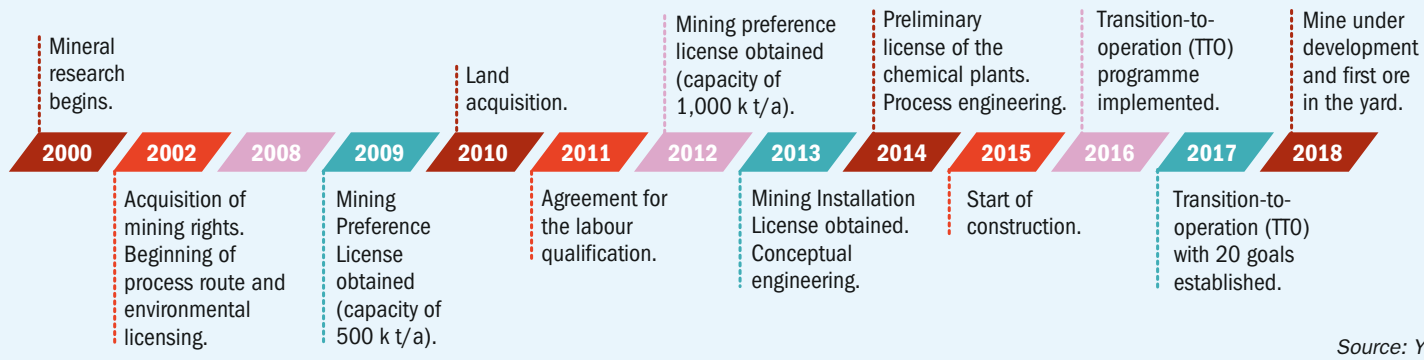
Following the Galvani acquisition last October, local subsidiary Yara Brazil now owns the Paulínia SSP plant and bulk blending unit outright, together with the under-construction Salitre phosphate project.

"This deal streamlines our production footprint in Brazil, securing full ownership of key Yara Brazil production assets, complementing its extensive distribution capabilities and achieving a more integrated position in the Brazilian market," says Lair Hanzen, executive vice president, Yara Brazil.

Yara's purchase agreement with the Galvani family includes a cash payment of $70 million over a 3-year period on closure of the deal, and a future payment conditional on project success. The full integration of Galvani into Yara Brazil should unlock annual savings (synergies) of $15 million after tax from 2020 onwards.

The Galvani family will still own and control the Bahia-based Luis Eduardo Magalhães production plant and the Angico dos Dias and Irecê mines, as well as the Santa Quitéria greenfield phosphate project. These assets now make up a new company worth around $90 million.

Fig. 2: **Salitre project timeline, 2000-2018**



Source: Yara

Building a fully-integrated fertilizer production plant in Brazil is a costly, complex and highly ambitious venture. The scale of the project is such that it will increase national P_2O_5 production by around 20 percent. Importantly, Salitre will ensure that Yara's Paulínia production plant is self-sufficient in P_2O_5 by providing a dedicated supply of phosphate rock.

Once operational, Serra do Salitre will generate:

- 900,000 tonnes of sulphuric acid
- 1.2 million tonnes of phosphate rock
- 250,000 tonnes of phosphoric acid
- One million tonnes of granulated finished phosphate products
- More than 1.2 million tonnes of gypsum
- 1,500 jobs during the operational phase
- Around 29 MW of energy.

The project's massive 2,500 hectare site will employ 3,500 contractors at its peak.

Major production investment

Salitre represents a major commitment by Yara to the growing Brazilian market, and a significant expansion of its in-country operations. It is also one of only a handful of priority investments Yara is making in international production capacity.

The Norwegian-headquartered company is sinking $250 million into the phosphate rock mining and production phases of the project, scheduled for 2018 and 2019 completion, respectively. Salitre delivered its first 150,000 tonnes of mined phosphate rock during the first quarter of 2018 and is scheduled to produce 800,000 tonnes of finished phosphate products by the end of this year.

Yara is also investing a further $100 million in another Brazilian project to modernise its Rio Grande fertilizer production and blending operations in Brazil by 2020.

In total, Yara has committed to investing NOK 6.7 billion ($770 million) in six major production projects during 2018-2019. These include the two projects in Brazil (Rio Grande and the Salitre), four European projects – at its Porsgrunn, Norway, Köping, Sweden and Sluiskil, Netherlands sites – and the recently-completed Freeport, Texas, ammonia plant in the US, a joint venture with BASF. Also in Brazil, Yara has committed a further NOK 2.1 billion ($240 million) to the acquisition of the Vale Cubatão production complex in São Paulo state.

Project progress

Yara provided a progress update on the Salitre project in October. The company confirmed that:

- Phosphate rock mining had started with the delivery of the first production tonnages

- Chemical production of finished phosphate products is due to start-up by the end of 2019
- The production mix will include diammonium phosphate (DAP), monoammonium phosphate (MAP), nitrophosphate (NP), single superphosphate (SSP) and triple superphosphate (TSP)
- The project is on-course to deliver annual production of 1.2 million tonnes of phosphate ore and 1.5 million tonnes of finished phosphates (SSP equivalent) by 2021.

Although its origins stretch back to 2000, the project's transition-to-operation (TTO) began in 2017 (Figure 2). This set 20 milestones to ensure the project's delivery. These required the achievement of the following critical and sequential objectives:

- Production of 150,000 tonnes of phosphate rock during the mine development stage
- The first ore drop at the homogenization yard
- Commissioning of the dry processing route
- Obtaining a preliminary operating license
- Process plant start-up
- Tailings dam operation start-up
- Production of first tonnages of phosphate rock concentrate
- Storage of 10,000 tonnes of phosphate rock concentrate at the coarse phosphate rock silo
- First-ore-on-truck (FOOT) to Paulínia
- First-ore-in- Paulínia (FOIP) processed
- First fertilizer lot produced at Paulínia using Salitre rock

Yara commits to Brazil

In keeping with the company's long-term strategic ambitions, Yara is continuing to increase its already sizeable presence in Brazil, a pre-eminent global fertilizer market. Its Yara Brazil subsidiary employs around 5,500 staff, as of December 2017, and generated $3.2 billion in revenues from sales of more than nine million tonnes of fertilizers in 2017.

The company recently added to its assets through a $255 million takeover of the Cubatão fertilizer complex in Brazil from Vale. The Cubatão nitrogen and phosphate complex has an annual production capacity of 0.2 million tonnes for ammonia, 0.6 million tonnes for nitrates and almost one million tonnes for phosphate fertilizers.

Importantly, the Cubatão acquisition establishes Yara as a nitrogen producer in Brazil, strengthening its production position and complementing its blending and distribution assets in the country. Cubatão made combined sales of around 1.3 million tonnes for nitrogen and phosphate products in 2016. Yara is due to invest $80 million in upgrades at the complex by 2020. These should help deliver cost savings (synergies) of $25 million.

The ample availability of water and uncultivated land will allow Brazil to further expand its agricultural production in future. This, in turn, will undoubtedly fuel rising fertilizer demand. Yara, through its investments in domestic production capacity in Brazil, is attempting to meet this demand and prevent the gap between domestic supply and imports from widening.

The company's large-scale inward investments, and commitment to reducing Brazil's fertilizer import reliance, makes commercial sense. Yara's strategy in the Brazilian fertilizer market – to improve the availability of agricultural inputs by elevating domestic supply – will also be welcomed by Brazil's government and farmers. ■

Alternative potash options

We assess the expanding market for potassium-containing alternatives to potassium chloride (MOP). A wide range of alternative potash product options are available and marketed globally, including SOP, KNO_3, SOPM, MKP and polyhalite.

Potassium chloride (KCl, muriate of potash, MOP) has a number of well-known natural advantages as a fertilizer. It is widely available, relatively low-cost and readily soluble in water. Equally importantly, it has the highest potassium content (60-62% K_2O) of any of the mineral forms of potash.

Potassium chloride delivers K to plant roots both quickly and effectively, and also mixes well with other nitrogen and phosphate fertilizers. Indeed, the evidence suggests that the use efficiency of N and P fertilizers improves when applications are combined with K[1].

Potassium plays a key role in photosynthesis and the formation of sugars. It also has a direct role in protein synthesis and is therefore an essential element for cell growth and development. Potassium is also an important nutrient when it comes to mitigating the effects of salinity, cold, frost, waterlogging, drought and other stresses on crop production. It also offers protection against insects, pests and various diseases[1].

In contrast, the chloride component of KCl benefits some crops but can have an adverse effect on others, in certain circumstances.

Different crops exhibit a range of responses to chloride. Applications of MOP and other chloride-containing fertilizers can usually be applied at rates of up to 140 kg of Cl per hectare with no negative effects on crop growth or yield[2]. However, careful or restricted application sometimes becomes necessary for a limited number of chloride-sensitive crops – especially when exacerbated by factors such as soil salinity and salt stress.

Chloride, plant growth and yield

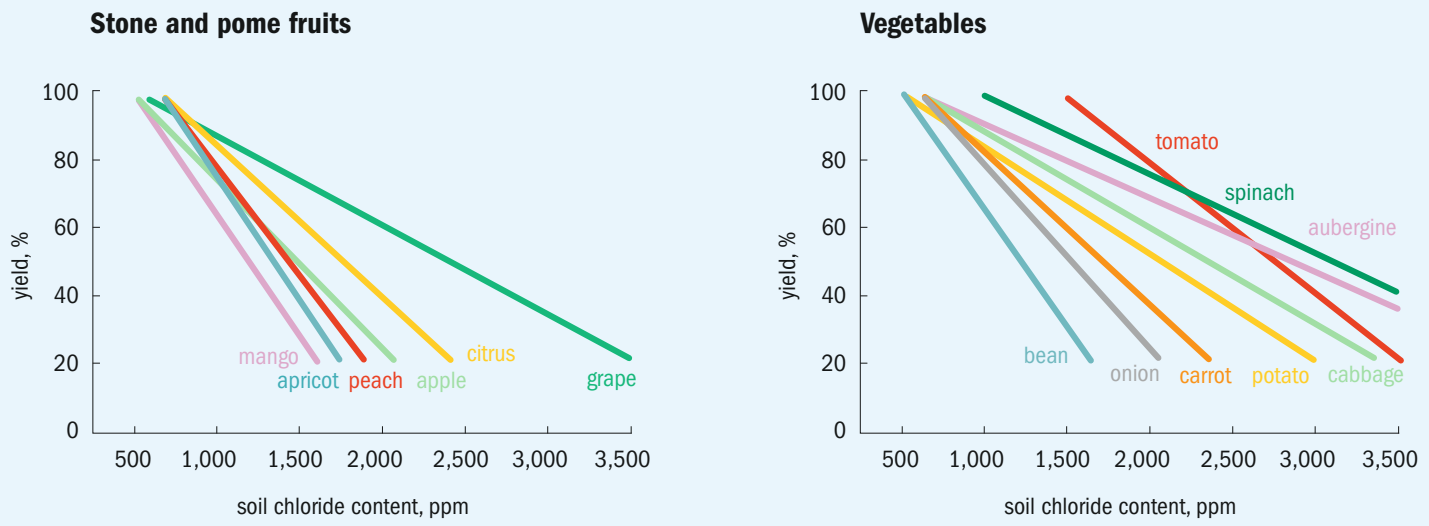
Chloride is required by plants for photosynthesis, fluid pressure control (osmoregulation) and for specialist parts of the leaf (stomatal guard cells). Although chloride application is rarely needed at rates over 10 kg/ha, relatively large amounts of Cl are essential for some crops such as kiwifruit and sugar beet[2] (*Fertilizer International* 471, p39). Oil palms and coconut plants also need Cl to help the outer layer of their leaves function (charge balance in guard cells).

Yield response to chloride varies widely (Figure 1) with some crops exhibiting a high degree of tolerance.

As a general rule, non-woody plants are less susceptible to Cl toxicity than woody plants such as citrus trees. Wheat, for example, will tolerate Cl in soil at 340 kg/ha without any detrimental effects on growth and yield. Cotton yield and quality are also unaffected by Cl concentrations below 1,600 mg/kg. Other insensitive crops, such as rice, corn, sorghum, cotton, tomatoes, aubergines, bananas and peaches, can tolerate Cl in fertilizers at rates of 1,350-1,800 mg/ha each season[1]. Critical soil Cl toxicity concentrations for different crops are shown in Figure 2.

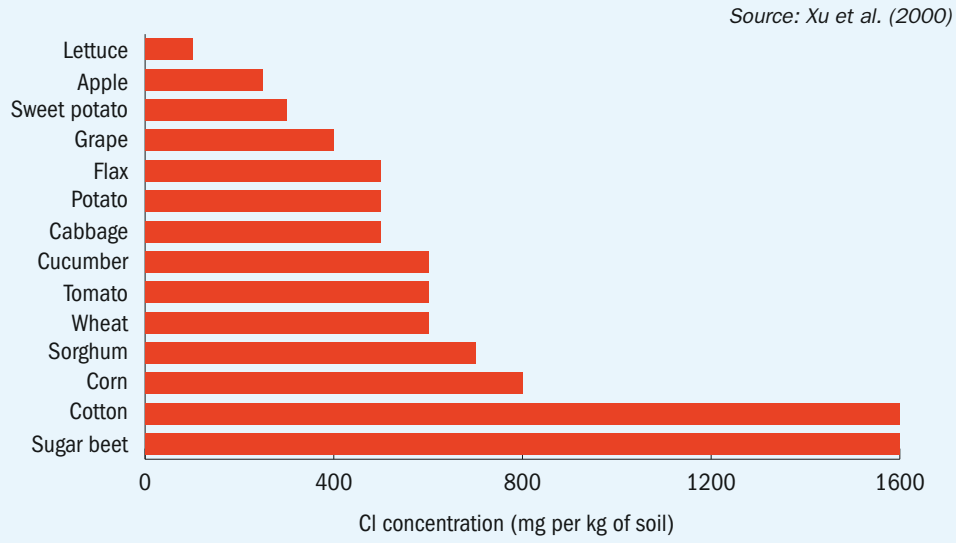
Application rates of chloride-containing fertilizers such as MOP do need careful management for some crop species. Applications for crops with a moderate chloride tolerance, such as soybean, pea, strawberry, peanut, apple and sugarcane, should typically fall within the range of 675-1,350 mg/ha. Other crops, especially

Fig. 1: **The effect of chloride on selected fruit and vegetables**



Source: K+S

Fig. 2: **Critical soil chloride toxicity concentrations for selected crops**



pepper, cabbage, lettuce, rape, tobacco, potato and sweet potato, are more chloride sensitive and Cl applications should not exceed 675 mg/ha each season[1].

The presence of chloride in sprinkler irrigation water can also result in foliar injury in some crops (Table 1).

Selection of a fertilizer with a lower salt index (Table 2) is one option for chloride sensitive crops, particularly under saline growing conditions. This lowers the risk of salt burn and damage to seedlings and young plants.

Chloride-free fertilizer options

Potassium sulphate (sulphate of potash, SOP, K_2SO_4) is the most commonly used alternative to potassium chloride. Whilst MOP may be the preferred potassium fertilizer for cereals and oilseeds, SOP often finds favour for more chloride-sensitive, higher-value cash crops, notably fruits, vegetables, tobacco and tree crops (*Fertilizer International* 458, p48). The other obvious advantage of SOP is that it is also a source of sulphur and can therefore be applied to address sulphur-deficiency.

Other chloride-free fertilizer options include:

- Potassium nitrate (KNO_3)
- Potassium magnesium sulphate ($K_2Mg_2(SO_4)_3$, SOPM, langbeinite)
- Polyhalite ($K_2Ca_2Mg(SO_4)_4.2H_2O$)
- Monopotassium phosphate (MKP, KH_2PO_4)

These can all offer agronomic advantages over MOP under certain crop and soil conditions.

"Chloride-free options can offer agronomic advantages over MOP.

Table 1: **Crop sensitivity to foliar injury from chloride in sprinkler irrigation water**

Crop	Sensitivity to foliar injury (Cl concentration, mmol/litre)
Almond, apricot, citrus, plum	<5
Grape, pepper, potato, tomato	5-10
Alfalfa, barley, corn, cucumber, sesame, sorghum	10-20
Cauliflower, cotton, sugar beet, sunflower	>20

Source: Xu et al. (2000)

Table 2: **Salt indices for selected fertilizer products**

Product	Salt index
Potassium chloride (MOP)	116.3-109.4
Ammonium nitrate (AN)	104.7
Urea	75.4
Potassium nitrate	73.6
Ammonium sulphate (AS)	69.0
Calcium nitrate (CAN)	52.5
Potassium sulphate (SOP)	46.1
Potassium magnesium sulphate (SOPM)	43.2
Monoammonium phosphate (MAP	34.2
Diammonium phosphate (DAP)	29.9
Ammonium phosphate	26.9
Superphosphate	7.8-10.1

Source: FAO

Total agricultural use of potash products globally was around 105 million tonnes (39 million tonnes K_2O) in 2017. Oilseeds, fruit and vegetables, corn and other coarse grains collectively account for almost 60 percent of total potash consumption (Figure 3).

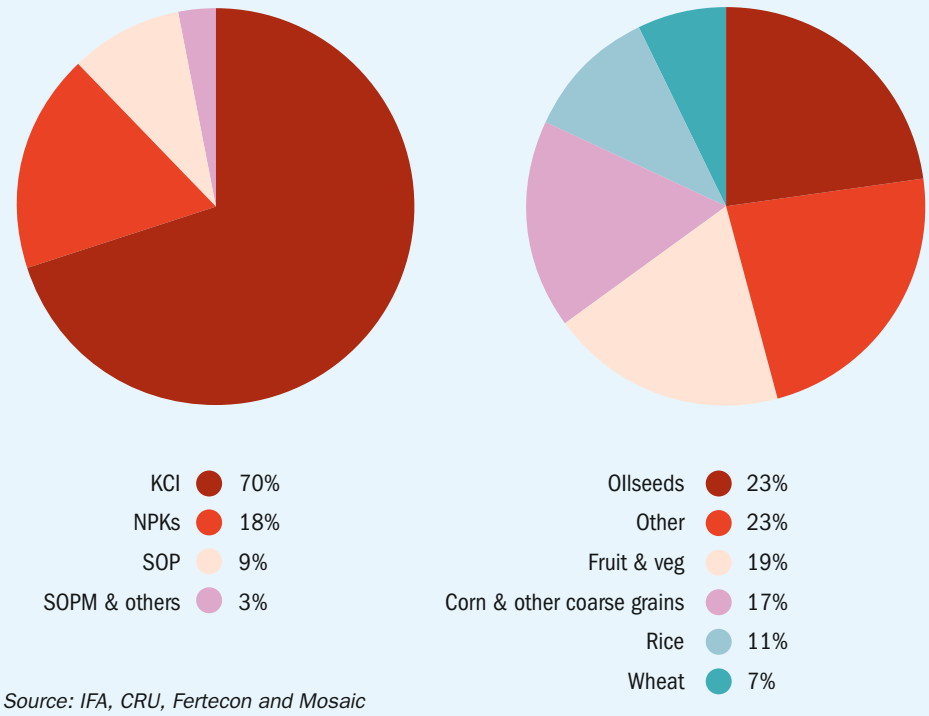
On a product basis, the market divides into MOP (70%), SOP (9%), NPKs (18%) and SOPM/others (3%) (Figure 3). Initial estimates of global MOP deliveries for 2018 are around 67 million tonnes, and are forecast to increase to around 68 million tonnes this year.

Potassium sulphate

Potassium sulphate (SOP, K_2SO_4) is the most commonly used alternative to potassium chloride. Fertilizer grades of SOP range from 50-54 percent K_2O, and also contain 18 percent sulphur in sulphate form.

SOP commands an attractive price premium over MOP. While MOP (f.o.b. Vancouver) has been appreciating throughout 2018, trading in the region of $210-260/t for much of the year, the SOP price (f.o.b.

Fig. 3: **Potash consumption by product (left) and by crop (right)**



Source: IFA, CRU, Fertecon and Mosaic

Western Europe) has been relatively stable at €420-450/t ($479-513/t) – potentially offering a premium of around $220-300/t.

World SOP production capacity is estimated at around 4.7 million t/a K_2O, having risen from 3.1 million tonnes in under a decade. This capacity equates to more than nine million tonnes of SOP on a product basis, although actual output and world supply depends on operating rates. Primary production from natural resources accounts for 44 percent of world SOP capacity, while the other 56 percent of capacity involves secondary production, usually by combining MOP with sulphuric acid using the Mannheim process.

Leading SOP producers outside China include **Tessenderlo** (*GranuPotasse*, *SoluPotasse*, *K-Leaf*), **K+S Group** (*KALISOP*), and **Compass Minerals** (*Protassium+*), who collectively account for around 30 percent of total world SOP supply (circa seven million tonnes).

China's SOP capacity has expanded fast, rising from less than two million tonnes in 2007 to more than five million tonnes currently, and is expected to grow by another 2-3 million tonnes by the end of the decade. Xinjiang-based SOP producer **Luobupo** transformed the Chinese market by supplying an extra one million tonnes of low-cost primary SOP from 2009 onwards. China's primary SOP capacity is concentrated in the far western provinces of Xinjiang (1.4 million tonnes) and Qinghai (1.2 million tonnes) (*Fertilizer International* 475, p49). Canadian-registered **Migao Corporation** manufactures SOP at four sites in China with a combined capacity of 320,000 tonnes.

The key advantages of SOP over MOP are its chloride-free nature and high sulphur content. Indeed, SOP has the lowest salt index (Table 3) of the three most commonly-applied potash fertilizers (MOP, NOP and SOP). Its use is generally advised for:

- Chloride-sensitive crops – including many fruits and vegetables
- Areas at risk from salinity, particularly semi-arid or arid regions with low rainfall, where excessive use of chloride-containing fertilizers could eventually 'poison' the soil.

SOP also remains the cheapest low-chloride source of potassium, according to Tessenderlo Kerley International. The ability to supply plant-available sulphur is becoming increasingly valued too (*Fertilizer International* 476, p19). Sulphur fertilization is particularly important in crops with a high sulphur demand such as brassica, canola and onions.

Global demand for SOP is around seven million tonnes currently, with China alone consuming around 60 percent of this volume. The global SOP market is growing at 2-2.5 percent per annum. Most standard and granular products are used to manufacture compound and blended NPKs. Indeed, growing demand for SOP-based NPKs is expected to drive consumption in the European market.

The water-soluble segment, although representing less than 10 percent of the total SOP market, is growing at a faster rate of around five percent p.a. Most water soluble SOP, unlike granular product, is sold straight, although some is used to manufacture water-soluble and liquid NPKs.

There is still unmet demand for SOP in the market, according to Tessenderlo Kerley International: "We believe that SOP market growth is probably constrained by supply. The supply/demand balance remains very tight – it is difficult to supply all demand – [and] if there was more product on the market it would almost certainly be consumed. So, potentially, growth could be even higher than 2-2.5 percent, if more production was available."

Potassium nitrate

Potassium nitrate (KNO_3, 13-0-45) offers a chloride-free source of both potassium and nitrogen, and is widely used as a water-soluble fertilizer in irrigation systems (fertigation) and foliar sprays. Relatively high productions costs have tended to limits its use to higher-value cash crops.

Irrigation systems generally require nutrient-rich and highly-soluble fertilizers that have a low salinity index and are free of impurities and insoluble material (*Fertilizer International* 486, p28). Potassium nitrate meets all of these requirements and has become a popular and market-leading fertigation product due to its ability to combine nitrate-nitrogen with a chloride-free source of potassium. It is also widely used in foliar applications to correct crop nutrient deficiencies.

Potassium nitrate is available in crystalline and prill form. Crystalline potassium nitrate is ideal for fertigation and foliar application, while prills are suitable for split applications to soil (basal and side or top dressing).

Potassium nitrate is marketed on its ability to increase the quality and yield of harvested produce. It is said to promote stronger and healthier crops by increasing plant tolerance to abiotic and biotic stresses. Potassium nitrate offers the following advantages over other forms of potash:

- Improves tolerance to drought, frost, pests and diseases
- Increases water use efficiency
- Enhances organoleptic properties of fruit (colour, sugar content and aroma)
- Promotes the synthesis of lycopene to create a deep red colour in fruit, for example

- Supplies nitrogen in non-volatile nitrate form, allowing easy handling, with no need for incorporation into the soil
- This avoids the soil acidification associated with the nitrification of ammonium fertilizers
- Nitrate can be readily absorbed by plants through highly efficient direct uptake from soil
- Higher nitrogen use efficiency improves yields and prevents unwanted nitrogen loss to the environment
- Nitrate promotes the uptake of other valuable plant nutrients (K, Ca, Mg)
- It also improves phosphorus and micronutrient availability
- Nitrate helps combat soil salinity and relieves salinity stress by counteracting the uptake of chloride
- Reduced salinity build-up also eliminates the need for additional irrigation to flush salts from the soil
- Conversion of nitrate to amino acids takes place within the leaf, an energy-efficient process that helps promote plant growth and fruit fill.

World potassium nitrate production capacity (primary and secondary) is around 1.3 million tonnes K_2O. The main producers are SQM, Haifa Group (*Multi-K*), Yara (*YaraTera KRISTA K PLUS*), KEMAPCO and Migao Corporation.

Chile's **SQM** is the world's largest producer of potassium nitrate with sales volumes of around 601,400 tonnes in 2017. The company estimate that this volume accounts for around 54 percent of global potassium nitrate sales. The completion of a new potassium nitrate plant at Coya Sur in 2011 increased SQM's potassium nitrate production capacity by 300,000 tonnes. SQM's largest competitor is Israel's **Haifa Group** who contributed about 18 percent to world potassium nitrate sales (outside China) during 2017.

Similar to SOP, China is a key market for potassium nitrate, with annual demand estimated at 400,000-420,000 tonnes, although this is largely fulfilled by domestic producers. The country imported just 20,000-30,000 tonnes of potassium nitrate in 2017. China's tobacco growers and horticultural sector are the main consumers, with an annual requirements of around 130,000 tonnes and 120,000 tonnes, respectively. The Migao Corporation operates an 80,000 t/a capacity potassium nitrate production plant in Sichuan and a 400,000 t/a capacity potassium nitrate/NPK plant in Yunnan.

Potassium magnesium sulphate (SOPM)

Potassium magnesium sulphate ($K_2Mg_2(SO_4)_3$, SOPM) is manufactured by extracting and processing naturally-occurring deposits of the mineral langbeinite. SOPM is valued as a fertilizer for its magnesium and sulphur content, as well as being a chloride-free source of potassium.

SOPM has been mined in the United States for over 70 years from what **The Mosaic Company** describes as "the world's largest and purest deposits of langbeinite ore" at Carlsbad, New Mexico. Two producers, Mosaic and Intrepid Potash, mine and manufacture SOPM at Carlsbad and market this under the *K-Mag* and *Trio* brand names, respectively.

Mosaic offers *K-Mag* in three formulations:

- *K-Mag Premium* (0-0-22.5+10.5Mg+21S, 2.5% Cl) is suitable for high-quality blending due to its uniform particle size

- *K-Mag Granular* (0-0-22.5+10.5Mg+21S, 2.5% Cl) is typically used in bulk blends
- *K-Mag Standard* (0-0-22+10.8Mg+22S, 2.5% Cl) is suitable for direct application and as a key ingredient for granulation.

K-Mag is recommended for chloride-sensitive vegetable and fruit crops requiring high fertilizer application rates. It typically benefits crops with a high potassium and magnesium demand that are also sensitive to chloride, such as tobacco.

According to Mosaic, *K-Mag* is an excellent source of non-chloride potassium, water-soluble magnesium and sulphur. With less than three percent chloride content, the risk of fertilizer 'burn' is also minimal. The combination of magnesium and potash in *K-Mag* improves plant resistance to winter kill and insects. The product's magnesium content also activates the enzymes that synthesise chlorophyll, while the sulphur it supplies boosts amino acid formation.

Intrepid markets its SOPM brand *Trio* as: "A long-lasting, readily-available source of low-chloride potassium, magnesium and sulphur ideal for fruit, vegetable and row crops grown in magnesium-deficient soils." *Trio* is also offered in a number of grades:

- Premium (0-0-21.7+10.9Mg+21.8S, 3.0% Cl)
- Granular (0-0-22.1+11.2Mg+22.2S, 1.4% Cl)
- Standard (0-0-22.1+11.2Mg+22.2S, 1.5% Cl)
- Fine standard (0-0-21.7+11.0Mg+22.2S, 2.0% Cl).

OMRI-listed versions of granular, standard and fine standard grades are also approved for organic farming.

Monopotassium phosphate (MKP)

Monopotassium phosphate (MKP), also known as potassium dihydrogen phosphate (KH_2PO_4), is sold commercially as a fertilizer, food additive and fungicide.

Fertilizer-grade MKP is a high-analysis product (0-52-34) that provides plants with a concentrated supply of both potassium and phosphorus. MKP is primarily marketed as a speciality fertilizer for use on high-value crops, to justify its premium pricing (*Fertilizer International* 459, p43). Its high purity and water solubility make it an ideal fertilizer for fertigation – hydroponics in particular – and foliar application.

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

MKP is fully water-soluble with a low salt index and is free of chloride, sodium and other deleterious constituents. It can be used as a buffering agent in fertigation solutions due to its moderately low pH. MKP helps to optimise the plant absorption of nutrients by maintaining pH at 4.5.

MKP is mainly produced by reacting phosphoric acid with potassium chloride followed by solvent extraction. Alternatively, phosphate rock and phosphoric acid can be reacted with monopotassium sulphate without a solvent. A third production process involves the reaction of phosphoric acid with potassium hydroxide.

Leading suppliers of MKP include ICL Specialty Fertilizers (*Nova PeaK*), Haifa Group (*Haifa MKP*), Prayon (*Hortipray MKP*) and Yara (*YaraTera Krista MKP*). **ICL** is the largest manufacturer of MKP fertilizers worldwide. Its *Nova PeaK* (0-52-34) MKP product offers the following benefits:

- The highest concentration phosphorus fertilizer
- Very low salt index
- Very safe for fertigation applications (drip irrigation, hydroponics, sprinkles, pivots) or foliar spraying, being free of chlorine, sodium and impurities, without the risk of phytotoxicity or leaf burn
- Buffering effect stabilises the pH of nutrient solutions
- The absence of nitrogen permits nutrient application at the optimum P:K ratio for growth stages – such as rooting, flowering, fruit set, ripening and harvest – where lower nitrogen levels are required.

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

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

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

Polyhalite

Polyhalite is attracting increasing attention as a potash alternative. **ICL Fertilizers** recently switched all production at its UK Boulby Mine in North Yorkshire from MOP to its new polyhalite product *Polysulphate*. ICL has successfully trialled *Polysulphate* as a low-chloride, multi-nutrient (sulphur, magnesium, potassium and calcium) fertilizer on a wide variety of crops, including barley, brassica, canola, coffee, oil palm, potatoes and wheat.

ICL offers a family of three polyhalite products as part of its new *FertilizerpluS* line of premium fertilizers:

- Straight *Polysulphate* in granular or powder
- The *ICL PKpluS* range of PK (phosphorus and potassium) granular fertilizers containing *Polysulphate*
- *ICL PotashpluS*, a granular fertilizer formulated from a combination of MOP (KCl) and *Polysulphate*.

Polysulphate contains:

- 48 percent SO_3 as sulphate
- 14 percent K_2O as potassium sulphate
- 6 percent MgO as magnesium sulphate
- 17 percent CaO as calcium sulphate

Applying *Polysulphate* ensures a continual supply of sulphur to crops throughout the growing cycle, and reduces the risk of sulphur leaching in sandy soils, especially under high rainfall conditions. It also provides magnesium to support crop yield and quality. This is becoming ever more important now that soil Mg deficiency is becoming increasingly widespread. Granular *Polysulphate* (2-4mm) has excellent spreading characteristics and is an ideal fertilizer to apply alongside straight nitrogen. It is also approved as an organic fertilizer in the UK, France, Italy, the Netherlands, Austria, the US, Canada and Israel.

ICL PKpluS, produced at the company's plants in Amsterdam and Ludwigshafen in

Germany, allows the application of P and K to be separated from nitrogen applications. By avoiding N overdosing or leaching, the use of *PKpluS* improves nitrogen use efficiency and helps prevent costly and environmentally-damaging nitrogen losses. *PKpluS* is also a cost effective PK fertilizer for nitrogen-fixing legumes, such as soybean, peas and alfalfa, which require no additional nitrogen fertilization.

ICL PotashpluS has a much lower chloride level than MOP due to its *Polysulphate* component. Its sulphur content also meets the fertilization requirements of crops with high sulphur demand, such as canola, wheat, legumes and grassland. In addition to supplying potassium (37% K_2O), *PotashpluS* supplies sulphur (9% S) in sulphate form for protein and oil formation, magnesium (3% MgO) for photosynthesis, and calcium (8% CaO) for strong, high-quality crops – all in the same application. It also contains boron.

Another company, **Sirius Minerals**, is currently investing $4.2 billion in the construction of the Woodsmith Mine, a large-scale, deep-shaft polyhalite mine in England's North Yorkshire region. The mine will eventually produce 10 million tonnes of the polyhalite product *POLY4* annually. The first production tonnages are due towards the end of 2021, under the current project timetable.

Sirius has commissioned extensive agronomic trials evaluating crop responses to its polyhalite product *POLY4* (*Fertilizer International* 474, p44). These have demonstrated a high yield response to the Ca, K, Mg and S content of *POLY4* for a wide range of broad acre and high-value cash crops.

Sirius believes that large-scale production of polyhalite will help satisfy current unmet demand in the market for low-chloride sources of potassium. It calculates that demand from chloride-sensitive crops should account for 32 percent of total global potash consumption. However, due to cost and limited availability, only nine percent of this demand is currently supplied by low-chloride sources of potash. This suggests that unmet demand for low-chloride potash could be as high as 23 percent of total potash consumption. That is equivalent to a potential demand of around 11 million t/a (K_2O basis) for low-chloride products such as *POLY4*.

There is similar unmet market demand for sulphur, magnesium and calcium fertilization too, Sirius suggests. The company calculates that global sulphur deficiency alone could accommodate incremental *POLY4* applications of 60 million t/a, for example. Sirius predicts that agricultural intensification will also lead to increased demand for magnesium supplied by products such as *POLY4*. Demand for sources of calcium with soil conditioning properties is also expected to increase, to help combat soil erosion.

The agricultural industry's increasing focus on nutrient use efficiency and soil quality will promote the use of multi-nutrient, low-chloride fertilizers in future, according to Sirius Minerals. Polyhalite products such as *POLY4 can* help improve the strength and structure of soils and also reduce nutrient losses to the environment. ■

References

1. Ren, L. et al., 2015. *The Value of KCl as a Fertilizer with Particular Reference to Chloride: A Mini Review*. Research Findings, International Potash Institute (IPI), e-ifc No. 40, March 2015.
2. Xu, G. et al., 2000. *Advances in Chloride Nutrition of Plants. Advances in Agronomy, Volume 68*. Academic Press.

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