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TFI World Conference, San Francisco

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Water-soluble fertilizers

Canpotex profile

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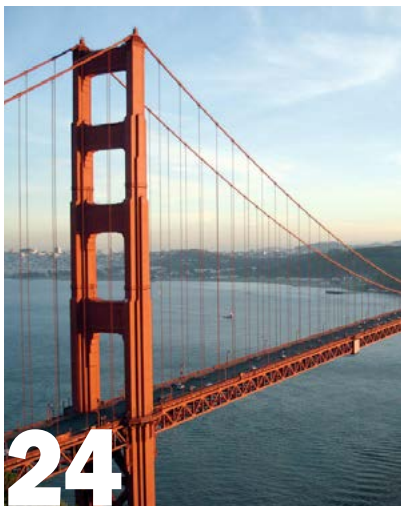

TFI World Conference

Canpotex profile

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REGULARS

One piece of the jigsaw

While the fertilizer market remains the central theme, it is incredibly refreshing to attend a conference that views crop nutrients as just one piece of the wider agricultural jigsaw.

The autumn conference season is fast approaching. In September, *Fertilizer International* will be the official media partner for two major international conferences: The 9th GPCA Fertilizer Convention in Muscat, Oman (p42), and CRU's 2018 Africa Fertilizer Agribusiness Conference in Cape Town, South Africa (p22). In October, we will also be exhibiting at TFI's World Fertilizer Conference in San Francisco, California (p24), and at IFA's Crossroads Asia-Pacific Conference in Singapore.

CRU's Africa Fertilizer Agribusiness Conference, although a relatively new fixture on the industry calendar, has gone from strength-to-strength. Its success is partly explained by CRU's excellent choice of collaborator – the African Fertilizer Agribusiness Partnership (AFAP). What really makes the event almost unique, though, is that it encompasses the whole of the agricultural value chain. While the fertilizer market remains the central theme, it is incredibly refreshing to attend a conference that views crop nutrients as just one piece of the wider agricultural jigsaw.

Africa's much vaunted promise as a fertilizer growth market is inexorably, year-on-year, starting to become a reality. CRU and AFAP's conference success certainly reflects a growing thirst – both inside and outside Africa – for knowledge and intelligence about the very latest African market developments.

Africa's enormity and diversity is what defines the continent. The Sahara desert – that striking and vast feature of African geography – is an imposing barrier that divides the continent in two. On its northern flank are the Mahgreb countries – Algeria, Morocco, Tunisia, Libya, Mauritania – plus Egypt, while to its south lies the bloc of 41 sub-Saharan African (SSA) countries.

As a whole, African fertilizer consumption is extremely low by international standards. The continent's annual consumption – of around seven million nutrient tonnes – accounts for a lowly three percent of global fertilizer use.

Yet Africa's fertilizer markets are as varied as the continent is diverse. Consumption tends to be concentrated in either the major fertilizer-producing nations and/or major cash-crop producing and exporting countries. Two countries, Egypt and Algeria, for example, account for some 90 percent of demand north of the Sahara. And three SSA countries, South Africa, Nigeria and Ethiopia, are the dominant fertilizer consumers in southern, west and east Africa, respectively.

African fertilizer consumption is on the rise, having increased by around two million nutrient tonnes between 2010 and 2016. But that growth is just a fraction of Africa's enormous longer-term growth potential as a fertilizer market.

That optimism stems from several striking fundamentals. Africa's population is expected to triple by 2060, for example, with most of that growth concentrated in the SSA region. In Africa's most populous nation, Nigeria, the population is expected to soar to close to half a billion by 2060, up from 190 million people currently.

If African food self-sufficiency is to ever become a reality, then the continent's agricultural productivity will need to keep pace with and match population growth rates. And a step-change in fertilizer consumption will be central to delivering the yield improvements that will undoubtedly be needed to deliver this.

Current application rates in SSA remain the lowest in the world, averaging around 12 kg/ha compared to the world average of 110 kg/ha. Fortunately, action is being taken to build on that very low baseline and fully realise the African fertilizer market's huge potential.

The African Development Bank is championing efforts to raise fertilizer consumption on the continent via the African Fertilizer Financing Mechanism. This has set an application rate target of 50 kg/ha by 2030. Over the shorter-term, the World Health Organisation expects average applications rates in SSA to approach an achievable 17-18 kg/ha by 2021.

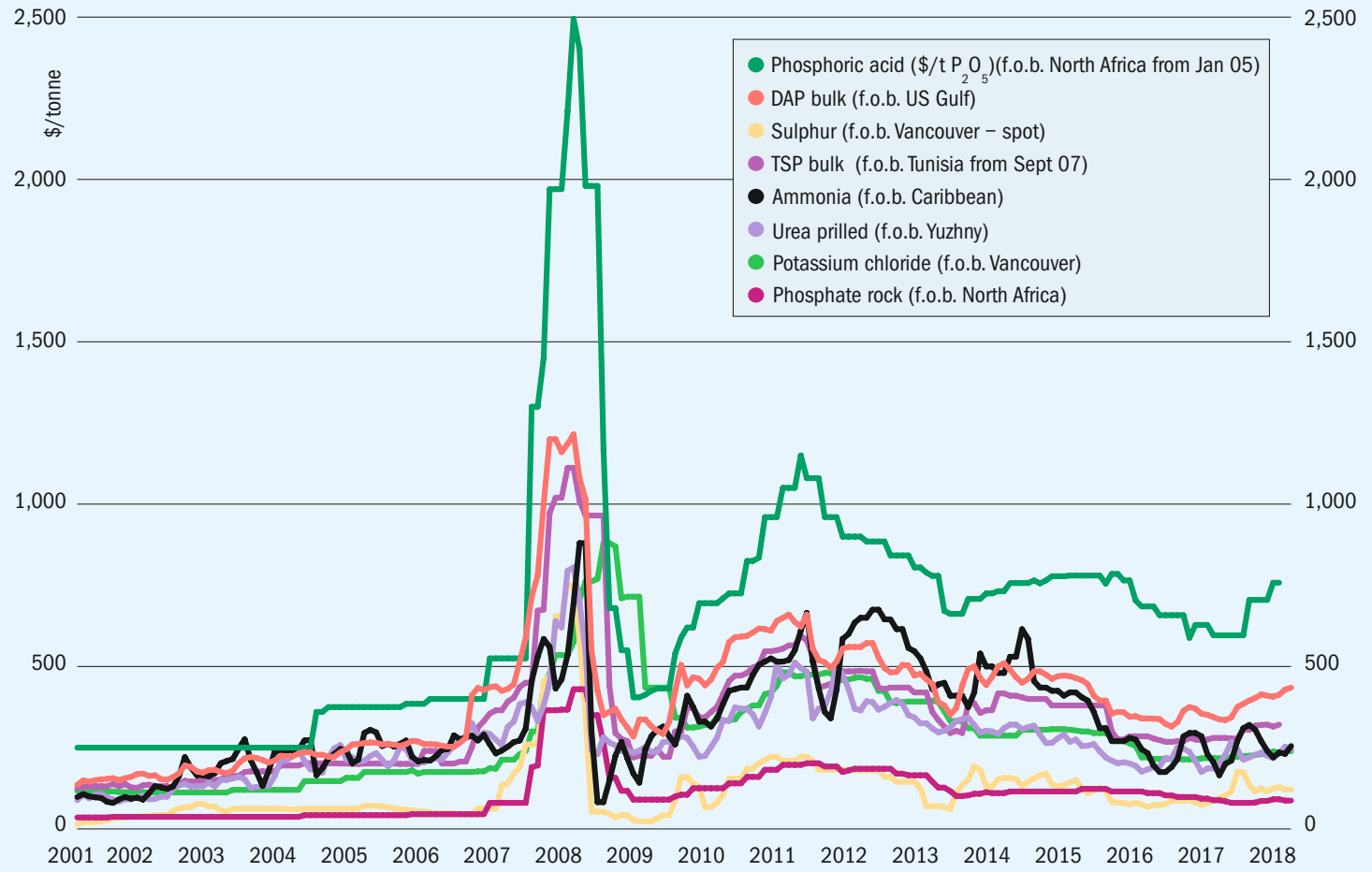
Brakes on the continent's fertilizer demand still exist though. And efforts to dramatically boost fertilizer adoption since the Abuja Declaration almost two decades ago have clearly failed. The reasons for this are well known: weak access to credit, poor logistics, the widespread absence of farmer training and extension services, and the lack of institutional capacity. Volatile weather conditions, particularly drought, have also hit agricultural output and fertilizer demand hard.

What makes the CRU/AFAP agribusiness conference in Cape Town this September so encouraging is that is brings all of the sector's actors together in one place – to network, learn and collaborate. The event aims to unlock the full potential of African agriculture. If that is the ultimate goal, then creating a thriving fertilizer market in Africa is going to be key. ■

Simon Inglethorpe, Editor

Market insight

Historical price trends $/tonne



Source: BCInsight

Market insight courtesy of Integer Research

PRICE TRENDS

Ammonia: Plant shutdowns tightened the market and rapidly pushed up prices in late-July and early-August. Above expectations, Black Sea and Middle East benchmarks gained over $60/t to reaching $310/t f.o.b. The subsequent market pause during Eid celebrations provided a week or two of stability. Indonesia's PT Panca Amara Utama (PAU) plant has belated come on-steam. This is now allowing Mitsubishi to load vessels from the plant, rather than covering its commitments through costly spot purchases. However, PAU remains in commissioning and is still operating well below nameplate capacity. Elsewhere, Yara's Pilbara plant is still offline for maintenance, while two of Nutrien's Canadian plants are also down for planned turnarounds, limiting merchant availability from Alberta.

Urea: Most import markets are now closed to Iranian shipments following the Trump administration's reintroduction of US sanction on Iran. India does, however, remain open to Iranian business, as was the case under the previous sanctions regime. India's recent 712,000 tonne MMTC tender was entirely covered by Iran (assuming the 50,000 tonne Chinese contribution was re-exported Iranian product). Iranian exporters were forced to lower prices to secure this tender and to maximise exports in one of the last markets open to them. China is still largely absent from the seaborne market and its export business is limited to monthly availability of just 100,000 tonnes. In China's absence, recent South Asian and Brazilian buying has pushed prices to $300/t at the major f.o.b. ports in North Africa and the Middle East (heavy discounting by Iranian exporters being the exception).

Phosphate: Finished phosphates prices continued rising into the third quarter, driven upwards by tight spot availability and rising sulphur and ammonia costs. July-August DAP prices averaged $420-430/t f.o.b. at the major export hubs, some $15-20/t above second-quarter averages and $80/t higher year-on-year. Indian DAP import demand helped support prices. Non-integrated Indian DAP producers have become less competitive due to rising merchant-grade acid prices in the seaborne market. This has allowed imported DAP to substitute for domestic product. However, the end of India's agricultural season will prompt a slowdown in DAP imports during the remainder of 2018. With availability tight, Brazilian MAP prices, at $450/t cfr, are already $100/t above the average import price during 2017's third-quarter. MAP exporters to Brazil are expecting robust demand to lift off in September.

Potash: The market revived in August on news of outages in Russia and Canada. These developments suggest that prevailing market tightness could worsen and/or last longer. In Russia, Uralkali's Solikamsk-2 mine could be flooding irreversibly, according to unconfirmed reports, raising questions about whether the mine will be completely

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lost. Solikamsk-2 produces approximately 1.2 million tonnes annually, with a further one million t/a expansion planned. In Canada, K+S's new Bethune mine in Saskatchewan is also producing below expectations. Lower-than-anticipated ore quality is thought to be partly behind this. Bethune also ceased production for four days in June to allow repairs to a faulty boiler stack.

Potash demand in Brazil remains strong. Prices continue to firm with granular MOP reaching $337/t cfr in August. In contrast, the market in Southeast Asia is rather subdued, with some buyers waiting on the side-lines for news on price levels.

Sulphur: The global supply/demand balance has tightened over the last few months. This has driven up price sentiment and is adding to expectations that prices will remain at inflated levels, at least in the short-term. Pricing in China, the leading global importer of sulphur, remains the key market talking point in 2018. The current price level of around $160/t is the highest so far this year. A sulphur inventory build-up at ports in China should be putting prices under downward pressure. A net addition of 100,000 tonnes in July took inventories to 1.7 million tonnes. At this level, we would expect Chinese buying to reduce heavily. However, evidence of flat or falling imports has yet to show in the data.

Market price summary $/tonne – Mid-August 2018

Nitrogen	Ammonia	Urea	Ammonium Sulphate	Phosphates	DAP	MAP	Phosphoric Acid
f.o.b. US Gulf	235		cfr Brazil 145-150	f.o.b. US Gulf	434-435		
f.o.b. Yuzhny	264-275	235-255**		f.o.b. N. Africa	438-453		
f.o.b. Middle East	295-310	265-280***		cfr India	429-431		n.a.*
				cfr Brazil		454-455	
Potash	KCl Standard	K_2SO_4	**Sulphuric Acid**		**Sulphur**		
f.o.b. NOLA	261-269		cfr US Gulf	n.a.	cfr Tampa	121	
f.o.b. Middle East	250-274				f.o.b. Arab Gulf	140	
f.o.b. China		401-460			f.o.b. China	162-187	
f.o.b. Baltic	216-293				cfr India	n.a.+	

Prices are on a bulk, spot basis, unless otherwise stated. (= contract ** = prilled *** = 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

- **Ammonia:** Expectations of higher urea pricing should give ammonia pricing an upward lift, as will higher gas prices in Europe. (NW European gas hubs are pricing above $8.00/MMBtu again in August.) The urea market looks firm with further price gains expected as demand emerges from Turkey, Europe and the US in the coming months. On balance, we expect these market developments to offset any downward pricing pressures on ammonia from supply resumptions by PAU, Pilbara and Nutrien. Ukrainian ammonia exports remain a wildcard though. Production by OPZ is likely to restart on a tolling basis, should urea and ammonia prices rise further. The resulting addition of 65,000 tonnes to monthly merchant availability could quickly cap or dump ammonia prices. The start-up of EuroChem's Kingisepp ammonia plant should also act to dampen prices by the end of the year.
- **Urea:** Chinese pricing remains buoyant at $290-300/t. This suggests that operating rates are falling, in line with demand, limiting export availability. Chinese exports will be on course to undershoot two million tonnes in 2018, should current export levels be maintained over the next few months. Such an eventuality could herald a much tighter supply/demand balance in 2018's second half. Indeed, prices could make sustained moves above $300/t, with limited availability from China, as European and US buying begins to emerge in late September.
- **Phosphate:** India has already imported around four million tonnes of DAP so far this year, out of the five million tonne import total forecast for 2018. Demand for DAP from other parts of the southern hemisphere is expected to emerge during the fourth-quarter, with Southeast Asia and Oceania featuring prominently. Rising raw materials prices, rather than consumption, are likely to underpin DAP pricing during the remainder of 2018. In the MAP market, we expect robust trade in the final quarter of 2018, with delivered prices to Brazil in the range $440-460/t cfr.
- **Potash:** The market continues to wait for long-term supply contracts to be agreed with Chinese and Indian buyers. The consensus is that import contracts will be priced at least $30/t cfr over the 2017/18 settlement. Pressure is said to be building for China and India to settle, with port stocks in the latter reported to be low. We are reasonably bullish in our short-term outlook for potash prices, given current supply issues and the strength of demand. However, despite the slow ramp-up of new greenfield mines, the scale of capacity growth will undoubtedly weigh on prices over the longer-term.
- **Sulphur:** Trade this year is being increasingly driven by Morocco and Brazil. Sulphur imports to both two countries are growing impressively, a trend that is expected to continue in the year's second half. Morocco's imports are projected to carry on rising in 2019, as OCP ramps-up phosphoric acid production at Jorf Lasfar. Brazil's sulphur imports, in contrast, should ease, with sulphuric acid imports instead finding more favour. With global sulphur demand relatively stable, new supply will be the key driver next year – exerting a downward pressure on prices. Sulphur export availability in the Middle East will be boosted by the Barzan project in Qatar and the Clean Fuels Project in Kuwait. The ongoing ramp-up of the Kashagan project in Kazakhstan is likely to increase exports into 2019. Growing inventory levels observed in Kazakhstan and Russia in recent months will eventually be brought to market, contributing to a downwards pricing correction. Additionally, China's sulphur imports, around 11-12 million t/a currently, look set to decline due to increasing domestic supply from Chinese refineries.

UNITED STATES

JDCPhosphate produces high-quality acid

Florida-based JDCPhosphate has managed to successfully manufacture high-quality super-phosphoric acid (SPA) continuously.

This was achieved during prolonged operation of the company's proprietary improved hard process (IHP) at its new demonstration plant in Fort Meade, Florida.

The highly-innovative kiln-based IHP production route is designed to manufacture phosphoric acid from low-quality phosphate rock, without creating phosphogypsum waste. Instead, the process generates *J-Rox*, a commercially-useful aggregate, as a co-product.

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

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

"This is a major milestone for JDC and our technology, showcasing IHP's value as a cost-efficient and scalable new process," said Timothy Cotton, JDCPhosphate's CEO. "Our company, management team and stakeholders have dedicated a great deal of time and effort to prove the efficacy of this breakthrough process and we are very pleased with these recent achievements."

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

Luc Maene, former director general of the International Fertilizer Association (IFA), commented, "For many years I have been hoping that innovative technologies will improve the sustainability of the phosphate sector. JDC's IHP technology can make a major impact on phosphate sustainability by opening up new sources of phosphate rock while significantly reducing wastes."

JDC will be upgrading its commercial demonstration plant over the next few months to allow it be operated on-demand over long periods. The Fort Meade plant should be in a position to test various types of phosphate ore from early 2019 onwards. This will allow potential licensees to validate the process for their own specific phosphate ore and silica sources. As a next step, JDC plans to commercially deploy IHP technology, after completing process design engineering for a full-scale production process. ■

ADM revealed as Sirius customer

Sirius Minerals has revealed that Archer Daniels Midland (ADM) is its off-take partner in North America. The two partners made the disclosure in July.

Sirius originally entered into an offtake agreement with ADM in 2014, an agreement that was subsequently replaced and expanded in 2015. But the off-take's signatory remained unnamed and had been confidential, until now.

Sirius is the UK developer of the £2.4 billion North Yorkshire polyhalite project. The company is currently constructing the Woodsmith Mine near Whitby, close to England's North Sea coast. First production of polyhalite is expected in 2021, ramping-up to 10 million t/a by 2024.

Under the terms off-take deal, Sirius Minerals will supply ADM with up to 1.5 million t/a of its polyhalite product *POLY4* over a seven-year period from the start of production. The agreement includes two five-year extensions. These provide the option to increase the supply of *POLY4* to 1.5 million t/a in year five, with a further option for an additional 0.5 million t/a.

ADM is one of the world's largest agricultural processors and food ingredient providers, employing around 31,000 staff serving customers in more than 170 countries. Its fertilizer division, ADM Fertilizer, operates 14 river terminals and 12 interior terminals in North America and has been a wholesale distributor and a farm supplier since 2016.

As well as revealing its 'mystery' North America partner, Sirius also announced in July that ADM will supply the starch-based binding agent that will be used to produce *POLY4* granules. *POLY4* will be granulated by crushing and grinding polyhalite and then binding the powder obtained with starch using a patented process.

Chris Fraser, Sirius Minerals managing director and CEO, said: "Sirius has been working with ADM for more than four years and today's announcement further strengthens our relationship by securing ADM as an important supplier and customer."

Scott Nagel, ADM Fertilizer's president, said: "ADM was an early adopter of *POLY4* and is excited to bring this multi-nutrient low-chloride fertilizer to our diverse customers in the North American market, including Mexico. The opportunity to expand our distribution into the Mexican market with a product like *POLY4* supports the overall growth strategy of our business. We are looking forward to adding *POLY4* to our portfolio of fertilizer products."

In related news, Sirius Minerals also announced long-term supply agreements with two new Chinese customers, Eiliseng and YSA, for 1.2 million t/a and 800,000 t/a, respectively. These allow for the resale of *POLY4* into a number of southern and northern Chinese provinces for a 10-year term.

The move strengthens the company's distribution presence in Asia, building on its previously-announced agreement with Wilmar Group, one of the largest fertilizer buyers and distributors in South East Asia.

These two Chinese deals increase total contracted take-or-pay sales volume for *POLY4* from 4.7 million tonnes to 5.7 million tonnes per annum.

Sirius CEO Chris Fraser said: "China is a key market for *POLY4* and we are very pleased to have signed agreements with new customers who both have established fertilizer distribution networks and expertise relevant to their respective regions."

CANADA

Nutrien buys agtech firm Agrible

Nutrien has bought the leading US digital agriculture firm Agrible Inc for $63 million.

Agrible markets a broad range of digital agronomic products for farmers. They include *Morning Farm Report*®, *Spray Smart*®, *Nutrient Engine*® and *Find My Seed*®. The Illinois-based company has around 17,000 customers who collectively farm around 11 million acres in total.

"Agrible has developed a very impressive set of digital agronomic and sustainability tools which can be immediately incorporated into our existing digital platform," said Mike Frank, president of Nutrien Ag Solutions. "We are excited to welcome Agrible's talented team to Nutrien Ag Solutions' digital organization and to expand our presence into Champaign, Illinois, " Frank added.

"Agrible has dedicated its business strategy to building market-leading digital tools that provide growers with the information and insights they need, when and where they need them," said Paul Miller, chief science officer & co-founder of Agrible. "This exciting combination with Nutrien Ag Solutions is the ultimate validation of our strategy and the ideal platform to significantly scale-up the capabilities that we have built."

K+S sues Veolia over Bethune equipment collapse

K+S Potash Canada has launched a $180-million lawsuit against Veolia Water Technologies over the "catastrophic" collapse two years ago of large equipment at the company's Bethune mine in Saskatchewan.

K+S is blaming the "flawed design" of equipment manufactured by Veolia for $85 million in lost potash production.

K+S filed a claim alleging breach of contract and negligence on the part of French-headquartered Veolia Water Technologies at a Saskatoon Court in April. It is unclear when the case will be heard.

In 2012, K+S entered into a $324 million contract with Veolia for the design and supply of a crystallization and evaporation system for the Bethune solution mine (formerly the Legacy project). The Bethune mine was the first greenfield potash mine to open in Saskatchewan in 40 years.

The legal dispute centres on the overnight collapse of one of the Bethune plant's massive crystallization units on 17 July 2016. The 12 metres-high units weigh almost 500,000 kilograms. K+S is blaming Veolia for the collapse, as the company designed the steel frame and also provided the instructions for testing, it is claimed.

"The incident was a catastrophic event. All construction on the process plant of the Bethune mine came to a halt as a result of the incident. The process plant was evacuated due to hazardous conditions, including live electrical installation, flooding from the collapsed crystallizer and the instability of the collapsed structure," K+S said in a court-filed statement.

K+S is seeking damages of more than $180 million in total. This amount including $65 million in physical damage, and an estimated $85 million due to lost potash production. The latter was delayed by up to six months, according to court documents filed by K+S.

BELARUS

Sinochem and BPC agree MOP supply deal

Belarusian Potash Company (BPC) has agreed a speciality potash supply deal with China's Sinochem Group

A total of 700,000 tonnes of zinc- and sulphur-enriched white MOP (muriate of potash) will be supplied to the Chinese market for the five-year period 2019 to 2023. The terms of the supply agreement were set out in a memorandum signed by BPC and Sinochem in August. They includes the right to agree annual contracts for yearly volumes based on market conditions.

BPC has been marketing and selling Belaruskali-produced potash since 2013. The new memorandum is extra to an existing potash supply agreement signed by both companies in 2015.

Mr A Polyakov, BPC's deputy director general for sales and marketing, said: "The [deal between] Sinochem Group and BPC is a real strategic partnership, based on a long-term experience of successful collaborative work. We highly value the established business relations with our Chinese partners and believe that they will get stronger in the course of time."

Mr I Golovaty, Belaruskali's director general, said: "The signing of the new memorandum is a further acknowledgement of the fact that our product is highly demanded on the Chinese market. We are sure that our new product, with the addition of zinc and sulphur, will quickly become popular and not only in the Asia region. Moreover, the new memorandum… enhances strategic cooperation of Belaruskali and BPC with Sinochem Group, one of the largest potash importers in the world."

UKRAINE

Severodonetsk Azot re-starts

Severodonetsk Azot restarted ammonium nitrate (AN) production over the summer, producing its first thousand tonnes at the beginning of August.

The successful re-start of the AN plant follows the resumption of production at the site's ammonia plant. Severodonetsk Azot, part of the Ostchem/Group DF empire owned by Dmitry Firtash, is now planning to resume urea production.

Production at the site, which is located just 30 kilometres from Russian-occupied Luhansk Republic, was interrupted after fighting in 2014 cut electricity supplies.

The site did manage to re-start for a time in 2017, but operated at a very low gas levels due to its reliance on supplies from across the Russian border. However, the plant subsequently shut down again in April 2018 due to an electrical fault.

GERMANY

Severe drought partly halts potash output

K+S announced a partial shutdown of its Werra potash plant at the end of August. The company blamed the severe drought conditions affecting production at the multi-site plant located in Germany's Thuringia and Hesse regions.

"The persistent severe drought in recent months has led to production being temporarily interrupted at some Werra plants. The Wintershall site was shut down this morning and will not be able to start production again until further notice," K+S said in a statement on 27 August, adding: "Production at the Hattorf site is still secured, but if the water level continues to remain low, the operations will also have to be shut down."

The exceptionally low level of the nearby Werra river is limiting the company's ability to dispose of the wastewater generated during potash production. K+S does, however, believe production from it Unterbreizbach site can continue, based on current forecasts.

"K+S is making every effort to increase production at the Werra plant as soon as possible. Additional measures for wastewater disposal are currently being examined," the company statement added.

Nearly 4,400 staff work at the Werra plant, making it a major employer in the region, close to the cities of Bad Hersfeld, Bad Salzungen and Eisenach.

thyssenkrupp scale-up water electrolysis tech

Germany's thyssenkrupp has launched a new technology for industrial-scale water electrolysis. This should make large-scale hydrogen production economically feasible using renewable energy.

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

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

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

MOROCCO

'Green' fertilizer link-up

Morocco's OCP Group and Germany's Fraunhofer Institute are to collaborate on 'green' fertilizer production technology.

The two partners will work jointly on

producing hydrogen and ammonia using renewable electricity. The collaboration forms part of memorandum of understanding (MoU) between OCP Group and the Fraunhofer Institute for Microstructure of Materials and Systems (IMWS).

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

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

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

NIGERIA

Indorama starts 'Eleme II' construction

Indorama Eleme Fertiliser and Chemicals Ltd has started construction work on a second world-scale ammonia-urea production line at its Rivers State complex.

Indorama recently secured a $1 billion finance package for the 'Eleme II' project from a consortium of banks led by the International Finance Corporation (*Fertilizer International* 485, p10). The second train will effectively double Indorama's urea production capacity to 2.8 million t/a by duplicating the 1.4 million t/a capacity of the existing first train.

Bukola Saraki, the president of Nigeria's senate, laid the foundation stone at an official ground-breaking ceremony on 17 July. In a speech to mark the occasion, Saraki called for national unity. He pointed out that the urea produced on Nigeria's southern Atlantic coast is destined for use by farmers in the north of the country.

"That tells us that we must unite," Saraki said. "We must support ourselves irrespective of party affiliation. Without peace, there will be no urea. For all of us in Nigeria, let's work in the interest of our country." He also said that agricultural sector development was necessary for diversification of the Nigerian economy.

Rivers State Governor Nyesom Wike also attended the ground-breaking ceremony. He said that the multi-billion dollar project confirmed the region's status as a destination for inward investment.

UGANDA

Sukulu phosphate plant to open in October

The Sukulu phosphate production plant will become operational in October, its Chinese developer has said.

The completion date was confirmed by Jane Guo, CEO of Guangzhou Dongsong Energy Group, the company behind the project. According to local media reports, Ms Guo said fertilizer production will officially begin on 9 October – Uganda's Independence Day – and then ramp-up to full production by June next year.

The 300,000 tonne capacity Sukulu phosphate plant is being built on a 600-acre site in Uganda's Tororo district. Developer Guangzhou Dongsong also holds a license to mine the phosphate rock required for the plant from the Osukuru Hills. The project is backed by $650 million of finance secured through the Industrial and Commercial Bank of China.

"We are on course. Different sections have been given to different contractors and so far the progress is good. The project is good," Guo said, speaking to journalists on 20 July.

Agronomic trials and model farms in Kabale, Mbale and Masaka had delivered impressive results, according to Guo. She also stressed that the plant's phosphate fertilizer output would be entirely organic. "Our fertiliser is designed for Ugandan soil, climate and environment. We are purely organic," Guo said.

The project has experienced a number of delays since it was officially launched by Uganda's President Museveni in August 2014. The fertiliser plant was due to be completed in March under the latest timetable. Guo blamed rigorous testing of the production technology and financing hold-ups for project delays. She now expects the completion of the entire industrial park in June 2019.

"We had technological and financial challenges. It has taken us three years to develop the modern technology that we are going to employ in the project. We also got the funds last year. Construction started in February this year and we have the infrastructure for the entire plant," Guo said.

ERITREA

Government accepts Colluli plans

Eritrea's environment department (DOE) has accepted the social and environmental management plans (SEMPs) for the Colluli potash project. The news was confirmed in August by Danakali Limited, the project's developer.

The Colluli project is owned by the Colluli Mining Share Company (CMSC), a 50:50 joint venture between Danakali and the Eritrean National Mining Corporation (ENAMCO).

EuroChem recently signed a take-or-pay agreement to buy all of the future sulphate of potash (SOP) output from the East African greenfield project for 10 years, based on an annual production of 472,000 tonnes (*Fertilizer International* 485, p9)

The acceptance of the SEMPs follows an extensive review by the DOE, and builds on the project's previously-approved social & environmental impact assessment (SEIA). The Colluli project is fully permitted having been awarded mining licenses in early 2017. "The finalisation and acceptance of the SEMPs represents another strong milestone for CMSC as it prepares for project execution at Colluli," Danakali said in a statement

Danakali Limited was also admitted to the London Stock Exchange in July, trading under the ticker DNK. The company is now dual-listed having retained its Australian Stock Exchange listing.

Seamus Cornelius, Danakali's executive chairman, said: "We are delighted to deliver on another of our strategic goals for 2018. The LSE listing should increase our profile, liquidity and breadth of potential investors. It is a key milestone as we move towards construction and production at the Colluli potash project."

INDIA

Topsoe to license two ammonia plants

Haldor Topsoe has been awarded the ammonia technology licenses for two 2,200 t/d ammonia plants in Eastern India.

The plants are part of two identical fertilizer complexes in Sindri and Barauni being developed by Hindustan Urvarak and Rasayan Ltd (HURL). They each comprise of a 2,200 t/d ammonia and a 3,850 t/d

urea plant. Technip was awarded the contracts to build both complexes in May (*Fertilizer International* 485, p9).

The two new plants are part of the Indian government's plans to revive the country's fertilizer sector and promote self-sufficiency in urea production. Topsoe was also awarded the technology license for a 2,200 t/d ammonia plant, part of the Ramagundam Fertilizer Project, in 2015. Ramagundam is another Indian government 'revival project'. It is scheduled to begin operating before the end of the year.

"We are extremely pleased to be able to continue our long-standing support of the Indian government's efforts towards self-sufficiency in urea production and as a consequence: food security. Our world-leading ammonia technology and catalysts are the basis for three out of the four fertilizer plant revival projects in India right now," said Amy Hebert, executive vice president and deputy CEO, Topsoe.

BRAZIL

EuroChem opens second new fertilizer plant in Brazil

EuroChem Group has opened its second new fertilizer blending plant in Brazil this year.

The latest opening is part of the expansion of EuroChem subsidiary Fertilizantes Tocantins (FTO), a major fertilizer distributor in Brazil.

The new blending plant is located in the city of Catalão in Goias State, part of the Brazilian Midwest, a region that consumes about 3.2 million tonnes of fertilizer per year.

"Catalão has long figured in our expansion plans, and from here we can serve customers in this important agricultural region," said FTO's CEO, José Eduardo Motta.

The Catalão plant is one of the largest in Goias State, with a storage capacity of 80,000 tonnes. It employs 60 full-time workers and has a production capability of 60,000 tonnes of fertilizer per month. It will produce standard fertilizers and supply some specialty NPK fertilizers produced by EuroChem in Europe.

The opening of the Catalão plant comes weeks after FTO's new blending plant at Sinop began operating in the northern region of Mato Grosso. In addition to Catalão and Sinop, FTO has six other plants across the country and sold more than 1.2 million tonnes of fertilizers in 2017, making it one of the biggest fertilizer providers in Brazil. Its other plants are located in Porto Nacional, São Luis, Querência, Rondonópolis, Barcarena, and Anápolis.

"Our new plant at Catalão is further evidence of our determination to continue expanding in Latin America, and especially in Brazil," said Dmitry Strashnov, CEO of EuroChem. "We see significant opportunities for us in this important growth market."

The Group acquired a controlling interest (50%+) in FTO in 2016 as part of a strategy to strengthen its presence in the fast-growing Latin American fertilizer market.

WORLD

Market growing for controlled release fertilizers

The $2.35 billion global market demand for controlled- and slow-release speciality fertilizers is growing significantly, according to new report from IHS Markit. Led by China, the US, Western Europe and Japan, global demand for these specialty fertilizers currently stands at more than 1.5 million t/a, and is expected to grow at a rate of nearly 6 percent from 2017 to 2022. Chinese consumption, in particular, has been increasing significantly in recent years, and is projected to grow at nearly 10 percent annually. China currently consumes approximately 700,000 t/a of these speciality chemicals or nearly 46 percent of the global total, while the US consumes approximately 560,000 t/a, or nearly 37 percent of the global total. Western Europe's share is 10 percent and Japan's 8 percent. China is also the world's leading producer of these chemicals, having aggressively expanded its production during the past five years, to reach 750,000 t/a.

Historically, due to their high cost, these fertilizers were primarily limited to non-agricultural uses in niche applications such as golf courses, landscaping maintenance, and in nurseries and greenhouses. Increasingly though, they are being used for large, commercial agricultural applications, to feed an ever-expanding global population, especially among developing nations, like China and India. These countries are shifting away from carbohydrates to a more protein-based diet. This will require the use of more fertilizers, the report says.

IHS expects that costs for these products will go down over time. Their crop-yields and environmental benefits are eventually expected to outweigh the costs of increasing regulations and penalties for fertilizer run-off.

See our full report on page 25.

People

SQM's CEO **Patricio de Solminihac Tampier** has resigned and will be replaced by **Ricardo Ramos Rodríguez** from the start of 2019.

The company's board expressed its appreciation of Mr de Solminihac's contribution to the company stretching back more than 30 years.

"When Patricio de Solminihac began his career as an executive at SQM in 1988, the company had assets totalling approximately $152 million, today SQM has assets of over $4.3 billion," said Alberto Salas, chairman of SQM's board, adding: "It is difficult to summarize in a few words the achievements of Patricio. We regret his resignation, and appreciate his dedication and commitment over the past years."

In response, Mr de Solminihac said: "I would like to thank the entire team of over 5,000 employees in Chile and abroad for supporting me over the past three decades."

Incoming CEO designate Ricardo Ramos Rodríguez has been with SQM for over 29 years. He is currently chief financial officer (CFO) and vice president of corporate services.

"During this period, Ricardo Ramos has worked alongside Mr de Solminhac for over 20 years, which will ensure the continuity of the direction of the company, and ratifies the intention of the board to maintain the strategic path given by the current CEO," Alberto Salas said.

Sergey Momtsemlidze became Uralchem's new CEO in August, replacing Dmitry Konyaev who was named deputy chairman and will take control of strategic development.

In a statement, Uralchem praised Dmitry's contribution to the company: "Since 2011, when Dmitry Konyaev took over the CEO position, the company has significantly strengthened its position on the market. The commercial output increased from five million tonnes in 2011 to 6.3 million tonnes in 2017. The sales market now includes 80 countries (compared to 50 before), while the company's product portfolio has expanded by 2.3 times – from 30 to over 70 product grades, primarily due to highly efficient and innovative types of fertilizers."

Incoming CEO Sergey Momtsemlidze was formerly the director of Uralchem's KCCW Branch in Kirovo-Chepetsk, the largest enterprise within the company. He will focus on improving the operational activities and the efficiency of the company. During a seven-year tenure at KCCW Branch, Sergey invested RUB14.3 billion in production, increasing commercial output by 13 percent and average labour productivity by over 12 percent, while at the same time reducing unscheduled downtimes by more than five times. The construction of a large production plant for Uralchem's new high-purity and much-in-demand calcium nitrate product was a particular success.

Kuzma Marchuk became EuroChem Group's CFO in June. He succeeds **Andrey Ilyin** who has left the company after 10 years in the role. Mr Marchuk has been a non-executive director at EuroChem's since 2017. He is also a board member at SUEK, and served as that company's CFO and deputy CEO between 2011 and 2016. He was SUEK's CFO immediately prior to this, as well as being a member of Uralkali's board of directors from 2007.

Dmitry Strezhnev, EuroChem Group CEO, welcomed the appointment: "I am delighted that Kuzma Marchuk will take over as our CFO. He has worked closely with the Group in the past and is well known to our financial stakeholders. I would like to thank Andrey Ilyin for his extensive contribution to EuroChem over the past decade and wish him the very best for the future."

Kuzma Marchuk stated: "I am thrilled to take up this role at such an exciting time in the company's development, and I look forward to helping the Group through its next stages of growth."

CRU Group's former nitrogen team leader **Doug Hoadley** joined Crystal Peak Minerals as head of marketing in July. Doug's long and distinguished career in the fertilizer industry notably included a successful stint as director of agribusiness analysis at CF Industries.

Crystal Peak is a development-stage mining company. It hopes to start sulphate of potash production at its Sevier Playa project in Utah in late 2019.

John Mansanti, CEO of Crystal Peak, said: "We are very pleased to welcome Doug Hoadley to our team. Having worked previously at CF Industries, CRU, and Mosaic, Doug brings a deep knowledge of fertilizer markets to our company. He will be a terrific addition as we seek off-take agreements and work to penetrate key fertilizer markets in support of project financing. With the project moving rapidly through permitting and towards construction, the timing couldn't be better."

In reply, Doug Hoadley said: "I'm very happy to be joining Crystal Peak Minerals. I think the Sevier Playa project is one of the best greenfield fertilizer assets in the world and the company is well positioned to bring its products to markets. And, with the conclusion of permitting expected next year, I'm ready to find the right marketing partner." ■

Calendar 2018/2019

OCTOBER

1-3

TFI World Conference,
SAN FRANCISCO, California
Contact: Valerie Sutton
Fax: (202)-962-0577
Email: vsutton@tfi.org

23-25

2018 IFA Crossroads Asia-Pacific Conference, SINGAPORE
Contact: IFA Conference Service
Tel: +33 1 53 93 05 00
Email: ifa@fertilizer.org

NOVEMBER

5-8

Sulphur 2018 Conference,
GOTHENBURG, Sweden
Contact: CRU Events
Tel: +44 (0)20 7903 2444
Email: conferences@crugroup.com

MARCH 2019

4-7

Nitrogen+Syngas 2019 Conference,
BERLIN, Germany. Contact: CRU Events
Tel: +44 (0)20 7903 2444
Email: conferences@crugroup.com

28-29

European Mineral Fertilizer Summit,
AMSTERDAM, The Netherlands
Contact: Mado Lampropoulou, ACI
Tel: +44 (0)20 3141 0607
Email: mlampropoulou@acieu.net

JANUARY 2019

28-30

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

PICTURE THIS...

The US fertilizer industry

The US fertilizer industry contributes more than $155 billion to the domestic economy and provides nearly half a million US jobs, with nearly 90,000 of these directly employed in the sector. These major benefits were revealed by the third annual *State of The Industry* report published by The Fertilizer Institute (TFI) in February.

The 2017 report provides a comprehensive and up-to-date snapshot of almost the entire US fertilizer industry. The 33 participating companies account for 94 percent of nitrogen, phosphorus, and potassium production capacity in the United States and, additionally, 33 percent of the country's fertilizer retail sector.

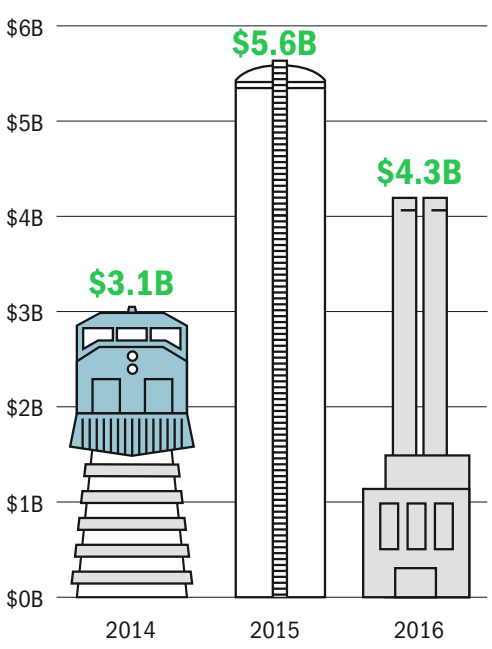
The publication of this highly accessible report – which is partly aimed at the general public – reaffirms the US fertilizer industry's commitment to transparency and openness. The report covers the 2016 calendar year and provides hard facts and figures for a wide range of economic, environmental and social indicators. In 2016, participating companies:

- Invested a total of $4.3 billion in capital projects. Innovation, infrastructure improvements, and more sustainable fertilizer production were the main priorities.
- Captured and reused 25 percent of their greenhouse gas (GHG) emissions, a saving equivalent to taking almost two million cars off the road for an entire year. GHG capture has risen steadily year-on-year since the nine percent level reported in 2013.
- Recovered over 110 million gigajoules (GJ) of waste heat to generate on-site energy or return to the grid. This is equivalent to almost 80 percent of total energy use – and enough energy to have powered nearly 220,000 homes for an entire year.
- Reclaimed 1.4 billion gallons of water and recycled another 461.9 billion gallons of treated wastewater. Water usage per ton of fertilizer has decreased every year since reporting began in 2013.

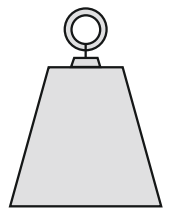
The US fertilizer industry is becoming safer too. Between 2013 and 2016, the sector's overall lost time incident rate has dropped from 1.1 to 0.8 cases per 100 full time equivalent employees. The US fertilizer sector, as a whole, is already two times safer than its industry peers. TFI is also encouraging fertilizer best management practices on the nation's farms and is playing its role in reducing nutrient losses. For example, the US fertilizer industry invested nearly $1 million in the 4R nutrient stewardship research fund in 2016. ■

Source: The Fertilizer Institute

CAPITAL INVESTMENTS



CO_2 CAPTURE



8 million
metric tons of CO_2

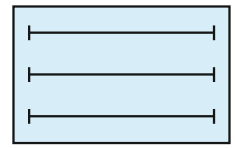
1,713,062
cars a year

WATER RECLAMATION

1.4 billion
gallons of water

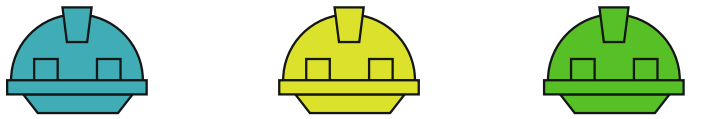
enough water to fill more than

2,100
olympic-sized swimming pools

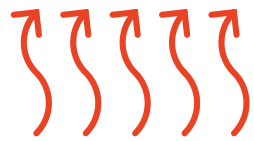


EMPLOYEE SAFETY

Lost-time incident rate	0.95	0.65	0.64
Government benchmark	2.6	1.6	1.2
	Blender and wholesaler employees	Mining employees	Manufacturing employees



WASTE HEAT



111.2 million GJ

79%
total energy use

Pursell Agri-Tech: the 114-year old start-up

Alabama-based Pursell Agri-Tech, although a relatively new start-up, can draw on a long heritage of fertilizer industry innovation. The company's chairman, **Taylor Pursell**, talks to Fertilizer International in an exclusive interview.

Pursell Agri-Tech officially opened an innovative new fertilizer coating plant in Sylacauga, Alabama, in June with its partner and shareholder Stamicarbon.

The low-cost, modular plant applies an innovative polymer coating using a proprietary coating process. The plant will produce the latest generation of low-cost controlled-release fertilizers (CRFs) and will target broad-acre crops, as well as other higher-value and speciality fertilizer markets.

Three products will be produced at Sylacauga: *PurYield*™ for broad-acre crops, *PurForm SA*™ for the speciality ag market, and *PurKote*™ for the golf, turf, landscape and ornamental segment.

This new, first-of-its-kind coating plant is designed to be placed close to agricultural end-markets to further minimise costs. Pursell Agri-Tech and Stamicarbon's ultimate ambition is to deliver significant improvement in nutrient-use efficiency – and limit the environmental impacts of fertilizer use – by producing affordable CRFs at scale in North America and other regions globally.

In a wide-ranging interview, Taylor Pursell, chairman of Pursell Agri-Tech, talks about the company's achievement to date, its future ambitions and where the fertilizer industry is heading.

Can you explain more about the history and origins of Pursell Agri-Tech?

You could say we are a 114-year old start-up! The roots of the company go back to 1904 when my great grandfather founded a fertilizer company here in Sylacauga, Alabama. The company began as a very small agricultural concern yet, over time, became Pursell Technologies, one of the largest speciality fertilizer companies in the world.

The proprietary controlled-release fertilizer (CRF) products we developed gained worldwide recognition. They were always aimed at speciality horticultural and landscape segments of the market, but considered too expensive for commodity agricultural markets, corn, rice, wheat, etc.

Pursell Technologies and its CRF range were eventually acquired by Agrium in 2006. They sold the business to Koch Agronomic Services around 4 years ago, who continue to sell the products today – and are doing very well from it too.

What is Pursell Agri-Tech doing to bring down the costs of controlled-release fertilizers?

Now, CRF technology has been around for 30-40 years. The challenge has always been: how can you manufacture CRFs at a cost that a farmer can afford, and actually get a payback from the resulting higher yields – so they becomes widely-adopted. How do you get the cost down low enough so a farmer – whether in the Ukraine or Illinois or in Mali – can afford CRFs and actually earn more money by using them.

Well, we've been able to drastically reduce production costs in three ways. One is the coating technology itself. We are very fortunate to have partnered with a US-based company that produces coating materials on a global scale.

The second part is the capital cost of the coating plant. We found a very long-standing but competitive European manufacturer of coating equipment. That partnership has brought the capital cost down by about 75 percent. We also saw real synergies when combining their equipment with our coating materials. They worked exceptionally well together – a case of one plus one equals three. The upshot is that building a 120,000 tonne capacity plant that might have cost $40 million ten years ago now costs us considerably less. It's a dramatically lower-cost process.

These plants are also modular – that's the third innovation. They have a very small footprint for their capacity. We're able to place these plants either close to the farmer or close to the urea plant, so there's no double- or triple-handling. What we're trying to do is keep costs as low as we can by eliminating one or two steps in the supply chain

What are the mutual benefits of joining forces with Stamicarbon?
Stamicarbon is one of the most interesting and well run companies I have ever dealt with. They have a huge market share, having licensed about half of all urea plants ever built. Plus they measure their success financially, socially and environmentally. They take this 'triple bottom line' very seriously and live by it.

Like us, Stamicarbon realises that current fertilizer technologies will need to be improved and become more efficient to meet the food security, malnutrition and environmental challenges of the future. Stamicarbon thinks that by 2030 over half of all the urea in the world will be enhanced in some way to improve nutrient use efficiency. That's around 100 million tonnes up from only a few million tonnes today, meaning there's going to be plenty of growth for everybody.

The one thing that we don't want to do is be disruptive to the urea industry. They manufacture a great product, it just needs to be more efficient in many parts of the world. So our goal is to be collaborative and work with everyone to help bring about this industry shift.

There are two options: we can retrofit at an existing urea plant with our coating technology at low-cost, or we can co-locate our modular coating plants on the same site. So we are going to work together in partnership with the urea industry, and the phosphates industry too, we are definitely on their side. We hope to collaborate closely with the fertilizer industry – especially on urea and phosphates – to help them produce more efficient fertilizers.

What's required of a CRF product like *PurYield*™ for it to sell into the broad-acre market?
To work for row crop agriculture, CRFs are going to need to be very cost-driven and location-driven. Our aim is to make the absolute lowest cost product, one that's capable of delivering nutrients over a 60-90 day period in the case of corn or wheat.

Let me explain, the value proposition is this: one short ton of urea will fertilize about six acres, yielding about 200 bushels of corn. If our more efficient product can deliver a five percent yield increase. Well, at current prices, that 10 extra bushels of corn will add $40 of margin for the grower per acre – or $240 per ton of urea. So any grower paying $80-100 over the urea price for a more efficient CRF will get a 2-3 times return. Also, it is important to point out that, due to their nutrient use efficiency, CRFs can be used at lower application rates than conventional fertilizers.

And this goes back to my original point – there has to be a yield increase to pay for it. We can talk all day about the desirable environmental benefits. But, the way we look at it, for farmers it's just business and they have to be profitable to survive. With CRFs, there has to be a yield bump and a clear payback – so that's where we're focussed.

Taylor offered these final thoughts on where the fertilizer industry needs to be heading:
Our goal is to help the fertilizer industry make a fundamental shift to more efficient nutrient delivery. One that is as profound as the petroleum industry's move from leaded to unleaded gasoline. It would be a great thing to see fertilizer producers globally successfully adopt more efficient fertilizer technologies. Because that's what needs to happen if we're going to guarantee food security, address malnutrition and help protect the environment over the next three decades in a world of over nine billion people.

Boron bestows benefits

Boron is a key micronutrient required by crops such as alfalfa, corn, cotton, rice, sugar cane, oil palm, potato and soybean. We look at the agricultural importance of boron and the wide range of products on the market.

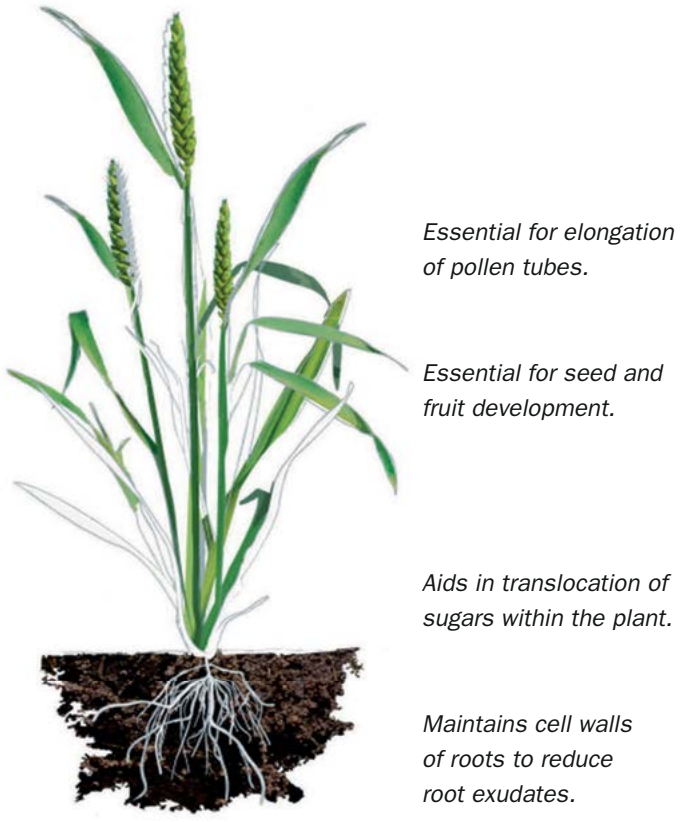


Fig. 1: Boron's role in plant nutrition. Source: ATP Nutrition

Boron is essential for plant growth. It helps plants to synthesise structural carbohydrates and build strong, stable cell walls. Boron also enables sugars to form in leaves and then helps transport these to parts of the plant where they are required – especially new growth and the root system.

In crops, boron plays a particularly vital role in the development of seeds and fruits – controlling flowering, pollination, reproduction, germination and fruit development. The formation of root nodules in legumes also depend on an adequate supply of boron.

Boron's promotion of pollen tube growth is another key function. This is because successful pollination leads to good seed set and ultimately to abundant fruit, nut and grain yields. Boron's many influences as a plant nutrient can be summarised as follows (Figure 1).

- Aids production of sugar and carbohydrates
- Enables the translocation of sugars within plants
- Regulates metabolism of carbohydrates
- Helps synthesise nucleic acids
- Essential for cell division and development
- Maintains integrity of root cell walls – reducing root exudates
- Speeds up the onset of plant maturity
- Essential for elongation of pollen tubes
- Improves seed set
- Essential for fruit set and development
- Required for nodulation and nitrogen fixation in legumes
- Enhances the uptake of other nutrients such as Ca, Mg and K

Boron, by maintaining the function and structure of root cells, is linked to improved uptake of phosphorus and potassium from soil. It is also believed to play a role in root colonization by *Mycorrhizal* fungi, another influence on phosphorus uptake. There is also evidence to suggest that boron helps protect plants against aluminium toxicity in low pH soils.

Deficiency: causes and symptoms

Boron deficiency is mainly associated with soils low in organic matter and coarse-textured, well-drained sandy soils – due to the potential for boron leaching. Soils with high nutrient adsorption and retention capacities – such as high pH soils and those rich in clay minerals and iron or aluminium oxides – can also be affected by boron deficiency.

Organic matter generally increases boron availability as it typically acts as a store for plant-available boron in soils. Boron deficiencies are exacerbated by low soil moisture and drought periods because of the general decrease in root activity. Balanced crop fertilization generally helps to optimise boron uptake by improving plant vigour and healthy root growth. High calcium soils, however, may require additional applications of boron.

Boron deficiency is the second most widespread micronutrient deficiency globally after zinc. Unsurprisingly, deficiency is particularly prevalent in those crops with higher-than-normal boron requirements. Alfalfa, canola, coffee, corn, cotton, oil palm, olives, peanuts, rice, soybean, sugar beet, sugar cane, tree fruits and vegetables are all notably boron-hungry crops.

Signs of boron deficiency firstly appear at new growth points. Water absorption, root growth and translocation of sugars in plants are all negatively affected. Deficiency is damaging as it commonly results in empty pollen grains, poor pollen vitality and a reduced number of flowers per plant. Low boron supply can also stunt root growth – in soybean and canola, for example. Common deficiency symptoms in crops include:

- Poor seed set or fruit set
- Breakdown of growing tip
- Yellowing between veins on young leaves
- Stunted new growth and dieback of shoot tips in vegetables
- Short bushy cotton plants
- Missing kernels in corn
- Yellowish to reddish yellow discolouration of the terminal foliage in alfalfa
- Root crops such as beets and turnips will breakdown and develop a corky dark discolouration
- Poor *Rhizobia* development in the roots of legumes

The boron deficiencies that afflict particular crops may have different causes:

- Alfalfa: high soil pH
- Canola: leaching in coarse soils
- Cotton: low soil organic matter
- Fruit trees: low soil moisture
- Vegetables: high calcium levels

Micronutrient with macro effects

While boron is classed as a micronutrient its effects can be macro, with a sometimes startling ability to improve crop yields. In trials, boron fertilizers have been shown to multiply corn yields and increase cotton yields by hundreds of kilos per hectare, for example. Yet boron deficiency remains one of the most widespread of all crop deficiencies globally, affecting many major crop types. The role of boron in soybean, corn and cotton – all globally-important broad acre crops – is highlighted below.

Soybeans: all legumes have a high boron requirement – and soybean is no exception. Boron is necessary for:

- Stimulating root growth and root nodule development for nitrogen fixation
- Increasing branching, flowering, bloom retention and pod numbers
- Enhancing seed development and improving grain yield

Boron fertilization at many US locations has been shown to increase grain yields in soybean by 5-18 bushels/acre (0.3-1.2 t/ha).

Corn: this crop generally requires high nutrient applications to ensure maximum economic yields. Boron is necessary for:

- Stimulating root and shoot development
- Tassel and silk formation
- Movement of sugar from leaves to ears
- Pollen germination, pollen tube growth and seed formation
- Better water use efficiency and drought tolerance

Independent trials with boron have demonstrated that yield increases of 9-37 bushels/acre (0.6-2.5 t/ha) are achievable.

Cotton: Boron is required during all stages of growth and fruiting – particularly with fast-fruiting, high-yielding varieties. Adequate supply of boron:

- Ensures more squares are kept
- Increases bloom pollination and boll set
- Produces strong, well-developed fibres
- Helps crops to mature rapidly

Boron is generally recognised as the most important micronutrient for cotton production. Research has shown that as little as one pound (0.45 kg) of boron can increase seed cotton yield by more than 500 pounds/acre (560 kg/ha).

Producers and products

Selected agricultural boron products and their suppliers are highlighted below. Many of these products are marketed at the growing North American market. This leading corn-, cotton- and soybean-producing region has been quick to recognise the agronomic importance of boron and, consequently, has been an early-adopter of boron fertilization products.

US Borax is the world's leading supplier of borates for agriculture. The company has conducted a number of studies and field trials for cultivated crops across the world, making it a technical leader in the industry. Part of London-based Rio Tinto Group, US Borax operates California's largest open pit mine at Boron in the Mojave Desert. This is one of only two world-class borate deposits globally, and supplies nearly a third the world's demand for refined borates.

The Boron Operations mining and refinery complex started life in 1927 as an underground mine, before being converted to a surface mine in the late 1950s. Extensive ore refining facilities were also built around this time. In 1980, US Borax constructed a boric acid plant at the site, helping secure the company's position as the world's leading boric acid producer.

US Borax manufactures and markets three main products for use in agriculture: *Fertibor*®, *Granubor*®, and *Solubor*®. *Fertibor* is a sodium borate (15.0% boron) used in the manufacture of ammoniated, granulated, and suspension fertilizers. It works best in fertilizer suspensions broadcast before planting but also it is the main source of boron in compound NPK fertilizers. *Granubor* is a granulated form of sodium borate (14.3% boron) for use with bulk blended fertilizers. It is suitable for dry blends broadcasted prior to planting. *Solubor* is a soluble form of sodium borate (20.5% boron) designed for liquid fertilizers and foliar sprays. It can be dissolved in water and applied to soils or directly on crops, with or without pesticides. In addition to these three main products, US Borax manufactures a number of other borates with different chemical formulations. These are designed to meet specific fertilizer industry requirements and include *Optibor*® (boric acid) and *Dehybor*® (dehydrated sodium borate). In the last few years, US Borax has also developed a microgranular soluble borate for foliar spray (*Solubor DF* – dry flow) and a solvent-free liquid suspension (*Solubor Flow*).

US Borax provides comprehensive agronomic support. A series of wide-ranging crop guides and crop recommendations are available on the company's website (www.agriculture.borax.com).

Its agriculture products are all organic certified.

US Borax is adding agronomic trial results for different crop types year-by-year, as new boron deficient areas are identified and new trials are launched. Even crops classed as having a low boron demand can show good results after boron fertilization, says US Borax. The company also points out that the low dosages required by crops usually makes the application of boron highly profitable from an economic point of view.

Boron deficiency is widespread, affecting crop production and quality across North America, according to **The Mosaic Company**. To address this, Mosaic launched *Aspire*, a boron-enhanced potash fertilizer, in 2014. This first-of-its-kind premium potash fertilizer (0-0-58-0.5B) combines potassium chloride (58% K_2O) with boron (0.5%).

Aspire is formulated to provides season-long boron availability by containing both quick-release sodium borate and slower-release calcium borate. Boron is also uniformly distributed within potash granules using Mosaic's proprietary *Nutriform* technology. *Aspire* is being targeted at crops such as alfalfa, corn, cotton, potato, sugar cane and soybean, and has demonstrated significant yield improvements for these crops in field trials (Table 1).

Compass Minerals Plant Nutrition manufactures *Wolf Trax*™ *Boron DDP*®, a product containing 18.5 percent boron, as part of its popular *Wolf Trax*™ *DDP*® (Dry Dispersible Powder) *Nutrients* product line. *Wolf Trax*™ products are applied to NPK granules during blending and incorporate two proprietary innovations:

- *EvenCoat*™ technology coats every NPK granule in a fertilizer blend with micronutrients. Once applied, this coating does not come off during handling and transport. This ensures micronutrients are evenly distributed across the field and are available in close proximity to plant roots for early plant uptake.
- The patented *PlantActiv*™ formulation improves micronutrient availability by providing micronutrients in an optimal particle size with multiple forms of the nutrient, ensuring timely uptake.

Boron DDP® is marketed for crops such as alfalfa, canola, corn, cotton and fruit and vegetables. For alfalfa, a boron application

Table 1: **US trial results for Mosaic's *Aspire* boron-enriched potash product versus standard MOP (muriate of potash)**

Trial/Study	Year	Number of locations	Crop yield increase	Sugar yield increase
Corn high-population	2014-15	4	8.7 (bu/ac)	
Corn high-yield	2011-14	5	8.8 (bu/ac)	
Corn – fall vs spring broadcast	2016-17	9	5.3 (bu/ac)	
Alfalfa boron fertility	2013-15	6	0.5 (st/ac)	
Alfalfa yield	2013-16	20	0.5 (st/ac)	
Sugar cane & sugar content	2013-16	5	4.1 (st/ac)	3.9 percent
Sugar cane & sugar content	2013-14 & 2016-17	2	6.5 (st/ac)	0.8 (st/ac)
Soybean two-year cropping rotation	2014-15	4	1.0 (bu/ac)	
Soybean boron fertility	2013-15	13	1.3 (bu/ac)	
Soybean boron	2013-14	12	1.6 (bu/ac)	
Soybean high-yield	2015-16	6	2.7 (bu/ac)	
Cotton boron	2013	6	64 (lbs/ac)	
Cotton side-dress	2014	5	146 (lbs/ac)	
Potato (long-season variety)	2015-16	1	42 (cwt/ac)	
Potato (short-season variety)	2016-17	1	36 (cwt/ac)	

Source: Mosaic (www.aspireboron.com)

is recommended to provide the following benefits:

- Maintain a balance between sugar and starch to improve quality
- Promote pollination and plant reproductive health
- Improve water regulation by improving potassium transport in cell membranes

The benefits of *Wolf Trax™ Boron DDP®* and *Zinc DDP®* applications for potato growers were evaluated as part of a 2014 field trial near Othello, Washington. These were applied as part of a 'grower standard practice' blend (NPK+S).

Wolf Trax™ DDP® Nutrients were found to increase the amount of #1 size potatoes by an extra 11 percent, compared to an equivalent application using granular micronutrients (zinc sulphate and granular boron). The *Wolf Trax™* treatment also increased potato size, with the most #1 potatoes weighing in above six ounces (170 g). At a typical potato price ($8.50/cwt), these yield and quality improvements translated to gross revenue increases of:

- $224/ac over grower standard practice alone (NPK+S without micronutrients)
- $159/ac over grower standard practice with granular micronutrients (NPK+S with zinc sulphate and granular boron)

In North America, early season cold temperatures can damage corn yields by causing plant stress. Plant root growth, in particular, may suffer as farmers plant into colder than ideal soils. To protect against the effects of early cold and wet weather, Compass Minerals advises applying zinc and boron to corn as part of a nitrogen fertilizer application. Zinc ensures adequate phosphorous uptake and root hair growth while boron promotes sugar translocation and cell division. Suppling boron in sufficient amounts avoids aborted crop rows by ensuring that the corn plant's 'ear factory' has an adequate supply of energy.

Wolf Trax™ Boron DDP® and *Zinc DDP®* products can be added to corn via top-dress urea applications. There is also the additional option of applying zinc using two products from Compass Minerals' *ProAcqua®* water-soluble product range. *ProAcqua® Zinc EDTA* and *ProAcqua® Nourish Zinc* can be incorporated in side-dress applications of liquid urea ammonium nitrate (UAN) to corn. Both are highly compatible with UAN and offer a fully-chelated source of micronutrients. Three *ProAcqua®* products, *ProAcqua® Zinc EDTA*, *Nourish Zn* and *N-Micro*, can also be applied as foliar sprays to complement soil applications.

Compass recently launched the triple micronutrient product *3-Trax™ DDP®*, the latest addition to its *Wolf Trax* portfolio. This contains zinc, manganese and boron in a balanced ratio. It contains three percent boron, 13 percent manganese and 26 percent zinc. This three-in-one micronutrient formulation is designed for convenience as well as higher yields. The new product delivers multiple crop benefits: the zinc present improves early-season root growth and tolerance to cold stress, while the inclusion of essential manganese and boron boosts nitrogen assimilation and plant metabolism.

Ohio-headquartered **Nachurs Alpine Solutions** is one of North America's oldest and leading liquid fertilizer manufacturers. Products are sold under the *NACHURS* brand in the US and under the *ALPINE* brand in Canada. The company has six manufacturing sites: Belle Plaine, Saskatchewan; Corydon, Indiana; Marion, Ohio; New Hamburg, Ontario; Red Oak, Iowa; and St Gabriel, Louisiana.

The company manufactures and markets *NACHURS 10% Boron*, a boric acid (H_3BO_3) based liquid fertilizer contained 10 percent boron. It can be applied with liquid fertilizers, fertilizer suspensions, nitrogen solutions or with water. Broadcast, banded or foliar application are recommended where soil and/or plant tissue analysis has indicated a boron deficiency. Banded and foliar applications are recommended as starter applications, but are not expected to correct severe deficiencies.

Manitoba-based **ATP Nutrition** offers *Granular Boron* as part of its soil-applied *Ruffin-Tuff* micronutrient product line. This range of patented, lignosulfonated (LS) granular micronutrients products are designed to address specific soil micronutrient deficiencies and increase nutrient use efficiency.

Granular Boron contains 10 percent water-soluble boron. The incorporation of LS technology protects micronutrients, according to ATP Nutrition, allowing them to remain available and more mobile in the soil for longer periods of time.

The Canadian company also markets the foliar product *Kinetic Boron*. This helps ensure adequate cellular strength, pollination and sugar movement in crops. Boron is also incorporated in ATP Nutrition's crop-specific, multi-nutrient products such as:

- *Ruffin-Tuff Crop Mix II:* granular micronutrients
- *PreCede Cereal:* seed nutrient dressing
- *PreCede Canola:* seed nutrient dressing
- *ReLeaf Canola:* foliar macronutrients
- *42Phi Canola:* foliar macronutrients

For each of these products, ATP provides supporting crop trial results demonstrating typical agronomic performance.

Power your innovation with PENXCEL Technology

PENXCEL™ Technology is a unique, patented formulation system to deliver EEF additives for dry and liquid fertilizer. Discovered by a PhD who used similar compounds in human pharmaceutical formulations, the technology has been harnessed to deliver innovative ingredients for agriculture. The PENXCEL system delivers many performance benefits over industry standard formulations.

Penetrates Deeper For More Consistent Results

PENXCEL technology delivers active ingredients deeper into solid fertilizer granules more consistently. This innovative formulation allows the use of active ingredients previously deemed "impossible to be coated" on fertilizer. It also works well in liquid fertilizer providing an advantage over powders that stubbornly float on the surface and blow off granules in a cloud of dust.

Blends Faster Even In Challenging Cold Weather

Products using PENXCEL technology have low viscosity, so handling is easy. They pump or pour quickly, even in freezing cold temperatures, accelerating blending up to 25% faster than industry standard formulations. Saving time is critical during application season. PENXCEL provides superior performance in high-volume, high-speed mixers. The result is consistent fertilizer products that flow freely and perform in the field.

Excels In The Field, Excels In Safety

Field trials have demonstrated superior performance for PENXCEL technology, which has been attributed to more consistent coverage and deeper penetration of the active ingredients. Lab tests show that PENXCEL Technology is safer than the industry standard formulations. The key ingredient's safety profile, as proven by its use in human medicine, is evident in the results.

Leverage PENXCEL Technology In Your EEF Products For 2018

Want to drive innovation forward? PENXCEL Technology allows you to maximize your existing infrastructure to offer value-added EEF products with minimal investment. For more information visit InnovarAg.com today.

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Africa Fertilizer Agribusiness Conference 2018

CRU events will convene the 2018 Africa Fertilizer Agribusiness Conference at Century City, Cape Town, South Africa, 24-26 September.

Cape Town, South Africa, is the spectacular setting for this year's Africa Fertilizer Agribusiness Conference. The latest conference is the fourth in a series of fertilizer events held by CRU throughout Africa since 2016. Previous conferences were held in Tanzania in 2016 and Mozambique and Ghana last year.

These successful events, which regularly attract 250-300 delegates, are produced in collaboration with the African Fertilizer Agribusiness Partnership (AFAP). Their purpose is to promote investment, partnership and innovation across the African agribusiness sector. They offer excellent networking opportunities and are aimed at senior executives from the international fertilizer supply chain.

CRU has worked closely with key partners on the current and previous Agribusiness Conferences, including: International Fertilizer Association, Fertasa, Wesgro, Agro Dealers of South Africa, ECOWAS, World Cocoa Foundation, and West African Fertilizer Association.

Both CRU and AFAP look forward to welcoming delegates to the Cape Town event in September.

Nicola Coslett, CEO, CRU Events: "Through our unique partnership with AFAP, the conference provides unrivalled networking opportunities with senior decision-makers from the biggest fertilizer buyers and manufacturers in some of the world's fastest growing fertilizer markets. The event has gone from strength to strength, and CRU and AFAP are looking forward to continuing to build the event."

Jason Scarpone, president and CEO of the African Fertilizer and Agribusiness Partnership (AFAP): "The African fertilizer industry has come of age and is increasingly well positioned to contribute to economic growth and poverty reduction across the continent. The 4th Conference discussions will go well beyond just fertilizer usage to look more closely at how this commodity and other inputs are contributing to agricultural transformation across the continent."

Event highlights

- 400+ senior fertilizer executives and agribusiness stakeholders
- Technical agenda for African fertilizer production engineers and plant operators
- Hear the world's leading suppliers of fertilizer discuss their African growth strategies
- Major agriculture, agribusiness and agro-food companies outline market trends
- Unmatched networking opportunities throughout the three days
- Site visit to Kropz's Elandsfontein phosphate mine and plant

PHOTO: WOLFFPOWER / SHUTTERSTOCK.COM

Conference themes

- Mining for nutrients in Africa: latest updates on key projects across the continent
- Fertilizer plant round table: discuss your technical issues and solutions
- Cash crop market insights on cocoa, coffee and other growth markets
- Agri-investment showcases: agro-execs present projects to investors
- Spotlight sessions on Nigeria, Ghana, Kenya, and South Africa, and South African market dynamics
- Dedicated stream on speciality fertilizers and precision agriculture innovation
- How improvements in logistics, blending and soil science are building demand
- Agrodealer round table: distributors from the continent share views
- Comprehensive overview of the fertilizer agribusiness value-chain

Key speakers

- Alan Winde, Economic Opportunities Minister, **Western Cape Government**
- Jason Scarpone, President and CEO, **The African Fertilizer and Agribusiness Partnership (AFAP)**
- Onajite Okoloko, Group Chief Executive Officer and Group Managing Director, **Notore Chemical Industries Plc**
- Ashish Lakhotia, CEO, Fertilizer and Agribusiness, **ETG Inputs Ltd**
- Rajiv Ram, Demand Analyst, Fertilizers, **CRU**
- Balbir Singh, Head, Development and Agronomy, **Indorama**
- Luambo Munzhedzi, Chairperson, **Agro Dealers Association of South Africa (ADASA)**
- Mari Pennanen, Chief Business Development Officer, **DSM Corridor Group**
- Jeff Ivan, Managing Director, International Sales, **Yargus, AG Growth International**
- Amanda Tshaya, Head of the Agribusiness Investment Unit, **Wesgro**
- Kalim Shah, Chief Investment Officer, **International Finance Corporation (IFC)**
- Kinyua Mbijjewe, AFAP Technical Advisor, **The African Fertilizer and Agribusiness Partnership (AFAP)**
- Dr Shamie Zingore, Regional Director, sub-Saharan Africa, **IPNI**
- Ayodele Balogun, AFAP Technical Advisor for West Africa, **The African Fertilizer Agribusiness Partnership (AFAP)**
- Cyrille Allais, Business Development Manager, **Shell Sulphur Solutions**
- Dr Markus Walsh, Chief Scientist, **AfSIS**
- Senior representative, **Ma'aden**
- Senior representative, **Yara International**
- Senior representative, **OCP Africa**

See you in Cape Town!

Fertilizer International magazine is proud to be the official media partner for the 2018 Africa Fertilizer Agribusiness Conference. We will be exhibiting at the event and are very much looking forward to meeting industry friends, both old and new.

PHOTO: RICH NIEWIROSKI JR / WWW.PROJECTRICH.COM

TFI welcomes you to San Francisco!

The Westin St Francis in San Francisco, California, is the venue for The Fertilizer Institute's 2018 World Fertilizer Conference, 1-3 October.

San Francisco's iconic Golden Gate Bridge.

The Fertilizer Institute (TFI) is hosting this year's World Fertilizer Conference at the Westin St Francis in San Francisco. The early-October event is TFI's largest meeting of the year. Although US-based, the conference is truly global, bringing together around 900 industry delegates from 60 countries.

The opportunities for networking and conducting business has long made the World Fertilizer Conference an important date on the annual calendar. The three-day event and exhibition opens for registration on Monday 1st October. This year's conference then formally begins with a welcome reception on the Monday evening, sponsored by NAQ Global.

In keeping with conference tradition, delegates will hear from two distinguished and entertaining business speakers during breakfast sessions on Tuesday 2nd and Wednesday 3rd October. Speaking this year are General **Michael Hayden**, a retired four-star general and former director of the Central Intelligence Agency and the National Security Agency, and the leading economist **Brian Beaulieu**, the CEO of ITR Economics.

As head of the country's premier intelligence agencies, Michael Hayden was at the frontline during an exceptional period of global change, one that encompassed the war on terrorism and the growing threat of cyber-attacks. This has provided Michael with a deep understanding of the dangers, risks and potential rewards of the political, economic, and security situations facing us.

General Hayden dissects the current tumult in global geopolitics and dangerous flashpoints around the world – and what impact the outcome of the US presidential election is having globally – and analyses what this all means for Americans and America's interests. He also speaks about the delicate balance between liberty and security in intelligence work, as well the potential benefits and dangers associated with the internet and the cyber world. As the former head of two multi-billion dollar enterprises, he also addresses the challenges of managing complex organizations under stress in times of risk – and the need to develop effective internal and external communications.

Brian Beaulieu is recognised as one of the country's leading and most informed economists. As CEO of ITR Economics since 1987, Brian has a long-standing and proven ability to increase profitability through the use of business cycle analysis and economic forecasting. Brian has run numerous workshops and seminars on economic analysis in seven countries over the last 35 years, getting his message across to thousands of business owners and executives.

He is the co-author of *Prosperity in the Age of Decline*, a powerful book that examines how businesses and individuals can make the most of US and global trends over the next 20 years. Brian also co-authored *Make Your Move*, a practical and insightful how-to guide on increasing profits through business cycle changes, a book described by one reviewer as "simple, yet awesome".

Join us in the Golden Gate City

As we have done for many years, *Fertilizer International* will be exhibiting at TFI's 2018 World Fertilizer Conference in San Francisco this October. We are very much looking forward to being in the Golden Gate City to meet industry friends, both old and new. ■

Enhancing efficiency for greater growth

The imposition of new environmental regulations in key markets will drive greater use of controlled-release and slow-release fertilizers. Global demand for these environmentally-friendly and more efficient alternatives to conventional fertilizers is growing strongly in China and the United States, explains **Ralf Gubler**, director of research & analysis, fertilizer & industrial gases at IHS Markit.

Producing efficient fertilizers that directly deliver nutrients to plants in exactly the right amounts has clear economic and environmental benefits. Aligning nutrient release from fertilizers to plant uptake requirements is generally achieved by modifying products in one of two ways: by reducing their solubility chemically or by physically encapsulating granules within a semi-permeable coating.

These types of modified products are known collectively as slow- and controlled-release fertilizers (SCRFs) (see box). They are also referred to separately and individually as slow-release fertilizers (SRFs) and controlled-release fertilizers (CRFs).

SRFs are non-coated products in which nutrient release, though uncontrolled, is slow. Urea-aldehyde reaction products predominate, although other slowly-soluble products, such as fertilizer spikes, stakes, talbets or briquettes formulations, and ion exchange resin fertilizers are also produced. CRFs, in contrast, are a group of products coated with either a polymer or sulphur – or a combination of both.

SCRFs offer the following benefits over conventional fertilizers:

- Nutrients are supplied according to specific plant needs
- Lower number of soil applications required – just one application per season is necessary in some cases. This reduces associated labour and fuel costs and overheads
- Nutrient losses and environmental impacts are minimised, e.g. leaching into the soil, denitrification, or volatilisation into the atmosphere
- Field application can be made irrespective of irrigation schedules, as products stay in place and nutrients are available over longer periods

SCRFs belong to a much larger group of products called enhanced-efficiency fertilizers (EEFs). This group also include urea fertilizers treated with one or more of the following nitrogen stabilisers:

- Nitrification inhibitors: these delay bacterial oxidation of the ammonium ion by depressing the activity of *Nitrosomonas* bacteria in the soil
- Urease inhibitors: these prevent or depress the transformation of amide-nitrogen present in urea to ammonia and carbon dioxide

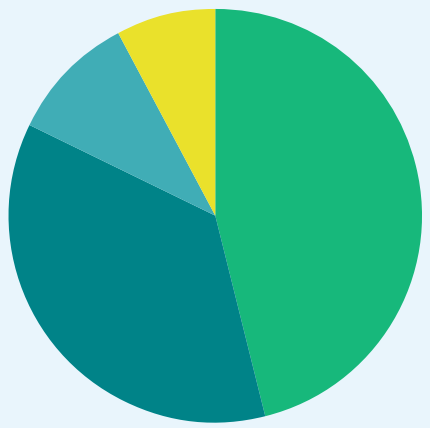
The bulk of the EEF market belongs to the above stabilised and inhibited products, while CRFs and SRFs are used in much smaller volumes in more specialised applications.

New market estimates

The global market for EEFs is currently valued at $2.35 billion and growing significantly. Demand for these more efficient fertilizers is underpinned by strong fundamentals, such a rapidly rising global population combined with a continuing decline in arable land per-capita. At the same time, sustainable agriculture is receiving much greater attention. These trends are being driven by changing climate patterns – which are leading to extreme drought conditions or untimely and intense rainfall events.

World demand for the SCRF segment of the specialty fertilizer market currently stands at more than 1.5 million tonnes. China, the United States, Western Europe and Japan are the leading global markets currently. World demand is expected to grow to at a rate of nearly six percent per annum during the period of 2017 to 2022, according to a new report from IHS Markit published this summer[1].

Fig. 1: **Controlled- and slow-release fertilizers, 2018**



Total consumption: 1.5 million t

Source: IHS Markit (2018)

China's double-digit growth

Chinese consumption of SCRFs, in particular, has increased significantly in recent years, and is projected to grow at nearly 10 percent annually during 2017 to 2022. China currently consumes approximately 700,000 tonnes annually of these specialty chemicals, nearly 46 percent of the global total, while the US consumes approximately 560,000, close to 36 percent of the global total (Figure 1).

Western Europe is the next largest SCRF market with more than 10 percent of the global demand, followed by Japan at roughly eight percent of global demand. China is also the world's leading SCRF

Slow- and controlled-release fertilizers (SCRFs)

SRFs and CRFs

SCRF fertilizers can be classified into two groups. The first group are **slow-release fertilizer (SRF)** products. These are prepared by adding urea and urea aldehydes, the most important ones being urea formaldehyde (UF), isobutylidene diurea (IBDU), and crotonylidene diurea (CDU). The second group consists of coated or encapsulated **controlled-release fertilizer (CRF)** products. These include sulphur-coated urea (SCU) or polymer-coated urea (PCU) products. These use a physical barrier to control the diffusion of nutrients across a membrane. Nutrient-release relies on soil microbial degradation.

Example technologies

Examples of fertilizer technologies that release plant nutrients slowly include:

- **Complexed/reacted products:** plant nutrients are contained in a water-soluble or insoluble compound that decomposes or degrades – by microbial activity, hydrolysis, or other means – thereby delaying or extending nutrient release. Examples include urea formaldehyde, isobutylidene diurea, or oxamide. These materials are commonly described as SRFs.
- **Coated products:** plant nutrients are encapsulated within an insoluble membrane or matrix that provides a physical barrier that limits their exposure to the soil and plant. Elemental sulphur coatings release nutrients by degradation and decomposition – by microbial activity, hydrolysis, or other means – thereby delaying or extending nutrient release. These coated fertilizers are commonly described as delayed-release fertilizers or SRFs. Polymer coatings, in contrast, remain intact and release nutrients progressively by diffusion or convective forces, thereby delaying or extending the nutrient release in a much more predictable manner. These coated fertilizers are commonly described as CRFs.
- **Occluded products:** plant nutrients are adsorbed, absorbed, entrapped, or physically bound by wax, resin, or other materials. These decompose, degrade, solubilise, or undergo ion exchange – as a result of microbial activity, hydrolysis, acidification, or other means – thereby delaying or extending nutrient release. Occluded fertilizers are commonly described as CRFs.

producer, having aggressively expanded its production during the past five years, to reach nearly 750,000 tonnes annually.

Agricultural applications take off

Historically, due to their high cost, the use of SCRFs was primarily limited to non-agricultural uses – the so-called turf and ornamental market. This included niche applications such as golf courses, landscaping maintenance, and nurseries and greenhouses.

However, SCRFs are now breaking through and finding increasing use in large commercial agricultural applications. Driving this is the need to feed an ever-expanding global population, especially among developing nations, like China and India, with greater economic buying power, according to the IHS Markit report[1]. These countries are also shifting away from traditional, carbohydrate-based diets and adopting protein-based menus which require more fertilizer use.

Environmental & regulatory drivers

Although the US has traditionally been the most significant market for SCRFs, China is witnessing extremely rapid growth in demand due to a host of market and social factors. These include economic and population growth, less arable land per-capita, and a strong desire to reduce the environmental impacts of fertilizers. Additionally, India – with its rapid economic growth and increasing environmental awareness – is another market where demand for these products is expected to grow strongly.

The 'zero growth in fertilizer use' regulations in China, and the EU's Nitrates Directive, are two examples of increasing regulatory influence, notes the IHS Markit report[1]. The US Good Agricultural Practices for vegetable farming is also acting as a regulatory driver in North America. The imposition of new environmental regulations, like the above examples, will only increase the size of the market for CRFs and SRFs, the IHS Markit report concludes[1].

China face broadly similar challenges to the United States, Europe and other regions. With pressures such as less available arable land, changing climate patterns and persistent drought conditions, China needs to feed more people with less land. Delivering this will require more efficient fertilizers able to increase crop yields while reducing their environmental impact. More efficient fertilizers such as SCRFs can help achieve those goals, albeit at a much higher cost than using traditional fertilizers.

Costs expected to fall

As stated earlier, SCRFs are modified products that differ from conventional fertilizers, being able to release nutrients more gradually to better match the uptake requirements of plants. The release of nutrients is regulated either chemically, to reduce solubility, or physically by encapsulating fertilizers within a polymer and/or sulphur coating.

Controlled- or slow-release fertilizers, such as polymer-coated or dual-coated varieties, can cost anywhere between 2.4 and 10 times as much as conventional fertilizers. The much higher costs of SCRFs explains why, traditionally, their use has been limited to non-agricultural uses such as golf courses and commercial nurseries – the so-called turf and ornamental market.

However, SCRFS are much more environmentally-friendly than conventional commodity fertilizers. They can also deliver costs savings to the farmer. SCRFs are more efficient because they release nutrients to plants more slowly over time, increasing nutrient uptake and the amounts absorbed by plants. As a result, less fertilizer is required – which saves resources and labour – and less product is lost and wasted as run-off, notes the IHS Markit report[1]. Nitrous-oxide emissions from nitrogen fertilizers are also reduced.

While the cost of producing SCRFs is undoubtedly a factor preventing their wider adoption currently, the costs for these products is expected to fall in future. The crop-yield gains and environmental benefits of SCRFs are also expected to out-

weigh their higher costs, especially as more stringent regulations and new penalties will require growers to minimize fertilizer run-off into streams and rivers.

Productivity and sustainability

Farmers are being asked to become ever more resource efficient by doing more for less – growing more food on less land in less predictable weather pattern, for example. SCRFs can help farmers achieve these goals by making crop fertilization more reliable and sustainable. Most farmers will welcome any farm input that helps increase crop yields, lessens uncertainty, and brings environmental benefits. When you can't control the weather, farmers know it helps to have better control of your crops at some level.

Market consolidation expected

Major global manufacturers of SRFs and CRFs include:

- Aglukon
- Compo GmbH and Co
- Haifa Chemicals
- ICL Group
- JCAM AGRI Co, Ltd
- Lebanon Seaboard Corp
- Nutrien
- Sadepan Chimica
- Shandong Kingenta

IHS Markit expects consolidation to continue in the specialty fertilizer sector as companies seek to strengthen their market positions and target growth. Major market players are solidifying their positions through acquisitions, new product launches, and joint partnerships. Significant recent market developments are highlighted below.

- In 2017, **ICL Innovation**, a subsidiary of ICL Group, announced a long-term research and development collaboration with biotech company **Evogene Ltd** to improve the nutrient efficiency of selected crops.
- In October 2017, **Stamicarbon** (a subsidiary of Maire Tecnimont SpA) acquired a 20 percent stake in **Pursell Agri-Tech**, LLC, a US-based start-up with expertise in the development and marketing of polymer-coated CRFs. In June 2018, Stamicarbon announced the launch of its Controlled-Release Fertilizer Design with *PurActive*™ Technology, which was developed along with Pursell Agri-Tech at Sylacauga, Alabama.
- In 2017, **International Finance Corporation** (IFC), a member of the World Bank Group, and **Kingenta** launched a new company **Jinfeng Agricultural Services Co Ltd** to promote and sell CRFs in China.
- German-based **COMPO** has partnered with **Kingenta** of China to jointly develop new enhanced-efficiency fertilizers that will initially be tested in China, Germany, the United States, Israel, and Thailand.
- In 2015, **Compass Minerals** acquired a 35 percent stake in **Produquímica** Industria e Comercio, based in Brazil, which produces and distributes specialty plant nutrients including controlled-release fertilizers.

References

1. IHS Markit, 2018. *IHS Markit Chemical Economics Handbook: Controlled- and Slow-Release Fertilizers Report*.
Please contact ralf.gubler@ihsmarkit.com

Water-soluble fertilizers: quality and compatibility

The high quality of water-soluble fertilizers is valued by growers and distributors alike. The use of low-quality products, or incompatibilities between fertilizers and irrigation water, can damage expensive drip irrigation equipment. We look at the quality and compatibility of water-soluble fertilizers and how this affects their performance.

Fertigation involves supplying plants with nutrients via a drip irrigation system. It allows nutrients to be applied precisely to crops where and when they are most needed during the growing season. Tailoring fertilizer use in this way helps to optimise crop yields, cuts input costs by avoiding over application, and also helps to reduce environmental impacts by preventing nutrient losses.

Protecting fertigation equipment

Fertigation systems are relatively complex and expensive. They can include pumps, backflow prevention systems, filters, nutrient storage tanks, fertigation injectors, timers, drip tubing and emitters. Efficiently delivering nutrients to plants through these systems using water-soluble or liquid fertilizers requires careful management and regular equipment maintenance. This is necessary to ensure fertigation delivers nutrients to plants efficiently and to protect investment by preventing equipment damage. The clogging of pipes and emitters, in particular, is a major concern.

Quality considerations

Single- or multi-nutrient solutions can be prepared for fertigation by dissolving soluble fertilizers in irrigation water. Fertilizers such as ammonium nitrate, calcium nitrate, monopotassium phosphate, potassium chloride, potassium nitrate, potassium sulphate, urea and urea-phosphate are commonly used[1].

The suitability of fertilizers for fertigation depends on a number of factors. Solubility, time taken to dissolve, solution pH, percentage insolubles and corrosiveness are among the most important quality characteristics (Table 1). Variations in solubility with temperature can also be an issue when preparing fertilizer stock solutions, as fertilizers which dissolve easily in summer may precipitate out in colder winter conditions[2].

Water quality also has to be taken into account. Irrigation waters can vary in terms of their pH, electrical conductivity (EC) and the concentration of dissolved cations and anions. Fertilizers need to be compatible, both with irrigation water and with the other fertilizers they are mixed with. Incompatibilities can cause solubility changes and

Table 1: **Solubility, insoluble content and solution pH of fertilizers used in fertigation**

	Maximum amount (kg) dissolved in 100 L at 20°C	Time to dissolve (min)	pH of the solution	Insolubles, %	Comments
Urea	105	20	9.5	neglibible	Solution cools as product dissolves.
Ammonium nitrate	195	20	5.62	-	Corrosive to galvanised iron and brass. Solution cools as product dissolves.
Ammonium sulphate	43	15	4.5	0.5	Corrosive to mild steel.
Monoammonium phosphate	40	20	4.5	11	Corrosive to carbon steel.
Diammonium phosphate	60	20	7.6	15	Corrosive to carbon steel.
Potassium chloride	34	5	7.0-9.0	0.5	Corrosive to brass and mild steel.
Potassium sulphate	11	5	8.5-9.5	0.4-4	Corrosive to mild steel concrete
Monopotassium phosphate	213	-	5.5+/-0.5	<0.1	Non corrosive
Potassium nitrate	31	3	10.8	0.1	Solution cools as product dissolves. Corrosive to metals.

Source: Kafkafi & Tarchitzky (2011)

the formation of undesirable precipitates and therefore need to be avoided (Table 2)[3].

Compatibility

Among the most popular type of water-soluble fertilizers for fertigation are:

- Monoammonium phosphate (MAP, $NH_4H_2PO_4$)
- Monopotassium phosphate (MKP, KH_2PO_4)
- Magnesium Sulphate ($MgSO_4$)
- Potassium Sulphate (SOP, K_2SO_4)
- Potassium Nitrate (NOP, KNO_3)
- Calcium nitrate ($Ca(NO_3)_2$)

Clogging takes place when calcium and magnesium in the irrigation water combines with fertilizer-derived phosphate and/or sulphate. This is a particular problem when irrigation water is 'hard' and contains high levels of calcium (Ca^{2+}), magnesium (Mg^{2+}) and bicarbonate (HCO_3^-) at alkaline pH. Reactions responsible for clogging of irrigation systems include:

- Calcium and phosphate: precipitate as insoluble calcium phosphates ($CaHPO_4$)
- Calcium and bicarbonates: precipitate as calcium carbonates ($CaCO_3$)
- Magnesium and phosphate: precipitate as insoluble magnesium phosphates ($MgHPO_4$)
- Iron and phosphate: precipitate as insoluble iron phosphates ($FePO_4$)
- Calcium and sulphate: precipitate as insoluble calcium sulphate ($CaSO_4$)

Injecting ammonia solution into an irrigation system can also result in the clogging of water emitters and filters. This happens when ammonia raises pH and causes carbonates to precipitate from irrigation water rich in dissolved calcium, magnesium and bicarbonate[2].

Certain phosphates also precipitate in hard, alkaline irrigation water, if levels of dissolved calcium and magnesium and the amount of phosphate in solution are high enough. Under such conditions, water-soluble (MAP), widely-used in fertigation, may precipitate out of solution as di- or tri-calcium phosphate and cause clogging[2].

Similarly, ammonium magnesium phosphate can precipitate out in the fertilizer tank, especially if irrigation water contains high levels of magnesium. The use of ammonium fertilizers should be specifically avoided under such conditions to avoid blocking emitters. It is also best to avoid using SOP with hard irrigation water as high levels of dissolved calcium can precipitate out as gypsum ($CaSO_4$) and clog the drip lines[2].

Some fertilizers can corrode the metal components of fertigation systems. Acidic and/or chloride-containing fertilizers are usually the most corrosive types.

Avoiding clogging

For fertigation, irrigation water and fertilizer solutions should ideally be slightly acid and kept within the range pH 5.5-7.0. If pH is too high, calcium and magnesium phosphates or carbonates may precipitate in irrigation lines. The plant availability of certain nutrients (P, Zn and Fe) may also be reduced. In contrast, too low a pH

Table 2: **Fertigation: fertilizer compatibility chart**

	Urea	Ammonium nitrate	Ammonium sulphate	Calcium nitrate	Potassium nitrate	Potassium chloride	Potassium sulphate	Ammonium phosphate	Fe, Zn, Cu, Mn sulphate	Fe, Zn, Cu, Mn chelate	Magnesium sulphate	Phosphoric acid	Sulphuric acid	Nitric acid
Urea	✓													
Ammonium nitrate	✓	✓												
Ammonium sulphate	✓	✓	✓											
Calcium nitrate	✓	✓	X	✓										
Potassium nitrate	✓	✓	✓	✓	✓									
Potassium chloride	✓	✓	✓	✓	✓	✓								
Potassium sulphate	✓	✓	R	X	✓	R	✓							
Ammonium phosphate	✓	✓	✓	X	✓	✓	R	✓						
Fe, Zn, Cu, Mn sulphate	✓	✓	✓	X	✓	✓	✓	✓	✓					
Fe, Zn, Cu, Mn chelate	✓	✓	✓	R	✓	✓	✓	✓	✓	✓				
Magnesium sulphate	✓	✓	✓	X	✓	✓	✓	✓	✓	R	✓			
Phosphoric acid	✓	✓	✓	X	✓	✓	✓	✓	✓	✓	✓	✓		
Sulphuric acid	✓	✓	✓	X	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Nitric acid	✓	✓	✓	✓	✓	✓	R	✓	✓	✓	✓	✓	✓	✓

✓ = *compatible* X = *incompatible* R = *reduced compatibility*

Source: Kafkafi & Tarchitzky (2011)

is detrimental to roots and may mobilise aluminium and manganese in the soil[1].

Nitric acid (HNO_3) or phosphoric acid (H_3PO_4) are generally used to lower pH levels in fertigation. As well as reducing clogging by dissolving precipitates, they also supply phosphorus and nitrogen to plants. Nitric acid can also help minimise saline injury to plants by reducing chloride salinity in the root zone in saline waters and calcareous soils[1].

Advice from equipment manufacturers

Netafim is a leading global manufacturer of drip irrigation equipment. Its maintenance guide[4] specifically advises against the use of the following chemicals in Netafim drip irrigation systems:

- Fertilizers containing more than 20 units of phosphorus.
- Polyphosphate
- Red potassium chloride
- Red potassium sulphate
- Borax
- Low-solubility fertilizers, e.g. gypsum
- Acid with a pH lower than 2

For fertigation, Netafim permits the injection of the following liquid or water-soluble fertilizers in drip irrigation systems:

- Nitrogen products: urea, ammonium nitrate, nitric acid
- Phosphorus products: phosphoric acid, water-soluble monoammonium phosphate (MAP), ammonium phosphate
- Potassium products: potassium nitrate, potassium chloride
- Micronutrients products: chelates, EDTA, DTPA, EDDHA, HEDTA, ADDHMA, EDDCHA, EDDHSA, boric acid

Netafim also offers the following six guidelines for fertigation systems:

1. Fertilizers must be completely soluble and free of impurities.
2. For neutral or basic pH (>7) irrigation water, do not use basic fertilizers and never use fertilizers containing calcium without specific permission from Netafim. Use of basic fertilizers is, however, permitted for acidic irrigation water (pH <5).
3. Only add stable, high-quality iron chelates to the system. Never inject cheap products (or ionic forms of iron) which may decompose in the system as these plug drippers and are ineffective as plant nutrients.

“To avoid incompatibilities and potential clogging, Prayon recommends using two fertilizer tanks during fertigation.

4. Stick to the following rules when using phosphate fertilizers as these can cause serious difficulties if used improperly:
   a. Avoid high concentrations of phosphate fertilizers in irrigation water.
   b. Turn off the fertigation pump before the end of irrigation in order to flush phosphate from the system.
   c. Only use orthophosphate-based fertilizers and never use those based on polyphosphate.
   d. Only use acidic phosphate fertilizers when irrigation water is basic (pH >7) or when water hardness is high.
5. The acidity of fertilizer solutions should be reduced to pH 6.0 during periods of heavy fertilization in greenhouses.

Anticalc properties

Prayon markets the *Hortipray® anticalc* range of water-soluble fertilizers for fertigation. The Belgium-based producer offers anticalc versions of both of its standard *Hortipray® MAP* and *Hortipray® MKP* fertigation products:

- *Hortipray® MKP anticalc* contains 52 percent phosphorus (P_2O_5) and 34 percent potassium (K_2O) and has a solubility of 229 g/L at 20°C.
- *Hortipray® MAP anticalc* contains 61 percent phosphorus (P_2O_5) and 12 percent nitrogen (as NH_4) and has a solubility of 384 g/L at 20°C.

Both *Hortipray® anticalc* products are acid with a pH of 4.5 (one percent solution). They are designed to ensure continuous and uniform irrigation and avoid the unnecessary loss of water and nutrients. Their anticalc properties prevent the build-up of limescale and phosphates on irrigation pipes and the growth of bacteria. This reduces the risk of blockages and uneven irrigation. It also extends the life of irrigation pipes.

Prayon advises that systems are at risk of clogging when irrigation water has a:

- pH above 7.5
- Calcium content >60 ppm (1.5 mmol/L, 3.0 meq/L)
- Magnesium content >30 ppm (1.2 mmol/L, 2.4 meq/L)
- Bicarbonate content >150 ppm (2.5 mmol/L, 2.5 meq/L)

To avoid incompatibilities and potential clogging, Prayon recommends using two fertilizer tanks during fertigation: one for calcium and magnesium nitrate fertilizers, and another for phosphate and sulphate fertilizers.

In 2012, Prayon announced a collaboration with Dutch fertigation system manufacturer HortiMaX (now part of agri-food company Ridder and rebranded FertiMix) to demonstrate the effectiveness of its *Hortipray® anticalc* water-soluble fertilizers. HortiMaX's irrigation checker tool was used to monitor their performance in a series of fertigation trials. These were carried out in greenhouses using hard irrigation water over a two-month period. A number of trials were planned with greehouse growers in Poland, Turkey, Mexico and Spain.

Strong acidifiers

Chile's **SQM** manufactures the *Ultrasol® Magnum* range of acidic water-soluble fertilizers for fertigation use. Their ability to reduce bicarbonate content and pH makes them particularly suitable for calcareous and alkaline irrigation waters and soils.

Although strong acidifiers (0.1-1.0% solutions have a pH of 2-3), *Ultrasol® Magnum* products are white, odourless, free-flowing, crystalline solids that are safe to handle and use. This offers distinct safety advantages as dry powdered products avoid the handling risks associated with the liquid nitric, sulphuric and phosphoric acids.

The *Ultrasol® Magnum* range of fertigation products includes:

- *Ultrasol® Magnum P44* (18-44-0) is a water-soluble NP fertilizer.
- *Ultrasol® Magnum Flex* is a water-soluble NPK fertilizer. Formulations are available for flowering and fruit set (15-15-30), production (14-7-39) and multipurpose (16-22-23) use.
- *Ultrasol® Magnum Special* is a water-soluble NPK fertilizer enriched with magnesium, sulphur and micronutrients. It is offered in a range of formulations and is a balanced source of three types of nitrogen (nitrate, ammonium, urea).
- *Ultrasol® Magnum Phoscal* is a high-analysis source of P, Ca and N. It keeps calcium and phosphate in solution, avoiding the blockages caused by insoluble calcium phosphate precipitation.

During fertigation, nutrients travel in solution from the fertilizer tank through the drip system to finally emerge in the soil and the plant's root zone. The transport of nutrients within a drip irrigation system may become obstructed by insoluble matter originating from two main sources, according to SQM:

- Residues present in water-soluble fertilizers
- Dicalcium phosphate (DCP, $CaHPO_4$) precipitated in irrigation water under alkaline conditions (>pH 6.2)

Ultrasol® Magnum products are effective at combatting these problems. They are almost completely soluble (typically >99.8 percent) and – as strong acidifiers – they can be added to fertilizer tanks to keep fertilizer solutions clear and precipitate-free. Their acidity also helps prevent pipes and nozzles in the irrigation system from blocking. This is a particular problem for 'hard' irrigation water containing high levels of dissolved calcium and magnesium in bicarbonate and carbonate form. *Ultrasol® Magnum* products can also improve nutrient uptake efficiency, and ultimately crop productivity, by increasing the availability of nutrients residing in the soil.

Tests run on hard water by France's Cemagref, an agricultural and environmental engineering research institute, have shown that routine use of *Ultrasol® Magnum* in irrigation systems can keep drippers clean. Under these conditions, Cemagref found that water-soluble MAP, in contrast, caused severe precipitation which invariably led to clogging of drip lines and poor discharge.

Ultrasol® Magnum P44 is a very efficient at acidifying hard irrigation water. A relatively small dose (346 g/m³) can reduce the pH of bicarbonate-rich water (200 g/m³) from 8.0 to 6.0. It can also be added during drip line maintenance (at 12.5 kg per 1,000 litres concentration) to dissolve inorganic precipitates.

Ultrasol® Magnum products have beneficial effects on calcareous, alkaline soils (pH 7.5-8.5). They have the ability to mobilise reserves of soil-fixed nutrients and make them available to plants, including phosphorus (Ca- and Mg-phosphates) and micronutrients, such as iron, zinc, copper and manganese, present as oxides and hydroxides. In trials, fertigation with *Ultrasol® Magnum*-based NPKs has been shown to increase nutrient availability in calcareous soils, compared to MAP-based NPKs.

Ultrasol® Magnum can acidify soils in two ways, according to SQM:

- Direct acidification through the lowering of pH.
- Indirect acidification by urea hydrolysis. This transforms urea into to ammonium in the soil which is then oxidised to nitrate.

High-purity calcium nitrate

Chemical purity is a valued quality characteristic of water-soluble fertilizers. **Uralchem** began producing what it says is the world's most concentrated calcium nitrate (CN) fertilizer, *Calcium Nitrate Concentrated*, in 2013. This is marketed by Uralchem as: "The only fully water-soluble and readily available calcium source for plants." The company believes the quality of its CN fertilizer surpasses that of rival international products

> **"Compared to standard products, the crystals in *Calcium Nitrate EXTRA* contain fewer water molecules, resulting in a higher concentration of nutrients."**
> Kurt Verhelst, Prayon

available on the market. To meet demand, the Russian producer has expanded production of this relatively-new product from a single line to three lines over the last five years, increasing its annual manufacturing capacity from 40,000 tonnes to 141,000 tonnes currently.

Calcium Nitrate Concentrated is produced to the following specification:

- Calcium content: 33 percent CaO minimum
- Total nitrogen: 17 percent minimum, 16.7 percent as nitrate-nitrogen, 0.3 percent as ammonium-nitrogen
- Insolubles: 0.1 percent maximum
- pH: 5.5-6.5, one percent solution
- Moisture content: three percent maximum

The product is around 98 percent pure, providing an extremely high concentration of calcium and nitrogen nutrients. It contains up to 25 percent more $Ca(NO_3)_2$ than some standard product types, according to Uralchem.

The purity and high solubility of *Calcium Nitrate Concentrated* (17-0-0 + 33% CaO) make it ideal for fertigation and foliar applications. In addition, the product's unique high-concentration formulation is said to boost the stress resistance of fruit crops, benefitting quality and extending shelf life. Providing nitrogen in the nitrate form, rather than as ammonium, also increases the uptake of other plant nutrients (Ca, Mg, K and micronutrients), claims Uralchem.

Prayon also added a *Calcium Nitrate EXTRA* (17-0-0 + 33% CaO) product to its *Hortipray®* range at the end of 2016. This highly-concentrated, water-soluble product boosts calcium content from 25 percent to 33 percent (CaO), compared to standard calcium nitrate. It also guarantees that at least 17 percent nitrogen content is available as nitrate.

"Compared to standard products, the crystals in *Calcium Nitrate EXTRA* contain fewer water molecules, resulting in a higher concentration of nutrients," explained Kurt Verhelst, Prayon's horticulture customer coordinator for Northern Europe.

Calcium Nitrate EXTRA is being marketed as an ideal alternative to liquid calcium nitrate. The new product is free of impurities, such as sodium, and contains a negligible amount of ammonium, unlike other standard types of calcium nitrate.

"In some hydroponic crops, excessive ammonium can cause growing problems resulting in yield and quality losses. [That is why] a liquid version of calcium nitrate – containing no ammonium – has been introduced into modern horticulture. *Calcium Nitrate EXTRA* is the perfect solid alternative to this liquid calcium nitrate," concluded Verhelst.

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PICTURE THIS...

European fertilizer consumption

Trade body Fertilizers Europe released its latest fertilizer consumption forecast for the European Union in January. "After several years of relatively solid growth, it looks as if the [EU] fertilizer market is now slowing down, especially for nitrogen. With lower commodity prices and the Russian embargo, European farmers are still feeling the pressure. Consequently, they have become more cautious in their spending, even on essential inputs like fertilizers," concludes Fertilizer Europe.

The EU currently applies a total of 16.7 million tonnes of nutrients to 134.5 million hectares of farmland. Total nutrient consumption – based on an average for the last three growing seasons – is split between 11.2 million tonnes of nitrogen (67%), 2.6 million tonnes of phosphate (16%) and 2.9 million tonnes of potash (17%). The grain sector (wheat, coarse grains and oilseeds) is a key segment of the EU fertilizer market, accounting for around three-fifths of total nutrient consumption, with wheat alone accounting for more than one-quarter.

The EU is a mature fertilizer market and consumption is expected to rise only marginally over the next decade, reaching 16.9 million nutrient tonnes by 2026/27. Significant rises in potash (+6.0%) and phosphate (+5.8%) consumption will be partly offset by a slight decline in nitrogen consumption (-0.2%).

EU farmers fertilize around three-quarter (134.5 million hectares) of the region's 178.9 million hectares of agriculture land. The remaining 44.4 million hectares that is not fertilized is divided between unfertilized grassland and idle land. On average, around two-thirds of the fertilized area in the EU is dedicated to arable crops (cereals, oilseeds and fodder), although this proportion rises to more than four-fifths for Central and Eastern European countries (EU-13) where arable production predominates.

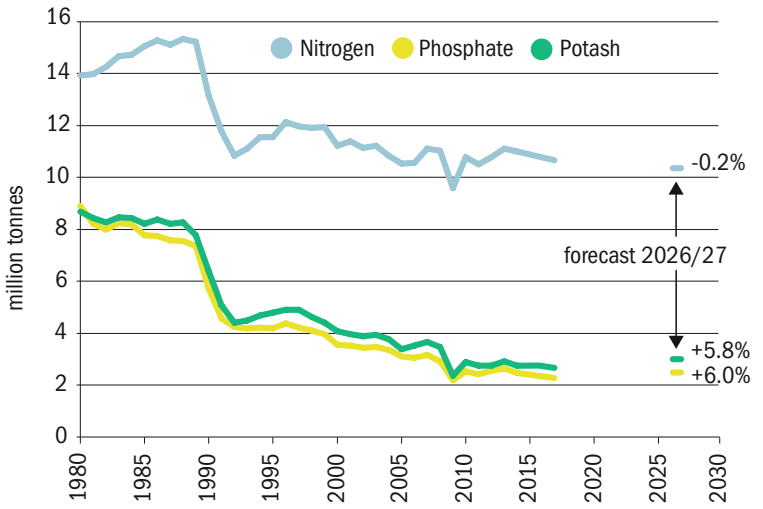
Nutrient consumption in the EU should rise by three percent over the next decade. The nutrient consumption of almost all major EU crop types is forecast to grow over this period – by six percent for sugar beet, for example, and four percent for cereals. Potato, where a decrease of five percent is forecast by 2026/27, is the exception.

Nutrient consumption is expected to grow most strongly in Central and Eastern EU countries (Bulgaria, Czech Republic, Hungary, Latvia, Poland, Romania) over the next 10 years as application rates rise. In contrast, consumption in several Western EU members states (Germany, France, the Netherlands) looks set to contract over this period, partly due to tighter regulation. ■

Source: Fertilizers Europe

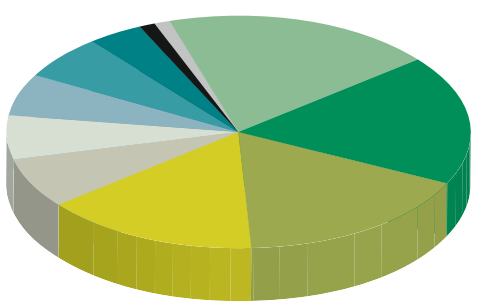
EU FERTILIZER CONSUMPTION

Levels lower since 2008/09 downturn



EU AGRICULTURAL LAND USE

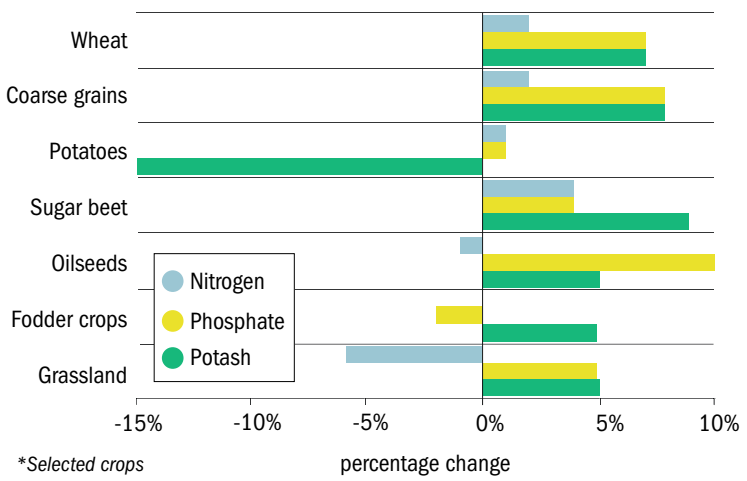
134.5 million hectares fertilized, 44.4 million hectartes unfertilized



Grassland: non-fertilized	19%	Permanent crops (fruit, vineyard, forest)	6%
Grassland: fertilized	18%	Oilseeds	6%
Coarse grains	17%	Other crops	4%
Wheat	15%	Potatoes	1%
Fodder crops	7%	Sugar beet	1%
Idle land	6%		

EU FERTILIZER USE BY CROP, 2017-2027*

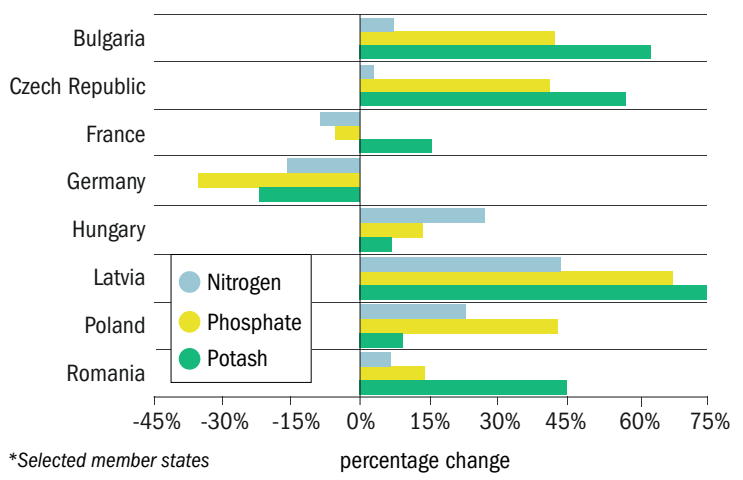
Central and Eastern growth, Western contraction



**Selected crops*

REGIONAL EU FERTILIZER USE, 2017-2027*

Increases except for potato



**Selected member states*

Southeast Asia's nitrogen market

Extra capacity is altering nitrogen market trade dynamics in Southeast Asia. New ammonia-urea plants in Indonesia, Malaysia and Borneo look set to ease import reliance and turn the region into a net exporter.

PHOTO: PETRONAS

Table 1: **Gas reserves and production in Southeast Asia, 2015 (billion cubic metres)**

	Production	Exports	Reserves
Brunei	12.7	8.7	275
Indonesia	75.0	32.4	2,840
Malaysia	68.2	34.2	1,170
Myanmar	19.6	13.4	530
Papua New Guinea	9.8	9.7	140
Thailand	39.8	-	220
Vietnam	10.7	-	615

Source: BP

A gas-rich region

Southeast Asia is richly endowed in gas resources. But geography has held-back the development of a regional gas economy– with fragmented island chains and mountain barriers making pipeline building difficult and/or prohibitively costly.

Yet the region has adapted and overcome these physical constraints by focussing on the production and export of liquefied natural gas (LNG) in Malaysia, Indonesia and Brunei. But geography has still left many gas reserves 'stranded' and disconnected from the centres of demand. This has limited the potential for downstream ammonia and urea production in the region.

However, a strong reserve base has enabled Malaysia and Indonesia to power ahead and become the region's dominant gas producers (Table 1). In Brunei and Myanmar, the combination of significant reserves and relatively low demand has allowed both countries to become sizeable gas exporters. Vietnam is self-sufficient in gas and does not import or export, while Thailand, Singapore –and to a lesser extent the Philippines – are reliant on gas imports, with little or no production of their own. Papua New Guinea is an interesting new player that is fast emerging as a regional gas production hub. Similar to Brunei, the country has reserves and production far in excess of its modest domestic needs.

Southeast Asia's pipeline network remains relatively underdeveloped (Figure 1) and has largely stalled, despite various regional initiatives. In contrast, the region's considerable investment in LNG capacity for gas distribution and export has proved a much more successful strategy for matching supply with demand, and

Fig. 1: **Southeast Asia's natural gas industries**

is an approach that is likely to continue and grow. Malaysia, for example, is planning to deploy floating LNG (FLNG) ships to access its remote offshore gas fields, while the Philippines and Vietnam are looking to import LNG to help meet their future domestic gas needs.

Coal feedstock

The use of coal as feedstock for nitrogen production in the region is on the rise and appears to have a definite future. Indonesia, with its massive resources and production might, is the region's coal giant, being the world's third largest coal producer after China and the United States. The country also recently edged Australia into second place as the world's largest exporter, a position secured through large deliveries to the Chinese market. However, Vietnam – not Indonesia – has been the first ASEAN country to adopt coal as feedstock for ammonia production, despite the relatively modest scale of its domestic coal industry.

Indonesia, though, with its ageing gas fields and rising domestic gas demand, is now beginning to replace its gas-based ammonia production with coal gasification. Japanese developer IHI has played a pioneering role, constructing a 50 t/d demonstrator coal-to-ammonia plant in Indonesia in 2016. State-owned fertilizer producer Pupuk is also converting to coal-based steam generation at its full-scale Kalim 5 nitrogen plant, and is advancing plans for further gas-to-coal feedstock switchovers at its other sites.

Indonesia

Indonesia is a regional gas giant with the largest reserves in the region by some margin. But gas production, consumption and exports have all started to slip as output from the country's mature fields has waned or stopped entirely. The end of production at the giant onshore Arun field in north Sumatra in 2014 – which once ran six LNG trains – was a particularly symbolic moment. At the same time, Indonesia has struggled to attract the foreign investment needed to develop its offshore fields. These are at a disadvantage, being more expensive to develop, technically difficult to access, and further away from end markets. Indonesia's lack of oil and gas pipeline capacity also means associated gas is often needlessly flared.

Indonesia's gas output peaked in 2010 and has gradually fallen in the years since then. Production has declined from 85 bcm to 75 bcm over the last seven years, for example, and consumption from 43 bcm to 39 bcm. Indonesia was also the world's largest LNG exporter in the early 2000s. But, again, its LNG exports have fallen subsequently, and also been eclipsed by the emergence of other gas producing and exporting countries such as Qatar, Australia, Malaysia and Nigeria.

Indonesia' oil and gas fundamentals remain extremely strong though. Proven and potential conventional energy reserves are estimated at more than seven billion barrels of oil and 150 trillion cubic feet of gas. The country also has enormous unconventional reserves, namely 450 trillion cubic feet of coal bed methane and 575 trillion cubic feet of shale gas. The

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

AMMONIA

NITRATES & PHOSPHATES

UREA

MELAMINE

METHANOL

SYNGAS

country's unconventional gas industry is still in its infancy, although the government did test market interest by offering five unconventional oil and gas blocks last year.

As stated previously, Indonesia also possesses huge coal reserves, mostly in Sumatra in the west, and in Kalimantanon on the eastern side of Borneo. Indonesia's coal production is currently booming, having tripled over the past decade, rising from 90 million tonnes oil equivalent in 2005 to 280 mtoe in 2014. Production did, however, fall back in 2016 due to lower exports to China.

Coal reserves also accompanied by coalbed methane in considerable volumes, although production so far has been relatively small-scale, and development slow-paced. Indonesia has looked at duplicating China's coal gasification success story, especially as gasification could help transform the country's enormous reserves of low-grade coal into a valuable chemical feedstock. These reserves are underused currently due to their high moisture and lower heating value content.

Indonesia's nitrogen industry is the largest in the region by some margin – an unsurprising fact given the size and maturity of its oil and gas industry. The country's production plants are exclusively state owned and operated by the government via its Pupuk Indonesia holding company. Nitrogen production is distributed across five main sites on Sumatra, Java, and on the east coast of Kalimantan, Borneo (Figure 1):

1. **PT Pupuk Kalimantan Timur (Kaltim).** The plant was established in 1977 at Bontang on the east of Borneo. Kaltim has five ammonia-urea trains with a total capacity of 3.4 million t/a of urea. These were mainly built in the 1980s, although the two most recent trains (Kaltim IV and V) started up in 2002 and 2015, respectively. Pupuk also took over responsibility for the 660,000 t/a Kaltim Pasifik Ammoniak (KPA) plant at the same site in 2014.
2. **PT Petrokimia Gresik, East Java.** Production at the site started in 1972. Fuel oil was originally consumed as a feedstock prior to the availability of gas. The original plant was replaced by a new ammonia-urea plant (460,000 t/a of urea capacity) in 1994.
3. **PT Pupuk Kujang at Cikampek, West Java.** Production at the site dates back to 1975. The site's two ammonia-urea trains have a combined urea capacity of 1.14 million t/a.
4. **PT Pupuk Sriwidjaja (Pusri).** This was established in 1963 at Palembang in South Sumatra as Indonesia's first nitrogen production plant. The site's original four trains have a combined urea capacity of 2.1 million t/a. An additional train, Pusri IIB, began operations in August 2016. This new plant has 660,000 t/a of ammonia capacity and 900,000 t/a of urea capacity.
5. **PT Pupuk Iskandar Muda (PIM).** This plant began production in 1982 at Lhok Seumawe near the Arun gas field in Aceh, North Sumatra. PIM currently has the capacity to produce 1.17 million t/a of urea and 750,000 t/a of ammonia, following the completion of a second production unit in 2004. The **PT ASEAN Aceh Fertilizer (AAF)** plant, established at Lhok Seumawe in 1981 as a joint venture by ASEAN, was subsequently idled due to lack of gas supplies – an issue which has also affected the PIM complex.

Indonesian government policy under President Joko Widodo has continued to provide state investment in downstream development of the country's energy and chemical sectors. This has proved a successful policy, the recent expansion of Pusri being one clear sign of this. Petrokimia Gresik is also constructing a second urea plant, Amurea 2, with 660,000 t/a of ammonia and 570,000 t/a of urea capacity. Site preparation and engineering is already under way, and the new unit was due to start up in late 2017. PT Pupuk Kujang IC, provisionally scheduled for 2020, would add a further 660,000 t/a of ammonia and 1.15 million t/a of urea capacity.

In the private sector, gas producer Surya Esa Perkasa has begun constructing an $830 million, 650,000 t/a capacity ammonia plant in central Sulawesi. The plant is located on a 192-hectare site near a gas field. This is jointly operated by Pertamina and energy company Medco Energi International, who will supply the plant with natural gas feedstock. Commercial operation was scheduled to begin in the fourth quarter of 2017 or early 2018. The plant's operator Panca Amara Utama (PAU) is 60 percent-owned by Surya Esa Perkasa and also has Japan's Mitsubishi Corp as a minority shareholder. PAU plans to sell its ammonia output domestically and to export markets in Asia.

As previously mentioned, Japanese engineering giant IHI Corp already operates a pilot coal-to-ammonia plant in Indonesia. This consumes 50 t/d of low-grade coal to make ammonia fertilizer and is hosted by state-owned fertilizer producer PT Pupuk Kujang. The project is funded by Japan's Ministry of Economy, Trade and Industry (METI) and has the active support of several Indonesian ministries. IHI has plans develop a commercial-scale 1,000 t/d ammonia plant in Indonesia over the longer term.

PT Pupuk Sriwijaya Palembang (Pusri) and state-owned coal miner PT Bukit Asam are also jointly carrying out a feasibility study for a coal gasification plant in South Sumatra. This will assess the viability of large-scale ammonia and urea production (1,500 t/d and 2,600 t/d, respectively) using coal as a feedstock.

Malaysia

Malaysia natural gas reserves exceed one trillion cubic metres, the second largest in the region after Indonesia (Table 1). But, with a population only one-eighth of Indonesia's, the country's domestic energy demand is correspondingly lower and gas availability for LNG export and downstream chemical production is correspondingly higher.

Malaysia operates three nitrogen plants currently. The first is **ASEAN Bintulu**, located on the northwest coast of Borneo (Figure 1, Site 6). This production plant has 400,000 t/a of ammonia and 540,000 t/a of urea capacity. It was developed as a regional joint venture by the ASEAN, similar to the PT ASEAN Aceh Fertilizer (AAF) plant in Indonesia (see above).

Malaysia's state oil company Petronas also operates two facilities. The company's stand-alone 450,000 t/a capacity ammonia plant at **Kerteh** in Terengganu province has been operating since 2002 (Figure 1, Site 7). The other **Gurun**, Kedah, ammonia-urea plant was built in 1999 and provides 595,000 t/a of urea production capacity (Figure1, Site 8).

Petronas is also bringing new nitrogen capacity on-stream. It is currently developing the $1.5 billion Sabah Ammonia Urea (SAMUR) project at the Sipitang Oil & Gas Industrial Park in Sabah. Japan's Mitsubishi Heavy Industries secured the engineering, procurement and construction (EPC) contract for SAMUR. Construction of the 740,000 t/a capacity ammonia and 1.2 million t/a capacity urea plant first commenced

in early 2012, and it was due to be completed by the end of 2016. Haldor Topsoe and Saipem, respectively, are providing the plant's ammonia and urea technology under license, while Uhde Fertilizer Technology is the granulation technology licensor.

Vietnam

Vietnam has four nitrogen plants. On paper, these should provide the country with excess urea supply and the potential to export, with a theoretical combined output of 2.65 million per year versus annual domestic demand of some two million tonnes. However, production and financial issues, coupled to the general oversupply in the global urea market, have made exporting difficult. In practice, the country's urea production just about meets its domestic needs.

Two relatively-modern gas-based plants are operating reliably in Vietnam. Both are supplied with feedstock from the Nam Con Son basin, developed by BP, PetroVietnam and Conoco. Both plants have a urea production capacity of 740,000 t/a. The first fertilizer and power plant complex was built during 2001-2004 at **Phu My**, where gas from the basin comes ashore (Figure 1, Site 10). A second, identical plant was later completed further south at **Ca Mau** in 2012 (Figure 1, Site 9).

Two other coal gasification-based ammonia-urea plants are located in the north of the country at **Ninh Binh** (Figure 1, Sites 11)and **Bac Giang** (**Ha Bac**) (Figure 1, Sites 12). Both plants have been plagued by production problem, serious financial difficulties and poor market conditions. State producer Hanichemco (Ha Bac Nitrogenous Fertilizer and Chemical Co Ltd), for example, spent $570 million from 2010-2015 upgrading and expanding the urea output at the Soviet-era Ha Bac plant from 180,000 t/a to 500,000 t/a. However, the plant was reported to have lost $30 million in 2015 and was on track to lose another $22 million in 2016. The other coal-based plant, Ninh Binh, owned by Vinachem (Vietnam National Chemical Co), was forced to close in May 2016 – with total losses of $120 million – after losing money during all four years of operation. With a nameplate urea production capacity of 560,000 t/a, Ninh Binh was built between 2008-2012 at a cost of $670 million, including $250 million in Chinese loans. The company was paying four percent interest on these loans, higher than typical market borrowing rates. Moreover, it faced coal price rises from $35/t to $90/t at a time when global urea prices plummeted from $600/t to $250/t. There are hopes that Vietnam's central government will approve a rescue package for the beleaguered plant.

Myanmar

After decades of isolation and international sanctions, Myanmar has pursued a path back to democracy since 2008. This culminated in the freeing of Aung San Suu Kyi and the entry of her National League for Democracy (NLD) party into government in 2015. The subsequent lifting of international sanctions has boosted much-needed foreign investment and, encouragingly, Myanmar's economy has grown seven percent on average for the past few years.

Most of Myanmar's natural gas output (c. 70%) currently comes from the offshore Yadana and Yetagun fields. Gas from both fields is supplied to Thailand via a pipeline running from Yangon. Natural gas production has also increased rapidly in recent years, rising from 12.7 bcm to 19.6 bcm between 2012 and 2015. Years of sanctions have, however, left Myanmar with a legacy of aging and poorly-maintained petrochemical infrastructure operating well below capacity. The State-owned Myanmar Petrochemical Enterprise owns five urea plants, namely:

13. **Kyung Chaung**, 66,000 t/a capacity
14. **Myaung Daga (Yangon)**, 165,000 t/a capacity
15. **Kan Gyi Dauk**, 165,000 t/a capacity
16. **Kyaw Zwa**, 200,000 t/a capacity
17. **Sale**, 66,000 t/a capacity

But only three of these five government-run plants are reported to be operative, as both the Kyaw Zwa and Kyung Chaung plants have been closed for some years. The remaining three plants are also said to be operating at less than 25 percent capacity due to gas shortages and maintenance issues. Myanmar's total annual urea production is around 100,000 tonnes with much of the country's fertilizer demand (1.2-1.4 million t/a) currently being met by imports from China and Thailand.

Fertilizer use in Myanmar is extremely low in comparison to neighbouring countries, at just 60 kg/ha versus 300 kg/ha in Thailand and 700 kg/ha in Vietnam. The country's overall nutrient consumption is thought to be around one-tenth of the regional average.

That suggests there is considerable potential for stimulating domestic fertilizer demand by increasing fertilizer production and availability. But a lack of modern equipment, high production costs and an inadequate supply of natural gas are collectively holding back the expansion of fertiliser production in Myanmar, according to the International Finance Corporation.

In 2016, Japan's Matsui unveiled plans to invest around JPY 1.2 billion ($135 million) in the construction of a 100,000 t/a fertilizer manufacturing plant in Myanmar's Thilawa Special Economic Zone. The plant is scheduled to begin producing fertilizers under the *Shwe Ohsi* and *Kujaku* brand names from October. The plant will be owned and operated by Agri First Co, a joint venture between Matsui, Germany's Behn Meyer and local agribusiness MAPCO.

However, apart from the proposed re-opening of the shuttered Kyaw Zwa urea plant, there are, few other signs of an imminent, large-scale renaissance of Myanmar's fertilizer industry, despite the opportunities for investment and renewal opened up by the lifting of sanctions.

Brunei

The Sultanate of Brunei, although geographically small, has been at the forefront of oil & gas development in the ASEAN region. Large oil and gas reserves were first discovered on the northern coast of Borneo in the 1960s. However, the country has focussed almost exclusively on gas exports at the expense of domestic downstream petrochemical production.

Brunei, by drawing on significant reserves, has kept its gas production relatively constant – while oil production has waned after peaking in 1979. The country first began exporting LNG from the Lumut LNG plant in 1972. Lumut's five production trains have a combined gas capacity of 9.5 bcm per year. Brunei exports the lion's share of its gas output as LNG – some 8.7 bcm in 2015 – mostly to Japan and Korea under long-term contracts.

The 850,000 t/a Brunei Methanol Company plant, which began operating in 2010, is currently Brunei's only downstream chemical production plant. Its development was co-financed by Petroleum Brunei and Japan's Mitsubishi and Itochu. Brunei is, however, now set to emerge as a

REGIONAL UREA SUPPLY AND DEMAND

Urea predominates

Almost all of the nitrogen production in the region is based on urea, apart from some ammonium sulphate and nitrate production in Indonesia. A breakdown of urea production and consumption across Southeast Asia is provided in Table 2. Indonesia, Malaysia and Vietnam are all major producers. Of these, Indonesia and Malaysia are the principle regional exporters. Vietnam, although notionally running a production surplus, has remained a slight net importer of urea in recent years. This has been due to the domestic operating costs, and production and financial issues at its coal-based plants (see main article).

Table 2: **Urea production and demand, ASEAN countries, 2014, million t/a**

	Production	Consumption	Imports	Exports
Indonesia	6.8	5.8	0.1	1.1
Malaysia	1.2	0.7	0.4	0.9
Myanmar	0.2	0.2	0	0
Philippines	0	1.1	1.1	0
Thailand	0	2.2	2.2	0
Vietnam	2.2	2.2	0.2	0.2
Total	**10.4**	**12.2**	**4.0**	**2.2**

Source: IFA

Indonesia's giant demand

Indonesia consumes almost six million tonnes of urea annually almost half of regional urea demand, and is far and away the region's largest urea consumer. Thailand and Vietnam are also significant urea consumers, each having annual requirements in excess of two million tonnes, while more moderate consumption levels are typical of Malaysia and the Philippines. Annual consumption in Cambodia, Laos, Brunei, Singapore and New Guinea generally amounts to less than 50,000 tonnes each.

As non-producers, Thailand and Philippines source all of their urea from imports. While there is intra-regional trade – with Indonesia supplying Vietnam, for example – Southeast Asia as a whole was a net importer of urea in 2014, with most imports coming from China, and to a lesser extent the Middle East.

Changing trade dynamics

Regional trade dynamics have shifted over the past decade. Vietnam was a major importer of urea until about 2012, for example, until the new Ca Mau plant and the expansions at Ha Bac came on-stream, displacing imports. Indonesia, usually a major exporter, was forced to restrict exports for a period around 2006. This was partly due to long-term LNG export contracts taking precedence over and limiting domestic gas availability, during a time of falling gas production. In recent years, Indonesia has once again been able to redirect gas towards domestic urea production as these LNG export contracts have lapsed. Malaysian urea exports, in contrast, have remained relatively constant over the last decade at around 800-900,000 t/a. ■

significant nitrogen fertilizer producer and exporter from 2021.

Construction of Brunei's first urea fertilizer plant began in August, following an official ground breaking ceremony at the 55-hectare Sungai Liang Industrial Park site in Kuala Belait. The $1.8 billion project is being developed by state-owned Brunei Fertiliser Industries (BFI). Once completed, it will be one of Southeast Asia's largest fertilizer plants, with 2,200 t/d of ammonia capacity and 3,900 t/d of urea capacity. thyssenkrupp Industrial Solutions (tkIS) is the EPC contractor for the project and is also the ammonia technology licensor. Stamicarbon is supplying the plant's urea technology. Brunei Shell Petroleum (BSP) is supplying the plant with 500 billion cubic feet of natural gas over the next 20 years. The plant's fertilizer output will target the export market in the region.

Brunei's other long-standing downstream production ambitions include a nitrogen fertilizer complex to accompany a possible a sixth LNG train at Lumut. Mitsubishi, Matsui and IncitecPivot have all been all interested in the prospective Lumut plant at some point. More recently, India – to help satisfy its large urea import demand – has also looked at developing urea production capacity in Brunei through an investment partnership with the government, similar to its successful Oman-India Fertilizer Company joint venture in the Arabian Gulf.

Nitrogen outlook

Nitrogen usage in the region's major consuming nations is relatively mature and unlikely to increase dramatically. Growth in regional demand is likely to be relatively modest, – despite the scope for future growth in Myanmar, Laos and Cambodia – and will certainly be outstripped by growth in regional supply.

New capacity has started up in Indonesia at Kaltim V (although this replaced the old Kaltim I plant) and Pusri IIB, for example, and the SAMUR plant in Malaysia is also due to start-up soon. These three new plants together will add an extra 2.7 million tonnes annually to regional urea capacity, more than enough to absorb Southeast Asia's current regional deficit, and even push it slightly into surplus.

Additionally, more plants are planned in Indonesia at PAU and potentially Pusri. The under-construction Brunei Fertiliser Industries (BFI) plant is also scheduled to come on-stream from 2021. There is also potential for further new capacity in Myanmar and Papua New Guinea – although prospects for these are less viable in a low price environment for urea, and while oversupply from China continues. These same factors also limit potential for urea exports from the region, as these similarly depend on favourable international prices prevailing.

The gas supply situation in Indonesia, having limited urea production in the past (see box), remains another key uncertainty. Gas curtailments further down the line could potentially force some ammonia-urea plants to switch to coal as a feedstock, and result in others operating more seasonally, depending on gas availability, as currently happens in Pakistan and Bangladesh. ■

9th GPCA Fertilizer Convention

The Gulf Petrochemicals and Chemicals Association (GPCA) is holding the 9th GPCA Fertilizer Convention at the Kempinski Hotel, Muscat, Oman, 18-20 September 2018.

This year's GPCA Fertilizer Convention has the theme "New Frontiers and Opportunities". The Convention is being held in Oman for the first time, with the kind support of the Oman India Fertiliser Company (Omifco).

Distinguished speakers

The GPCA has secured an impressive line-up of high-level speakers for this year's Convention. The GPCA's vice chairman, **Dr Abdulrahman Jawahery**, will welcome delegates to the event by delivering the opening remarks. **Rakesh Kapur**, the current president of the International Fertilizer Association (IFA), and joint managing director of Indian Farmers Fertilizer Cooperative (IFFCO), will present the keynote address on the first day, while **Charlotte Hebebrand**, IFA's director general, will deliver the second keynote address on day two.

Other distinguished speakers include:

- **John Baffes**, senior economist, World Bank
- **Seta Tutundjian**, director of partnerships & knowledge management, International Center for Biosaline Agriculture (ICBA)
- **Thomas Rings**, partner, AT Kearney

A strategic industry

The Gulf Cooperation Council (GCC) region benefits immensely from its abundant hydrocarbon resources, strategic geographic location and competitive feedstock position, making it an important global producer of high-quality fertilizers. The fertilizer industry contributes significantly to job creation within the region and its economic growth. The expansion of fertilizer production also forms a vital part of the strategy to diversify the economies of countries within the GCC region.

Warmly welcoming delegates

Dr Abdulwahab Al-Sadoun, GPCA secretary general, looks forward to welcoming delegate to Oman:

"As the first GPCA event to take place in Oman, the Fertilizer Convention will shine a spotlight on the fertilizer industry in the Sultanate and the GCC, and its crucial role in supporting local agriculture and contributing to socio-economic growth.

"As the global population continues to grow and environmental challenges put pressure on farmers to produce healthier and abundant crops, fertilizers remain vital for ensuring food security in a world with rising demand for nutrition. Held under the theme "New frontiers and opportunities", the 9th GPCA Fertilizer Convention will provide exclusive access to networking with high-level officials, and promote regional innovations in agriculture."

Leading regional event

The GPCA Fertilizer Convention has established itself as the Middle East's leading regional event for networking, sharing best practice and exchanging ideas. Each year, industry experts, thought leaders and senior officials from the GCC region and beyond come together to connect, expand their knowledge and share insights about current fertilizer market trends.

This year's Convention will discuss the latest developments in global trade, and their impact on the region's heavily export-oriented fertilizer industry. Technical sessions will cover operational efficiency and environmental sustainability. While a workshop on customer value management (see page 43) will provide further opportunities to share knowledge and best practice.

Fertilizer International magazine is proud to be the official media partner for the 9th GPCA Fertilizer Convention. Please visit www.gpcafertilizers.com for more information about this year's event.

CVM: creating and capturing value

Customer Value Management (CVM) can provide fertilizer producers with a greater insight into the needs of their customers and what drives value within their businesses. **Phil Allen** of CVM€ and **Dimitrios Dimitriou** of Nexant explain how traditional, low-cost, commodity-based producers can use CVM to move downstream and get closer to customers. In doing so, they can differentiate products to create and capture more value – and radically improve their profitability and market position in the process.

Combatting commoditisation

The fertilizer market remains overwhelmingly commodity-based. For the most part, urea, potash and DAP (diammonium phosphate) are mass-produced as undifferentiated products and traded internationally with little or no regard to who produced them. The same applies to feedstocks used in their manufacture, such as sulphur, ammonia and phosphate rock. The process by which products become so commonplace that they no longer retain any intrinsic competitive advantage is known as 'commoditisation'.

The combination of a commoditised market and chronic over-supply are undoubtedly creating a challenging operating environment for the global fertilizer industry currently. Such trading conditions tend to depress profitability and increase consolidation. In a commoditised market, competitive advantage mainly comes from operational efficiency – achieved through the pursuit of production integration and lower raw material, production and distribution costs.

But current market conditions are also creating opportunities. One widely-adopted strategy for securing longer-term business success, for example, involves shifting portfolios away from commodities to higher value-added products with lower nutrient losses and less of an environmental impact.

In this article, we argue that traditional low-cost, commodity-based producers can radically improve the profitability of their existing businesses by making changes to their sales and marketing strategy. This will be necessary if they are to secure a sustainable, profitable market position and wish to compete more effectively against the better differentiated business models being adopted by some North American and European producers, many of whom are increasingly well-integrated down the value chain.

In particular, we are proposing a successful and proven business strategy based on improved customer focus. This aims to maintain existing cost leadership advantages while moving closer to a differentiated market position. In this article, we advocate the pursuit of downstream value chain integration in combination with Customer Value Management (CVM) to achieve this transformation.

Customer Value Management (CVM)

Customer Value Management (CVM) is a proven, proprietary business model. For more than 30 years now, CVM has delivered impressive results for many major multinationals and leading global players in a variety of business-to-business sectors and markets. Examples of its adoption range from mining, minerals and oil, to construction materials, chemicals and plastics, engineered and manufactured products. Many companies in these sectors have faced similar challenges to those being experienced by today's fertilizer producers – such as increasing competition, diminishing cost advantages and commoditisation pressures.

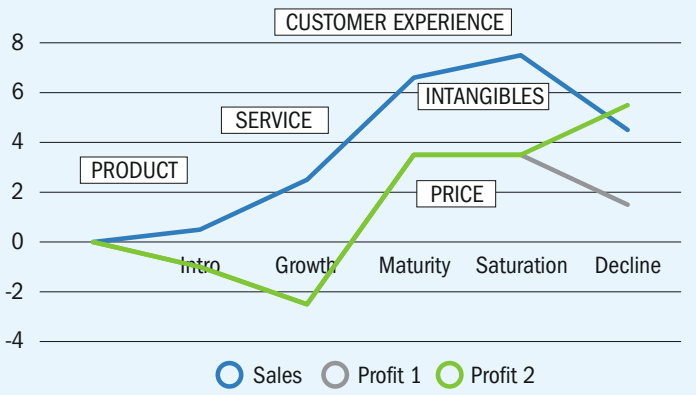
By adopting a proven CVM approach, companies in other sectors have improved their market position and created sustainable, profitable growth. This transformation in business fortunes has often taken place in undifferentiated commodity markets similar to the current fertilizer sales environment.

CVM is a unique approach to business management, marketing and sales. It is driven by a relentless focus on customers: what they need and value most; what drives their buying decisions; and how and why they choose suppliers. The ultimate and critical success factor in CVM is a complete and detailed understanding of what customers are willing to pay for.

Over the years, CVM has had a positive impact on the quality of a number of businesses. It has been shown to improve profitability, secure a better market position and achieve sustainable, profitable growth. It does this by creating within companies new skills, new perspectives and a new mind-set for marketing and sales.

CVM can certainly offer fertilizer producers greater insight into the needs of their customers and what drives value within their business. Initially, this requires in-depth analysis of the fertilizer value chain, and how customers are segmented based on their buying behaviours. Ultimately, by adopting CVM, fertilizer producers will be able to implement a value-based pricing strategy – one that differentiates and tailors their market offerings to match the needs of target customer segments.

Fig. 1: **Key differentiators in the market life cycle of products: customer experience based on product, service, price etc.***



** Price pressures eventually lead to decline in profit (Profit 1) unless a value-based strategy is adopted to fully leverage 'intangibles' such as brand image (Profit 2).*

Source: CVM€/Nexant

Fig. 2: **The differential pricing of products: value-based approach to the pricing of commodity chemicals.**

VALUE PRICE reflects the value of the offering

=

INTANGIBLES sustainable differentiation

+

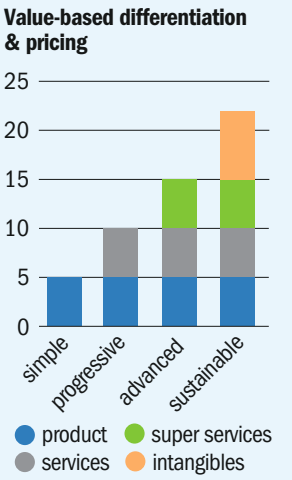
SUPER SERVICES advanced differentiation

+

SERVICES progressive differentiation

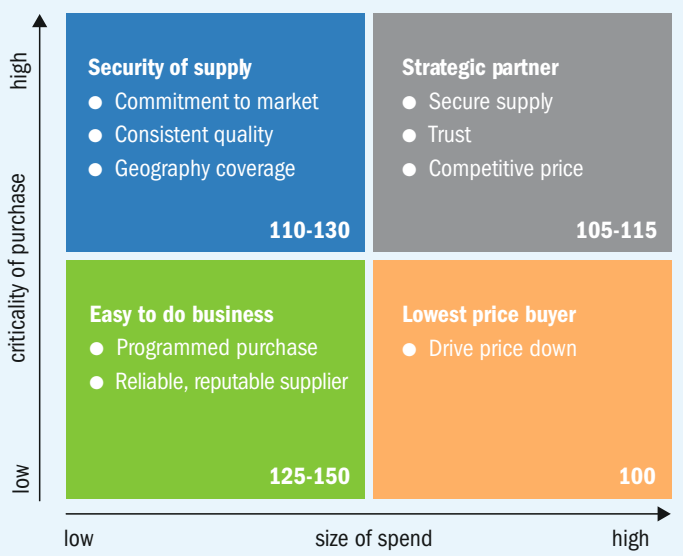
+

PRODUCTS simple differentiation



Source: CVM€/Nexant

Fig. 3: **Customer needs/buying behaviour and willingness to pay: four main segments based on how critical the purchase is versus the size of the spend.**



Example for a commodity chemical producer

CVM uncovered differences in willingness to pay for certain product offerings based on the needs of four distinct customer segments. This led to the producer adopting a value-based pricing strategy. This was supported by a CVM marketing and sales strategy underpinned by differentiated value propositions. Key segments were:

- **Strategic Partner** customers were willing to pay a 5-15% premium over Lowest Price Buyers for the benefits of an offering fulfilling their needs.
- **Security of Supply** customers were willing to pay a 10-30% premium over Lowest Price Buyers for the benefits of an offering fulfilling their needs.
- **Easy to do Business** customers were willing to pay a 25-50% premium over Lowest Price Buyers for the benefits of an offering fulfilling their needs.

Source: CVM€/Nexant

Product-market life cycle

The product-market life cycle, although a powerful predictive model for CVM, is regrettably under-used in business-to-business marketing. It describes an inevitable evolution followed by every product in every market. (It's just a matter of time!). For any manufacturer, finding where you are currently positioned in the life cycle enables you to forecast where your product and business is heading, and set your strategy accordingly.

How products are differentiated changes as a company moves through the product-market life cycle (Figure 1):

- Suppliers entering a new product-market enjoy an initial differentiation based around the product and its performance
- As competitors bring similar products into the market, they need to shift their differentiation emphasis – typically towards value-added services.
- Price eventually becomes the prime differentiator, all too easily, as the market matures and offerings become more comparable and commoditised.

However, this cycle can be broken, through the adoption of CVM strategies. These enable commoditisation and pricing pressures to be avoided by using valued 'intangibles' such as reputation (brand image), reliability, responsiveness, relationship and trust to differentiate your product portfolio. This CVM-based approach delivers sustainable and profitable growth based on strong differentiation in the offering ('value proposition') and value-based pricing strategies (Figure 2).

Differentiation in commodity markets

Many firmly believe that commoditisation is an inevitable outcome when moving through the product-market life cycle. However CVM demonstrates that this need not be the case. CVM strategies enable business-to-business companies to sustainably differentiate their products in undifferenti-

ated commodity markets. This is achieved by identifying and offering other value-creating elements beyond the product.

Here is an example where a leading commodity chemical producer used CVM to achieve differential pricing in a highly competitive and commoditised market – with more than 10 competing producers – by identifying segments based on customer needs, buying behaviour and value-drivers (Figure 3).

The implementation of a CVM strategy has improved the bottom line of this producer by millions of euros annually over the last ten years. The CVM strategy also delivered a return on their original investment in CVM within 18 months.

CVM and the fertilizer industry

Downstream integration is becoming increasingly common within the fertilizer sector. It shows how far down the value chain a company has moved from its origins as a producer and how close it is to the ultimate end-user, usually the retailer or the farmer. A company's position in the value-chain also reveals whether it has pursued a product-push or market-pull strategy.

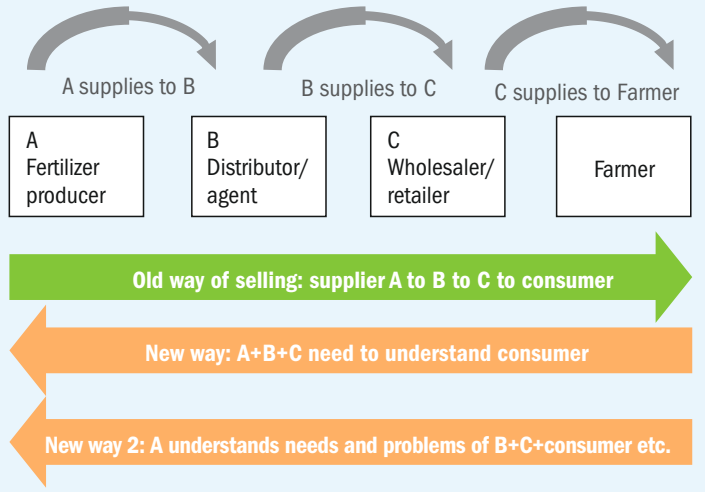
Many fertilizer companies in the Middle East and elsewhere have benefitted from a comfortable cost position over several years. In the main, the region's traditional low-cost producers have felt it unnecessary to venture downstream beyond distribution networks. Instead, they have largely focussed on efficiently managing their operations, extracting mineral resources and securing feedstocks. While they may distribute to wholesalers, such producers are remote and largely isolated from the far end of the value chain. This can limit understanding and awareness of trends in agricultural end-markets, and increase business exposure to competition and commoditisation. It can also place customer loyalty and retention at risk.

Some fertilizer producers, who do not enjoy the advantages of a low-cost feedstock position, have moved away from the industry's traditional production-based business model. They have reacted to commoditisation and increased competition by seeking to understand the needs of customers throughout the whole fertilizer value chain – and have subsequently developed product offerings to address those needs, which create and capture more value.

This has led to companies integrating vertically both up and down the value chain. Greater integration has delivered operational synergies and savings. Importantly, it also brings about closer contact and collaboration between producers/suppliers higher up the value chain and their customers lower down the value chain. This process leads to a deeper understanding of the needs of customers, and provides insights into how new offerings can be developed to fulfil such needs. This ultimately leads to the realisation that being closer to the final customer – and the better understanding of the end-market this brings – enables more value to be created and captured (Figure 4).

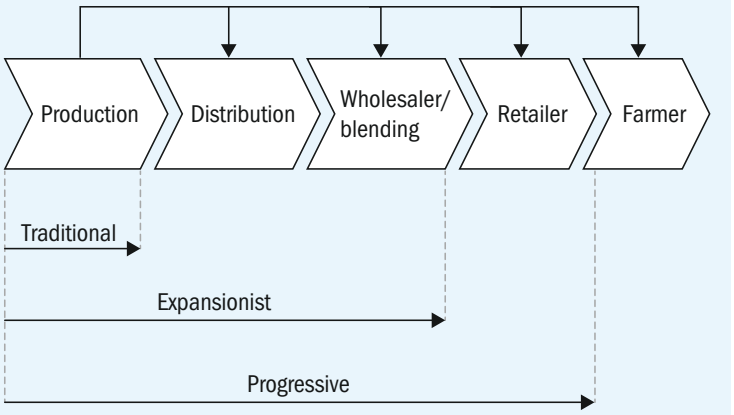
In CVM, the customer is defined very broadly. It can mean any player in the value chain who, directly or indirectly, purchases (or influences the purchase of) your products and services. This serves to create a much greater understanding and appreciation of where value can be created and captured. In the fertilizer value chain, this means taking into account the needs of

Fig. 4: **Shifting to a customer-centric approach and value-creation.***



** Taking account of the needs of distributors/ agents, wholesalers/retailers and the farmer.* *Source: CVMf/Nexant*

Fig. 5: **Three value-chain strategies based on integration: traditional[1], expansionist[2], progressive/enlightened[3].**



1. Non-integrated, production only
2. Partly integrated
3. Full value-chain integration

Source: CVM€/Nexant

– and what drives value for – distributors, agents, blenders, wholesalers, retailers and farmers. It also means being alert to groups who wield external influence such as governments, legislators, environmentalists and business lobbyists.

The pressures of cost, competition and commoditisation are high and relentless in the fertilizer market. These pressures will affect traditional, production-based companies the most intensely. Other companies have sought to alleviate these pressures by getting closer to the farmer, typically by expanding downstream into distribution, blending and wholesale activities. The most progressive companies have even gone one stage further by adopting a more enlightened and customer-driven CVM approach, in a bid to understand and directly cater to the needs of retailers and farmers (Figure 5).

Some companies are already operating at farmer- and retail-level in the market – and are finding success with such strategies. Yara, for example, is present across the entire value chain from production to trading to direct farmer support. Yara's innovative business model has achieved very close customer proximity by offering farmers a comprehensive package of agronomic products, services and tools. The company, by understanding farmers and their needs, has the knowledge and insight to develop relevant services and create a strong market pull for its products.

We highly recommend CVM to other industry players wishing to follow Yara's lead and break out of the 'commoditisation trap' – by developing and adopting similar enlightened and progressive strategies. When it comes to fulfilling the needs of customers throughout the whole value chain, CVM provides a clear way forward and provides a sound basis for building more sustainable and profitable growth.

CVM does demand a complete change of thinking and a different mind-set. In particular, it demands answers to a number of critical questions:

- How do you **create** value for your customers **today**?
- How could you **create** value for your customers in the **future**?
- How do you **quantify** value to the customer?
- Do you **understand** your customers' business and their view of the world well enough to be able to quantify value from their perspective?
- How do you **differentiate** the value you have created to your customers?
- Do you know what differentiates your offerings from those of your **competitors**?
- Do you **communicate** that differentiation effectively to those customers? (Different customer segments have different needs!)
- How do you **capture** your fair share of the value you have created for your customers?
- Do you have a pricing **strategy** that reflects the value you create for your customers?
- Does your pricing reflect the **value** that you have created for your customer – or are you under-pricing?

All of the above questions can be answered by adopting a CVM approach in your business.

Conclusions

Cost pressures and over-supply in the fertilizer market are making the future of existing commodity-based business models look increasingly uncertain. Some European and North American fertilizer producers have already taken a step up the value ladder using Customer Value Management (CVM). Producers in the Middle East and other regions need to be hot on their heels!

CVM has brought significant success and delivered profit growth to businesses in similar highly competitive, cost-pressured and commoditised markets. CVM enables companies to build a stronger market position and develop more enlightened marketing, sales and pricing strategies – based on customer needs and value-drivers.

We contend that CVM can create more sustainable, profitable growth for your fertilizer business – by providing you with the capabilities, creativity, confidence and courage to transform your business and market position. We are ready and able to advise you and demonstrate how to bring about this transformation.

GPCA Fertilizer Convention

Nexant and CVM€ will be delivering a workshop on the benefits of applying CVM to fertilizer businesses at the GPCA Fertilizer Convention in Oman on Tuesday 18th September. The workshop will be co-led by Phil Allen, CEO, Customer Value Management GmbH, and Dr Dimitrios Dimitriou, fertilizers sector lead, and Mr. Thomas Heinrich, senior consultant, at Nexant Limited.

Uniting the micro with the macro

MDS Zinc with added blue dye applied in a batch blender to an NPK blend.

Plant nutrients work best together in unison. To maximise crop yields, a wide spectrum of nutrients needs to be delivered in the right place at the right time in the right macro and micro amounts. The innovative micronutrient delivery system (MDS) from Omex Agrifluids does this by applying and keeping macronutrients and micronutrients together, as agronomist **Dr Terry Mabbett** explains.

Crops fertilization involves the application of larger amounts of macronutrients and smaller amounts of micronutrients. Mixing micronutrients evenly and in the correct proportions with macronutrients remains a technical challenge, due to the disparities in the amounts required by crops.

Traditionally, micronutrients are incorporated during fertilizer blending. Granular fertilizers containing primary nutrients (N, P and K), such as urea, MAP (monoammonium phosphate) and MOP (muriate of potash), are typically blended with dry powder formulations containing one or more micronutrients.

But this approach can fail to overcome a basic drawback: if the two classes of nutrient – the micro and the micro – are unevenly dispersed and separated in the blended end-product they will remain separate when delivered to root zones in the soil. Furthermore, the blending process can never guarantee that the micronutrient formulation will be completely uniformly distributed over each granule and between different granules. Because of this, there can be a tendency to add too much micronutrient powder during blending at needless extra cost.

Micronutrient delivery system (MDS)

The highly-innovative and proprietary micronutrient delivery system (MDS) developed and marketed by Omex Agrifluids works very differently. The MDS coats granular N, P and K fertilizers with a custom-designed fluid micronutrient formulation. The end result is an integrated, uniform product that keeps all of the nutrient components, both macro and micro, in close physical proximity and functional contact. With MDS, not only are macronutrients and micronutrients blended together, they are also applied together and stay together in the soil – especially in the root zone where they are most required.

Omex manufactures and markets a range of concentrated MDS aqueous-based suspensions for coating granular fertilizers with essential micronutrients (Table 1).

Boron (B), copper (Cu), manganese (Mn) and zinc (Zn) are among the key essential plant micronutrients required for rapid, robust and healthy plant growth. Well-structured and healthy soils will provide a full spectrum of essential plant micronutrients. But modern intensive farming invariably depletes plant-available micronutrients. These therefore need to be periodically replenished to maintain consistently high yields during continuous cropping.

Omex's MDS coats every single fertilizer granule with exactly the right amount of micronutrient fluid. This results in a uniform distribution of micronutrients in the blended product, delivering a correspondingly even application of micronutrients across the field. This helps guarantee the supply and availability of micronutrients to each and every plant, from the earliest stages of crop growth onwards.

Table 1: **The MDS product range from OMEX Agrifluids**

Product		Micronutrient content	
	Element	**w/w %**	**g/litre**
MDS Boron	B	8.4	125
MDS Copper	Cu	50.0	1,000
MDS Iron	Fe	20.3	300
MDS Manganese	Mn	27.5	500
MDS Selenium	Se	1.1	12.5
MDS Zinc	Zn	47.6	980
MDS ZB	B	8.0	125
	Zn	16.0	250
MDS ZMB	B	5.2	100
	Mn	8.7	167
	Zn	17.3	334

Notes: MDS Calcium and MDS Magnesium also available.
Multi-element mixtures can be tailor-made to suit specific crop requirements *Source: Omex*

Sound theory, good practice

Omex Agrifluids is a UK-based leader in soluble plant nutrient technology. To learn more about the company's novel and innovative micronutrient coating technology, I travelled to its headquarters in the ancient town of Kings Lynn, Norfolk, in Eastern England.

I was there to speak to Andrew Lawrence, Omex's fertilizer coatings export manager. Andrew oversees the company's research and development, field trials and the marketing of the micronutrient delivery system (MDS). Also present were Peter Prentis, the company's joint managing director, and Alan Lowes, regional director. Peter looks after the sales and marketing of the company's product range in Europe, the Middle East and Asia, while Alan has the same responsibilities for the Americas and Africa.

MDS is applied to fertilizer granules in the final stage of blending. I asked Andrew Lawrence which types of granular N, P and K fertilizers can benefit from the MDS coating process. "The widest possible range – including products like urea, and DAP (diammonium phosphate) – as well as the broadest range of blended formulations too," he replies.

Andrew went on to explain the potential advantages of the MDS over traditional systems based on solid powder formulations. In his view, Omex's aqueous-based suspensions are also superior to oil-based suspensions on many important counts. "MDS offers distinct advantages," says Andrew, "whether you are considering availability of nutrients to plant roots, operator safety during handling, or the integrity of the environment, including soil structure."

So how much MDS coating is needed in the blending process? Andrew Lawrence says Omex can coat at a rate of up to 10 litres per tonne of fertilizer granules, although in practice coating rates of around 3-5 l/t have proved sufficient to achieve the desired agronomic results.

"Customers can ask Omex for whatever combination of fertilizer granule and micronutrient mixture they want. This will clearly depend on a series of factors, including crop type, stage of growth, as well as particular soil problems such as zinc fixation," says Andrew.

Omex can manufacture custom-made formulations tailored to specific user requirements. For example, MDS CZS (250 g Cu, 250 g Zn & 10 g Se per litre) and MDS ZB 51 (500 g Zn & 100 g B per litre) have been developed for buyers in Belgium and Zambia, respectively.

Worldwide crop trials

I asked Andrew about Omex's global agronomic trials. The two standard micronutrient mixtures (Zn+B and Zn+Mn+B) applied to Canadian spring wheat have become a particularly important focus for the MDS.

"Ongoing trials in Manitoba are coating MAP granules with Zn, Mn, B and Cu micronutrients in all combinations," says Andrew. "The Canadian prairie has a severe winter and relatively short growing season, with wheat sown into recently frozen soils. It is therefore crucial to have the required package of micronutrients in place, together with phosphate from the MAP, for fast root growth and development as soon as the soil warms up."

In these Canadian trials, MDS-coated MAP produced higher wheat grain yields than uncoated MAP, generating a larger net return for farmers. Laboratory tests also showed that wheat plants from MDS-treated fields contained higher levels of applied micronutrients, compared with plants from fields where only MAP was applied. "This clearly demonstrates that the MDS-applied micronutrients were readily available and accessible to the wheat crop," says Andrew Lawrence.

Crop trials in Asia are another agronomic priority for Omex. So far, the MDS has been evaluated on paddy rice in Sri Lanka and maize (corn) in Shandong province in China. In an initial paddy rice trial in Sri Lanka, Omex's MDS Zn product was used to separately coat nitrogen and phosphate fertilizers. These were then applied according to government recommendations. A follow-up Sri Lankan paddy trial then compared two types of MDS-coated urea (MDS Zn and MDS Mixture) with an untreated urea control. Maize trials in China are also looking at a range of MDS coatings on various types of fertilizer granules.

In the first Sri Lanka paddy rice trial, MDS Zn out-performed the standard fertilizer on yield. Similarly, MDS Zn also out-performed the standard fertilizer plus zinc sulphate recommendation on paddy rice. The biggest yield increase was obtained using two split applications of MDS Zn: two litres with the base fertilizer and another two litres with the first application of urea. This treatment improved yield responses by 7.2 percent and 6.3 percent, respectively, compared to standard fertilizer without zinc and standard fertilizer plus zinc sulphate. These yield responses were equivalent to respective rice grain yield increases of 0.49 t/ha and 0.44 t/ha.

Results from the second paddy rice trial were even more impressive. Treating urea with MDS Zn and MDS Mixture boosted rice grain yields by 6.46 percent and 14.21 percent, respectively, in comparison to the untreated urea control.

Commenting on Omex's agronomic R&D work with MDS on maize in China, Andrew says: "We are coating two separate NPK blends (17-17-17 and 20-10-11) with a zinc + boron MDS mixture at two different application rates, two litres per tonne and four litres per tonne."

Omex is also evaluating MDS on other field crops in different parts of the world currently, including trials on soybean in Brazil.

Coating at any scale

A wide range of customers can benefit from Omex's novel and innovative micronutrient coating technology. The MDS has proved to be highly versatile and extremely adaptable, no matter what the scale. It is suitable for bulk blending systems operated by large international companies or for on-farm enterprises, explains Andrew Lawrence.

"Large manufacturers use a range of blending equipment, including batch and diminishing weight systems," says Andrew. "While, at the other end of the scale, small village dealerships, cooperatives or individual farmers might use a cement mixer."

In a cement mixer, a 50 kg bag of base fertilizer such as urea is simply poured in followed by 75-200 ml of the liquid coating formulation added from a small bottle. Alternatively, the required volume of coating liquid can be injected into the mouth of the cement mixer using a syringe. Mixing time can be as little 30 seconds, depending on local conditions. Production rates using a cement mixer can range from 60 to 400 tonnes per hour. The finished product is generally loaded into 50 kg- to 1,000 kg-size bags or onto trucks in bulk.

Advantages of MDS

The MDS offers the following advantages, according to Omex:

- It distributes micronutrients uniformly over N, P and K fertilizer granules. This results in even, and therefore more accurate, placement of both macronutrients and micronutrients within the root zone.
- Placing macronutrients and micronutrients in the same place, at the same time, and in such close proximity, creates synergistic effects. This allows two or more nutrients to work in unison to accelerate and fortify plant growth and development.
- The paint-like aqueous fluid used in the MDS is a highly-adaptable formulation suitable for the bulk blending systems used by big fertilizer manufacturers or the on-farm cement mixers used by single growers.
- The MDS optimises plant nutrient use, benefitting both farmer incomes and the environment. Accurate placement of plant-available nutrients, and timely applications, promote rapid and efficient root uptake. Excess nutrients are not left to upset the soil balance or be lost to ground or surface waters.

Omex have taken their acknowledged expertise in industrial liquid formulations and adapted this to the efficient fertilization of commercial crops. The company's micronutrient delivery system (MDS) is an innovative and forward-looking technology. Omex have used their technical know-how to develop a practical, affordable system for introducing micronutrients during fertilizer blending – one that overcomes many of the potential pitfalls.

The MDS helps to address concerns about excess agrichemicals in the environment. At the same time, results of global crop trials also show that the MDS can deliver a cost saving to farmers by improving nutrient use efficiency and boosting yields.

Wave goodbye to sulphur melter emissions

The MECS® *DynaWave*® scrubber from DuPont Clean Technologies is an innovative yet surprisingly simple solution for reducing sulphur melter emissions. **Yves Herssens**, global licensing manager, scrubbing technologies, DuPont Clean Technologies, explains more in this case study of an installation at The Mosaic Company's New Wales site in Florida.

Globally, the vast majority of sulphur used to produce sulphuric acid is shipped in solid form, either as bulk granules or prills. It is then melted and filtered by end-users at sulphuric acid plants prior to use.

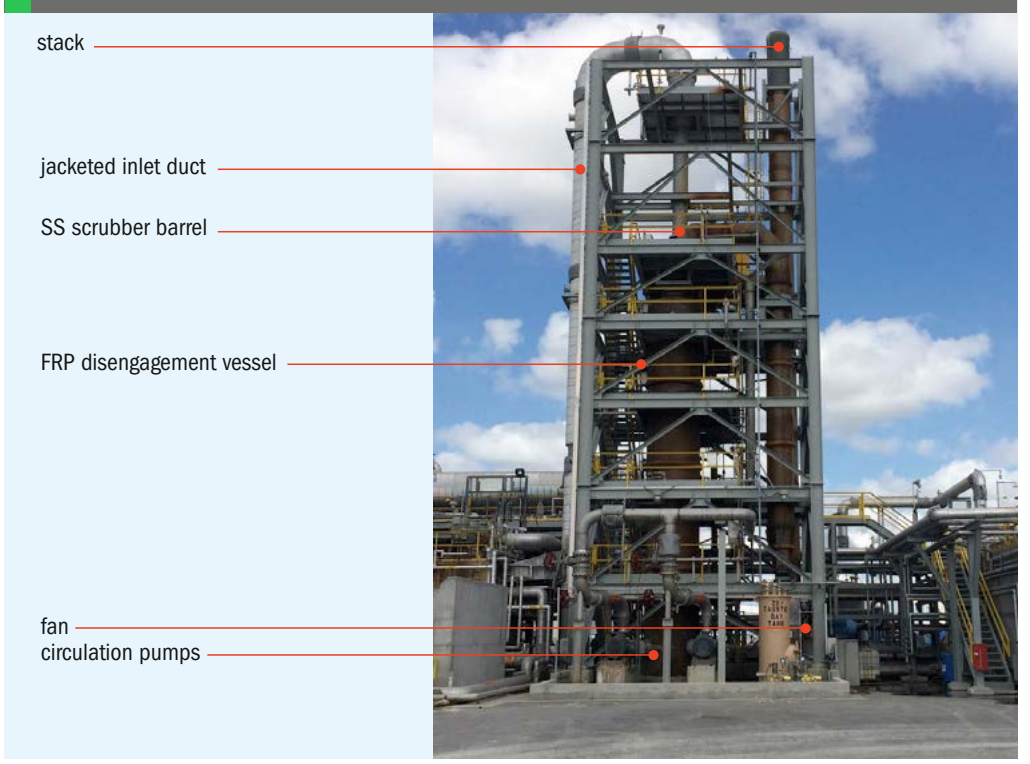
Melting solid sulphur is a relatively straightforward process. But the agitation and heating involved causes the release of dissolved sulphur dioxide (SO_2) and hydrogen sulphide (H_2S), along with sulphur vapour that condenses into fine dust. The low odour threshold for SO_2 and H_2S (below one ppm) means emissions can easily create an odour nuisance and prompt health concerns, even when emissions levels are relatively low. Sulphur's vivid yellow colour also makes any dust emissions highly visible, and the subject of unwanted attention from people living nearby.

For many years, the potential environmental and health nuisances associated with sulphur melting were generally tolerated simply because no single, straightforward, proven solution was available. But that changed in 2016 when The Mosaic Company started up the new one million t/a capacity sulphur melting unit at its New Wales site in Florida. This incorporated a *DynaWave*® scrubber, an innovative and highly-efficient new scrubbing technology developed by DuPont Clean Technologies.

The MECS® *DynaWave*® scrubber

This large-capacity melter unit at New Wales connects sulphur melter, precoat and clean sulphur tanks to a steam-jacketed manifold system. All of the SO_2, H_2S and dust collected from these tanks are directed to the MECS® *DynaWave*® scrubber. An installed fan maintains a slightly negative pressure on every tank vent. This collects and routes all of the SO_2, H_2S, and steam through the *DynaWave*® system (Figure 1) where emissions are scrubbed to very low levels before final venting to the atmosphere.

Fig. 1: **MECS® *DynaWave*® scrubber at Mosaic's New Wales site, Florida**



The key to *DynaWave*®'s success is the incorporation of froth technology. Very high removal efficiencies for fine sulphur particulates are achieved by a highly-turbulent and energetic froth zone within the scrubber. This froth zone also provides the intense mixing necessary for SO_2 and H_2S absorption.

A zero discharge system

The MECS® *DynaWave*® scrubber converts absorbed SO_2 and H_2S into a stable and benign sodium sulphate by-product via a reaction with caustic soda and a chemical oxidant. Forced-air oxidation of H_2S is very slow, so a chemical oxidant was required to convert H_2S into a stable sulphate compound. The conversion chemistry is as follows:

$$SO_2 + H_2O \rightarrow H_2^{2+} + SO_3^{2-} + 2NaOH \rightarrow NaHSO_3 / Na_2SO_3 + \text{oxidant} \rightarrow Na_2SO_4$$

$$H_2S + H_2O \rightarrow H_3O^+ + HS^- + 2NaOH \rightarrow NaHS / Na_2S + \text{oxidant} \rightarrow Na_2SO_4$$

The scrubber consequently produces a small by-product stream of sulphates and suspended sulphur particulates. Overall, the MECS®' *DynaWave*® scrubber is a zero-wastewater discharge system, as this by-product stream is reused in an upstream process.

Problem solving on start-up

As is often the case during commissioning, the scrubber initially experienced a few unexpected and challenging technical problems when melting first commenced in late 2016. The first issue was a loss of level indication. This was caused by the hydrophobic nature of ultra-fine sulphur particulates. The sulphur tended to float on top of the scrubber liquor – because it would not wet – so interfering with the guided wave radar level indicator. These hydrophobic sulphur particulates are shown in Figure 2. As can been seen, they appear to be dry and are floating on top of the water even though they are much denser (1.8 specific gravity).

After some experimentation, a suitable surfactant was identified to wet and disperse sulphur particulates in the scrubber liquor. A defoamer also needed to be added to stop the surfactant from foaming and causing cavitation in the circulation pumps. Once this problem was overcome, the level indicator functioned normally and scrubber level control was restored.

A second start-up issue was higher-than-expected reagent usage. Perplexingly, reagent consumption was much greater than could be accounted for by the concentration of incoming acid gases. After some research, the disproportionation reaction was identified as the most probable cause for this. Disproportionation involves the simultaneous oxidation and reduction of sulphur by water to yield two reaction products:

$$3S + 2H_2O \rightarrow 2H_2S + SO_2$$

The ratio of oxidiser to NaOH was three times greater than expected, based on the amount of acid gases entering the scrubber. The stoichiometry of the disproportionation reaction (above) accounts for nearly all of this disparity. That led to the conclusion that the disproportionation reaction was the only logical cause.

Fig. 2: Hydrophobic sulphur particulates floating in scrubbing liquor

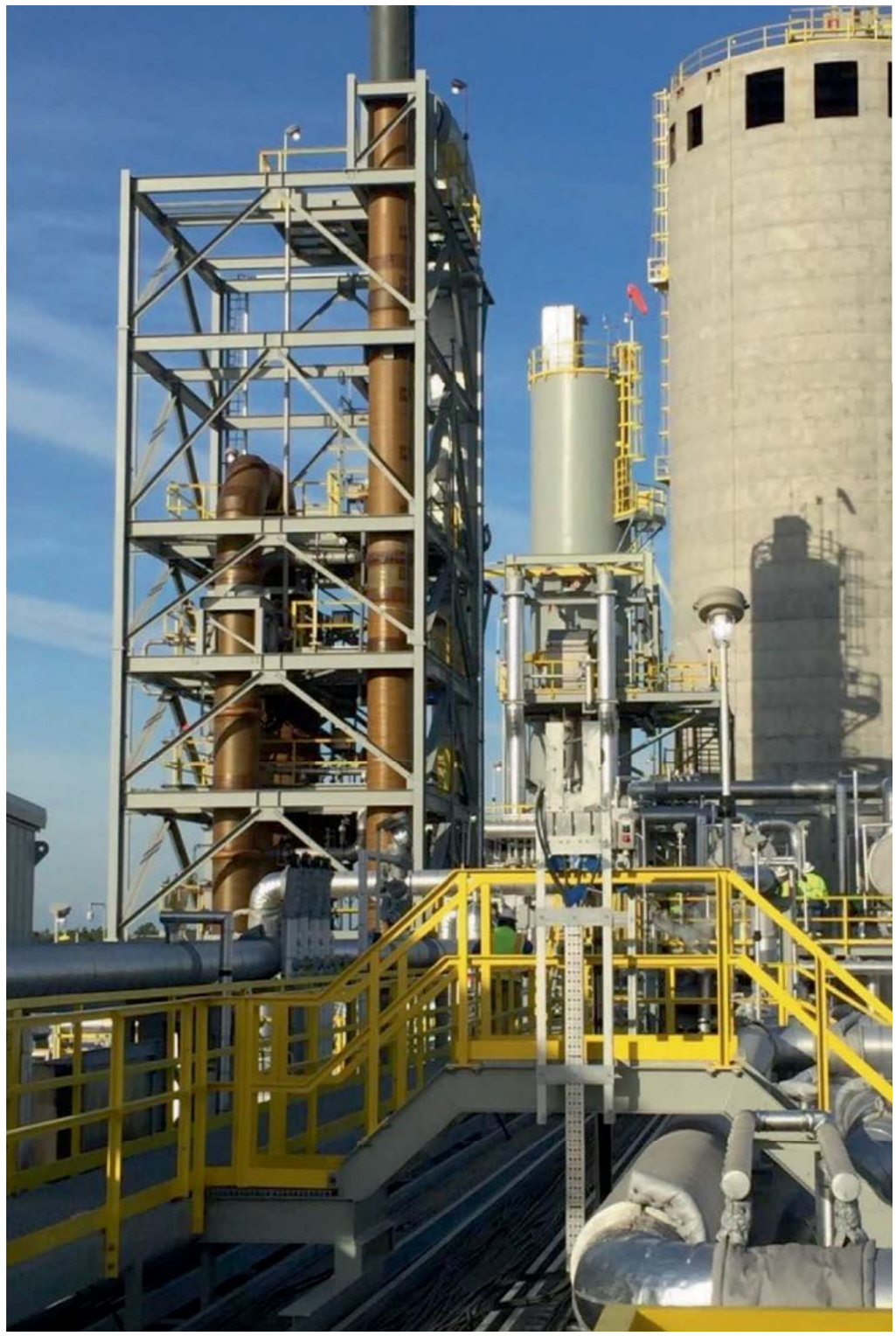


Fig. 3: Small scrubber plot requirement integrates well within the overall melter layout plan.

An operational success

The scrubber performance was tested once again, after the two start-up issues were fully understood and resolved, and was found to exceed all of the design expectations. During the operation of the melter, gas discharged to the stack contains <1 mg/SCF (<25 mg/Nm^3) of sulphur particulates and <5 ppm of SO_2 and H_2S. Also, the stack plume is completely clear, once the water vapour dissipates, with no visible particle emissions.

In summary, installation of the innovative MECS® *DynaWave*® scrubber at Mosaic's new large-scale sulphur melter at the New Wales site has proved to be an operational success. The melter now produces clean molten sulphur, while operating at modest cost, with minimal impact on the surrounding area and the environment. As this case study demonstrates, sulphur melter scrubbers have truly come of age. ■

Sulphur supply shifts east

Most of the new sulphur supply capacity expected globally over the next few years will come from a rise in sour gas production. New projects are concentrated in the Middle East, Central Asia and China. We review major new sulphur recovery projects in these three regions.

The rise of sour gas

Sour gas processing has transformed how sulphur is supplied and where it is sourced from. In recent times, it has resulted in a wholesale shift in sulphur production, away from direct Frasch mining of underground sulphur deposits towards the involuntary production of sulphur recovered from natural gas. Sour gas processing originated in western Canada and the United States. While Canadian sour gas production has declined in recent decades – as fields have matured and production has been undercut by cheaper US shale gas – sulphur extraction expertise and technology has been enthusiastically adopted by other global regions.

Concentrated production

Sour gas production is currently concentrated in three main regions: the Middle East, Central Asia and China.

In the Middle East, the main driver has been rapidly rising gas consumption and demand needed to generate power for fast-growing populations and cities in countries such as Saudi Arabia and the United Arab Emirates (UAE). Most of the region's domestic gas production generally comes from associated gas – and is therefore constrained by OPEC oil quotas. Sour gas production, in contrast, is decoupled from oil, being driven by the development of non-associated gas fields in Saudi Arabia, Abu Dhabi and Oman, most of which are sour.

In Central Asia, sour gas extraction is mainly from associated gas fields, and has largely been a secondary consequence of an expansion in oil and condensate production. This has generally made sour gas processing incidental to the main drive for greater oil production in this region.

Gas demand in China – similar to the Middle East – far outstrips supply. To meet the gap, China has turned to unconventional gas of all types –shale gas, tight gas, and coalbed methane – as well as sour gas production. As an added benefit, any sulphur extracted during sour gas processing helps to meet the large sulphur supply needs of China's phosphate fertilizer producers. China is currently the world's largest sulphur importer, importing more than 11 million tonnes of sulphur last year (*Sulphur* 377, p20).

Major sour gas project developments in the Middle East, Central Asia and China are reviewed below.

Abu Dhabi

Much of the Arabian Gulf has highly- or moderately-sour offshore gas reserves. These fields are claimed by Saudi Arabia, Iran, Qatar and Abu Dhabi, but also extend under most of the western part of the United Arab Emirates (UAE) and into Oman in the east. Ample supplies of gas from sweeter reserves meant that most of these fields were left untapped for many years. But growing demand from the rapidly-expanding Saudi and UAE economies is now triggering widespread exploitation of these sour gas reserves.

The Emirate of Abu Dhabi has been the region's leading sour gas project developer. **Habshan** is home to Abu Dhabi's Integrated Gas Development. This processes offshore gas from Umm Shaif/Das Island, the Bab onshore oil field and non-associated sour gas from the Habshan fields. The addition of the Habshan V processing plant in 2013, by adding a further 5,200 t/d of capacity, raised the Habshan site's total sulphur capacity to above 10,000 t/d.

The **Shah** project, a $10 billion joint venture between Adnoc (60%) and Occidental (40%), is located at an onshore sour gas field deep in the Arabian desert, more than 200 kilometres southwest of Abu Dhabi city. Shah's 20-30 tcf reserves have an H_2S content of 23 percent and a CO_2 content of 10 percent. Shah came on-stream in 2015 and at full capacity it processes almost 1 bcf/d of sour gas extracted from wells to produce 540 million scf/d (5.2 bcm/year) of sales gas. The project's sulphur production capacity is in excess of 9,200 t/d (3.1 million t/a). Shah's production is also due to be expanded by 50 percent by 2021, taking its total gas processing capacity to 1.5 bcf/d. A further expansion at the site beyond this date could eventually raise gas processing capacity to 2.0 bcf/d by circa 2026. These two expansion stages would increase sulphur output to 4.5 million t/a and 6 million t/a, respectively. Wood Group (Amec Foster Wheeler) is currently tasked with carrying out design work on the first stage.

In contrast, the **Bab** project to develop another onshore field 120 kilometres southwest of Abu Dhabi has stalled in recent years. Bab was originally conceived as a mirror of the Shah project, with Shell as the joint venture partner instead of Occidental. However, Bab's development was placed on the back burner following Shell's withdrawal in January 2016, with Shah's expansion taking precedence instead. The Bab field has a CO_2 content of 15 percent and H_2S content of between 15-50 percent. Bab's gas is also condensate-rich which, it was hoped, should offset the field's higher production costs.

The **Hail/Ghasha** fields are located offshore 100 kilometres to the west of Abu Dhabi city. Adnoc has appointed Al Hosn Gas to appraise and develop the project, with a front-end engineering design (FEED) tender being issued in November 2016. A production target of 1 bcf/d gas has been set (at 15 percent H_2S content), yielding around 400-600 million scf/d of sales gas. Developments costs are higher than for the Shah project because the fields are offshore, albeit in shallow water only 15 metres deep, although the proportion of sales gas recovered is greater due to their lower H_2S level.

Qatar

The enormous **North Field** straddles the Arabian Gulf. Qatar brings gas from the field ashore at its massive Ras Laffan complex on the northern tip of the Qatar peninsula. Gas is processed for use in the massive Pearl and Oryx gas-to-liquid plants at the site, as well as for LNG export via the Dolphin pipeline to the UAE. Rasgas and Qatargas together export 77 million t/a of LNG, making Qatar the largest LNG producer in the world. Sulphur recovered from all of these Qatari facilities is sent to the Common Sulphur Facility where it is formed and exported. Total sulphur recovery and forming capacity is approximately four million t/a, although actual production of 2.2 million tonnes in 2015 fell well short of this.

Qatar has blocked new gas developments for several years now, as it attempts to manage its existing gas supplies, and pending the development of the $10.4 billion **Barzan** LNG project. Barzan is owned and operated by state producer Rasgas. The long-delayed project has yet to enter production after a planned start-up last year was delayed by pipeline leaks. Under the project's first phase, six LNG trains will be fed by 1.7 billion scf/d of gas and condensate. Extraction will eventually ramp-up to 2.5 bcf/d by the project's third and final phase. When Barzan finally reaches capacity, the recovery of an additional 800,000 t/a of sulphur should increase Ras Laffan's total sulphur output to three million t/a. What impact the sanctions imposed on Qatar by Saudi Arabia, Kuwait, Bahrain and the UAE will have on Barzan's implementation and start-up remains unclear.

Saudi Arabia

The **Wasit** gas plant in neighbouring Saudi Arabia was built to process gas from the offshore non-associated **Arabiyah** and **Hasbah** sour gas fields. The plant has the capacity to process 2.5 billion scf/d of sour gas (4-8 percent H_2S content) and produce 1.7 billion scf/d of sales gas. Its sulphur recovery section has a total capacity of 4,800 t/d (1.6 million t/a). The plant became operative in 2016, reaching full production in July of that year.

Saudi Arabia's new **Fadhili** sour gas processing plant will start to process additional gas from the Kursaniyah and Hasbah sour gas fields in the near future. However, the plant's start-up was pushed back to the end of next year after its production target was increased to 2.5 billion scf/d. It is expected to produce 4,000 t/d (1.3 million t/a) of sulphur at full capacity.

Oman

Oman has two major sour gas processing projects. The first, **Yibal Khuff Sudair**, is a deep oil and associated sour gas field (three percent H_2S content) operated by Petroleum Development Oman (PDO). The company is majority-owned by the Omani government (60%), alongside stakes from its three partners, Shell (34%), Total (4%) and Partex (2%). The Khuff gas project incorporates a 85,000 t/a sulphur recovery plant that is due to be commissioned in 2019.

The other project, the **Rabab Harweel Integrated Project**, a joint venture between PDO and Petrofac, is due to start-up next year. However, during the first phase of the project, unprocessed sour gas from the Rabab gas field (2-3% H_2S) will be injected into the Harweel oil reservoir for enhanced oil recovery, and consequently no sulphur recovery or production is anticipated.

Iran

Iran's enormous, multistage **South Pars** project is located on the Persian side of the massive North Field. At 1,500 tcf, South Pars has the largest gas reserves in the world. Iran has been steadily progressing through the project's 29 phases, despite delays caused by international sanctions. All of these phases involve gas and condensate recovery, and many involve sulphur production. The H_2S content of the South Pars field is only 0.5-1.0 percent. But sulphur production should still be considerable due to the very large volumes of gas being processed. In 2016, Iran's total sulphur production from all sour gas sources was estimated at 1.3 million t/a, a total that is expected to rise to 1.8 million t/a by 2019.

Central Asia

The area of sour gas exploitation in Central Asia is mostly located in countries bordering the Caspian Sea – Russia to its west, Kazakhstan to its north and east – and a zone of sour oil and gas reserves extending south east into Turkmenistan and Uzbekistan. Onshore deposits in Russia and Kazakhstan are the most long-standing, with exploitation dating back to the 1980s. New exploration in the region, in contrast, has concentrated on North Caspian offshore reserves and Turkmenistan's onshore reserves

Russia

Russia operates two existing major sour gas processing plants. The first is at **Astrakhan** on the west side of the Caspian Sea. This processes highly sour gas (up to 25% H_2S) from the Gazprom-operated Krasnoyarsky gas/condensate field. Astrakhan's sulphur output of around 4.8 million t/a is mainly destined for export, and is responsible for most of Gazprom's sulphur production. Russia's second gas processing at **Orenburg** dates from the Soviet-era. The Orenburgm gas field has an average H_2S content of 2-6 percent and is processed to produce 1.5 bcf/d of sales gas. Sulphur production of 1.1 million t/d is mainly consumed domestically within Russia. Orenburg also processes production from the **Karachaganak** field across the Kazakhstan border. Karachaganak is operated by KPO, a consortium of Chevron-Texaco, Agip, BG, Lukoil and KazMunaiGaz.

Kazakhstan

The operating company TengizChevroil (TCO) processes associated gas from oil production at the **Tengiz** field, both offshore and onshore, on the northeast side of the Caspian Sea. TCO is a joint venture between Chevron (50%), ExxonMobil (25%), KazMunaiGaz (20%) and Russia's Lukoil (5%). H_2S content of extracted gas has varied considerably but has settled at around 16 percent. About 2.4 million tonnes of sulphur are recovered annually at Tengiz, even though some sour gas is reinjected to boost oil production. An expansion project is due to lift oil output from Tengiz from 600,000 bbl/d currently to 850,000 bbl/d by 2022. However, this is unlikely to result in extra sulphur production as the associated sour gas will be reinjected into the reservoir to enhance recovery. Although TCO has previously stockpiled large amounts of sulphur, these have been largely drawn down.

The huge and massively expensive $46 billion **Kashagan** project is Central Asia's largest and most significant new sour gas processing project. Kashagan is an extremely deep (4.2 kilometres), large and high-pressure offshore oilfield with associated sour gas (17% H_2S). The project is being developed by the North Caspian Operating Company (NCOC), a consortium led by Italy's Eni that partners ExxonMobil, Shell, Total, KazMunaiGaz, Inpex and CNPC. The long-delayed project initially came on-stream

CHINA SULPHUR MARKET INSIGHT

*A shift in China's sulphur market balance is set to reshape the international market, explains **Oliver Hatfield**, director of fertilizers at Integer Research. Integer's Beijing office has taken a deep dive into the fundamentals of the Chinese sulphur and sulphuric acid markets. The conclusions of their analysis are as follows.*

Influential player

Over the last few decades, China has become the sulphur market's most influential player. Supply from domestic production, although on the increase, has been greatly outstripped by rapidly increasing sulphur demand – primarily driven by the growth in its consumption as a raw material in processed phosphates production. The result has been a substantial rise in sulphur imports, which have reached 11 million tonnes p.a. in recent years, roughly equivalent to about a third of world sulphur trade. China's growing appetite for sulphur has been a key determinant of the tightness in the global sulphur market seen over most of the last decade.

Market changes

As we look forward, however, China's positive market influence is set to reverse. There are several reasons behind this:

- **Demand slowdown**. Firstly, after a period of rapid growth, the demand for sulphur from China's phosphates industry is starting to slow. The supply of phosphates from Chinese producers has now reached the point where the domestic market is saturated. At the same time, the emergence of exports from new low-cost phosphates capacity in Morocco and Saudi Arabia means Chinese phosphate exports now struggle to compete on the international market. As a consequence, China's wet process phosphoric acid production – having increased from seven million tonnes P_2O_5 in 2005 to nearly 17 million tonnes P_2O_5 in 2015 – has now gone into decline, falling back to just over 16 million tonnes P_2O_5.
- **Increasing sulphur supply**. We expect to see Chinese sulphur production (from oil and gas) grow from around six million tonnes in 2017 to reach nearly nine million tonnes by 2023. As already highlighted elsewhere in this article, China is pushing ahead with development of sour gas fields to meet the country's ravenous appetite for cleaner energy – a key feature of Chinese government's aggressive push to reduce pollution. China's expanding oil refining capacity – also partly linked to pollution reduction –will also lead to more sulphur production. Although new emissions control technology will undoubtedly help, increasing supply and consumption of lower sulphur fuel still holds the key when it comes to meeting China's new emissions limits.

Involuntary sulphuric acid

Furthermore, as we look ahead, developments in China's sulphuric acid industry are also expected to have a major impact on the sulphur market. A major increase in China's metals processing capacity will rapidly expand China's involuntary sulphuric acid production capabilities. China's copper refinery production, for example, will enter a period of rapid expansion during the next few years, with the country constructing 1.45 million t/a of refinery copper capacity. It is likely that this growth in by-product sulphuric acid will put voluntary virgin acid and co-produced pyrites-acid under pressure, particularly where there is significant competition between sources. Integer's market model indicates that China's smelter-based sulphuric acid production could increase by nearly 50 percent by 2023, to approach 50 million tonnes. An expansion in availability on this scale means that many Chinese virgin acid producers will find it more economic to procure involuntary sulphuric acid, instead of producing it in-house using sulphur as a raw material. Demand for sulphur will also therefore reduce due to the resulting acid substitution.

The net result

Overall, we think these various changes to the sulphur and sulphuric acid markets will trigger a substantial decline in Chinese sulphur imports over the next few years. Integer's analysis suggests that sulphur imports could drop to six million tonnes by 2023. That means sulphur suppliers elsewhere in Asia will no longer be able to rely on China to absorb their growing sulphur export availability. ■

in late 2013. But it was later shutdown to allow replacement of the entire double pipe system – this brings sour gas from wells located on an artificial island to the onshore processing plant – after it sufferied sour gas leaks and pipe corrosion. Difficult winter weather conditions and the high partial-pressure of H_2S have added to the project's problems. Oil production began again in late 2016, with sour gas being flared initially. However, Kashagan's 1.1 million t/a capacity sulphur recovery section did finally start-up in September 2017, a development that is expected to have a significant impact on sulphur market dynamics.

Turkmenistan

The **South Yolotan** reservoir in Turkmenistan has reserves of 700 tcf, according to some estimates, making it the world's second largest gas field – although not all of this volume is believed to be recoverable. The country also has a number of other smaller gas fields nearby, including Dauletabad and Shatlyk. The Galkynysh processing plant at South Yolotan came on-stream in September 2013. Galkynysh is currently operating at about half its full potential but should ultimately be capable of recovering 1.8 million t/a of sulphur from three billion scf/d of sour gas (H_2S content of 6%), once full capacity is achieved.

China

Most of China's sour gas fields are located in the southern province of Sichuan. The discovery and exploration of many of these fields began in the late 1990s and continued throughout the 2000s. Rapidly rising demand for natural gas in China has driven the large scale exploitation of these fields over the past few years, a development that is also dramatically transforming China's domestic sulphur supply and affecting its large import needs.

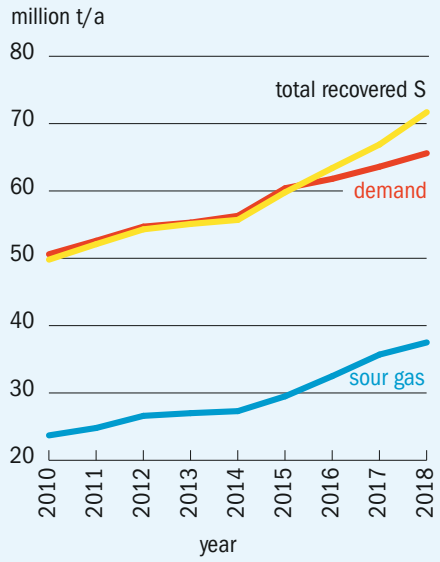
Puguang was the first sour gas field to be exploited in China. The field has 410 bcm of reserves with an H_2S content of around 15-17 percent. The Sinopec-operated sour gas processing plant at Puguang entered production in 2011. The plant has a maximum gas processing capacity of 1.2 bcf/d, equivalent to a sulphur output of 3.3 million t/a. However, Puguang is producing some two million t/a of sulphur, according to latest reports.

Yuanba, another Sinopec-operated gas field, is similar in size to Puguang –

Table 1: **New sour gas projects**

Project	Country	Sulphur output at capacity	On-stream date
Middle East			
Shah Expansion	Abu Dhabi	+1.6 million t/a	2021
Hail/Ghasha	Abu Dhabi	2.0 million t/a?	2022?
South Pars	Iran	+0.5 million t/a	2019
Ras Laffan	Qatar	+0.5 million t/a	2017
Wasit	Saudi Arabia	1.6 million t/a	2016
Fadhili	Saudi Arabia	1.3 million t/a?	2019
Khuff/RHIP	Oman	0.1 million t/a	2019
Central Asia			
Kashagan	Kazakhstan	1.1 million t/a	2017
South Yolotan	Turkmenistan	+0.9 million t/a	2020?
China			
Puguang	Sichuan	+1.3 million t/a	2019?
Chuandongbei	Sichuan	1.2 million t/a	2016-2019
Canada			
Various	Alberta/BC	- 0.5 million t/a	2016-2021

Fig. 1: **Sour gas as a proportion of total recovered sulphur**



Source: Sulphur magazine

estimates say 210 bcm – but extremely deep, averaging 6.7 kilometres in depth and below 7.5 kilometres in places. At five percent, Yuanba's H_2S content is also lower than at Puguang, but the field's high pressure places similarly severe demands on extraction and recovery equipment. Yuanba was developed in two phases, each with an equal gas processing capacity of 1.7 bcm/year. The first phase became operational at the end of 2014 and the second phase in late 2015. Both phases combined produce a total sulphur output of 300,000 t/a.

Chuandongbei is one of the few sour gas projects in China that involves a foreign partner. Chevron are developing the field with China National Petroleum Corp, with the two joint venture partners holding a 49 percent stake and 51 percent stake, respectively. Total proven reserves at Chuandongbei are put at 6.3 tcf, with H_2S content at between 7-11 percent. Chuandongbei is being developed in three phases. Gas will be initially extracted from the Luojiazhai and Gunziping fields during phase one, with gas extraction from the Tieshanpo and Dukhouhe-Quilibei fields adding to project supplies during subsequent phases. The first phase reached 260 million scf/d of processing capacity in April 2016, while the second phase started-up last year. The third phase is scheduled to follow in 2018-19. Each phase will bring on-stream sulphur production capacity of around 400,000 t/a.

Supply moves into overcapacity

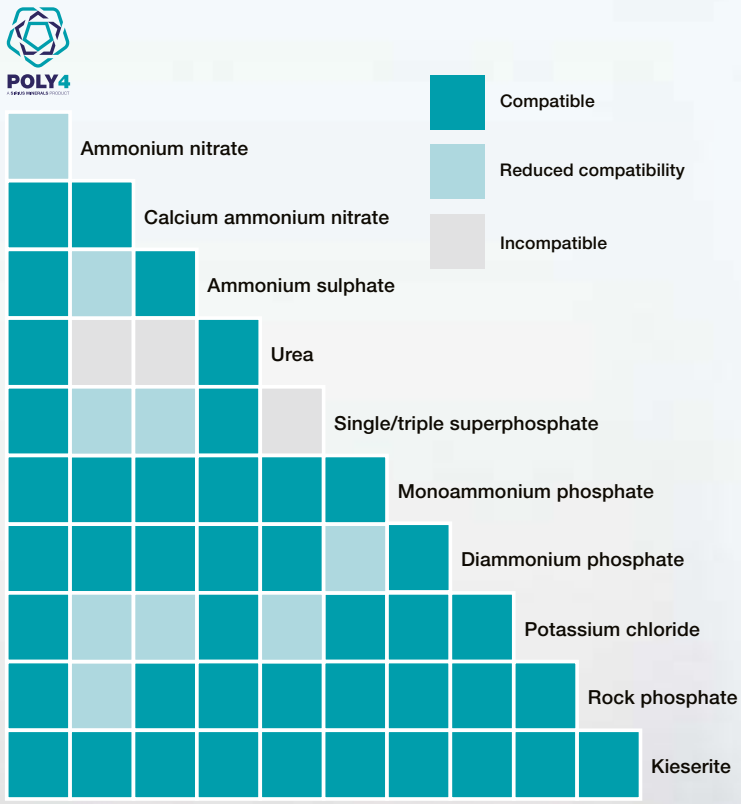
At full capacity, all of the above projects combined could result in an extra 11 million t/a of sulphur entering the market over the next few years (Table 1), even allowing for some decline in supply from western Canada. However, the time taken for projects to come on-stream and ramp-up can vary considerably, with Kashagan being indicative of how long such delays can become. Despite this, global sulphur supply is still projected to move into overcapacity in the next few years (Figure 1). More stockpiling of sulphur is likely in future because of this, especially in regions with poor logistics such as northern Alberta and Central Asia.

BEYOND THE NUTRIENT VALUE

Fertilizers are essential in today's farming practices. It is recognised that 50 per cent of crop yield gap is supported by fertilizer applications. Fertilizers are responsible for more than half of the world's food production, and, due to the increased food demand, additional fertilizer resources are needed. Agronomic advice is shifting, and fertilizer practice is seeking to apply a wider nutrient spectrum to achieve higher yields and better quality of crops. As a consequence, basic NPKs are superseded by NPK +S, NPKS +Mg or +micro nutrients, and so the value of multi-nutrient resources such as POLY4 is recognised.

Since many fertilizers are sold in blends, compatibility of POLY4 as an input for blending into NPK fertilizers is essential. Chemical compatibility in blends is the ability for materials to remain dry and free-flowing when blended together. Using a wide range of likely fertilizer combinations, testing showed that POLY4 has an excellent compatibility with other fertilizer products such as urea, nitrogen phosphates, rock phosphate and potassium chloride.

POLY4 compatibility based on the European Fertilizer Manufacturers Association guidelines (2006)



Visual observation	Compatibility rating
Dry and free-flowing	Compatible
Damp and free-flowing	Compatible
Damp and non-flowing	Reduced compatibility
Wet and non-flowing	Incompatible

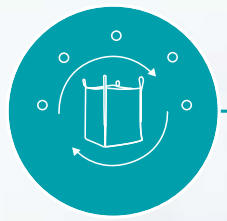
Agriculture and the fertilizer industry continue to develop towards mechanically applied multi-nutrient products. POLY4-NPK products have excellent characteristics including improvements in crush strength, dust reduction and abrasion resistance. Moreover, excellent compatibility, CRH and moisture penetration characteristics of these products reduce caking tendency thus improving fertilizer shelf life. Uniquely, it is now also possible to include POLY4 as a calcium source in chemical granulated NPK products which retain the availability of both the calcium and phosphorus components. All these qualities conclude that NPKs made using POLY4 as an input are eminently fit for purpose.

Futher reading: read POLY4 product handbook on www.poly4.com.

High crush strength

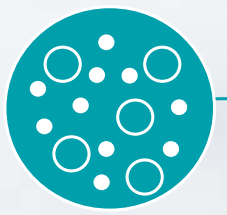
Fertilizers with a low crush strength can turn into dust making them unsuitable for transportation, handling and spreading. A crush strength greater than 3 kgf is recommended in the EU. POLY4 has a crush strength of 6.5 kgf. POLY4 inclusion in both compacted urea-NPK and AN-NPK products maximised crush strength at ~35% demonstrating improvement in fertilizer quality.

Low dust tendency



Fertilizers that generate dust attract moisture thus increasing caking and lowering shelf life. POLY4 positively reduced dust in steam granulated NPK compounds. Inclusion of ~50% POLY4 in urea-NPK lowered dust occurrence by 82% and in AN-NPK by 24%.

Better particle size distribution



POLY4 granules are manufactured within 2mm to 4mm in diameter. This consistency in particle size is essential for fertilizer spreading evenness and for meeting customer specifications.

POLY4
A SIRIUS MINERALS PRODUCT

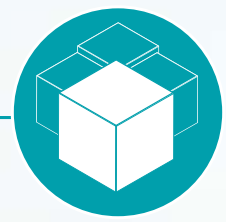
IMPROVING FERTILIZER QUALITY

Broader nutrient delivery

With four of the six macro nutrients (K, S, Mg and Ca), POLY4 offers an input which broadens the nutrient spectrum and lengthens the nutrient delivery profile via its moderate dissolution rate. POLY4's effective nutrient release pattern is focussed on the needs of the crop.

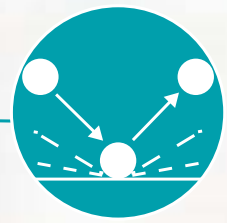
Low moisture content

A high moisture content absorbed by fertilizers can cause caking which leads to difficulties in its handling and spreading. POLY4 attracts less moisture as it has a CRH of 70%. Inclusion of 50% POLY4 in an urea-based NPK blend maintained CRH at 70-75% and in AN-based NPKs at 60-70%.



Low caking tendency

Fertilizers are affected by humidity and harden into lumps known as caking. This affects fertilizer shelf life, handling and spreading. At three months, steam granulated products that included POLY4 showed a significant reduction in losses due to caking. After six-month storage, the urea-based NPK containing 50.9% POLY4 showed 4.4% caking, and AN-based product containing 53% POLY4 showed 25.6% caking. The greater the POLY4 content, the lower the amount of moisture absorbed per unit area.



High abrasion resistance

Resistance to handling is important during transit and for on-farm use of product. Minimising degradation improves spreading patterns whilst supporting farm economics. Inclusion of POLY4 in steam-granulated urea and AN-NPK compounds reduced degradation from abrasion to near zero.

Quality spread pattern

POLY4 granules were tested using spreading machinery set to 24m and 36m bout widths, a typical distance for fertilizer application. The results showed that POLY4 spread patterns easily fall within the maximum 20% CV tolerance limit. POLY4's quality spread pattern reduces the risk of poor spreading, lost profit and expensive corrective action.

SIRIUS MINERALS PLC

References: IFDC (2017) 66000-IFDC-60010-17; University of Limerick (2015); Sirius Minerals in-house testing (2018); University of Limerick (2018) 32000-LIM-32013-18; SCS Spreader & Sprayer Testing (2013); Novochem (2016).

Young professionals

Ben J. Audet, 31 manager, international sales

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, Ben J. Audet of Nutrien talks to us about his career.

PHOTO: IFA

How did your career in the industry start?

I joined Potash Corp, now Nutrien, in 2014 as a supply chain analyst. My entry into the industry was almost by accident. I was accepted onto the Agricultural Economics Master's Program at Purdue University. I thought agriculture looked a good investment due to the job demand. I judged that feeding the world was going to become more and more vital.

How do you get the best from yourself and colleagues?

Communication and relationship building is key, both internally and externally. We have in-depth monthly planning meetings involving sales, production, T&D and marketing, as well as an informal WhatsApp group to quickly share what we're seeing and hearing in the market place. I also have quote on my office wall from President Calvin Coolidge: "Nothing in this world can take the place of persistence." An ethos of persistence –making your point, pushing colleagues to do better, getting better prices – really helps in my view.

What do you find most rewarding about your job?

I love my job and wake up motivated to try and do it better every day. Working across different cultures and continents is dynamic and a lot of fun. It's humbling seeing the results of your hard work being loaded into a vessel, then sent halfway around the world so farmers can feed the world, as well as their families and local communities.

Has mentoring been important to you?

Honestly, the hardest part is actually asking someone to be your mentor. I was fortunate enough to have our ex-president of sales as a mentor. He's been in the industry a very long time, formed the team I'm part of, and only recently-retired. He's very approachable, willing to help. He travelled with me, talked me through negotiations, pushed me to figure things out and be analytical.

What hurdles have you overcome?

Coming from a banking and real estate background was a challenge at first. What I did in my first year was learn – about the supply chain, about products, everything we do from the plant to the customer. My informal training came from interacting with upper management, production, sales, marketing, planning and finance people in the company.

What achievements are you most proud of?

The fast career progress I've made and the international network of contacts I have developed while working for the largest ag input provider in the world. I was promoted to the International Sales desk in my first year with PotashCorp and have not looked back.

Will your job and the industry change in future?

Yes! There's no question that agriculture in general is at the cutting edge of technological innovation, which makes it exciting and dynamic – just look at the advancement we have made in yield per acre over the last two decades, with less inputs! Driverless tractors, drone technology, sub-inch accurate planting, precise nutrient application is all either here or just around the corner. Nutrien is very focused on this change and the role we will play in the future of food production.

Would you recommend a career in the sector to others?

Yes, definitely. Every day in this job and in this industry, is different, which makes it exciting and motivating. To get up every morning and think that you are playing a small part in helping to feed the world is something I'm proud of and will be proud to tell my two year old daughter about.

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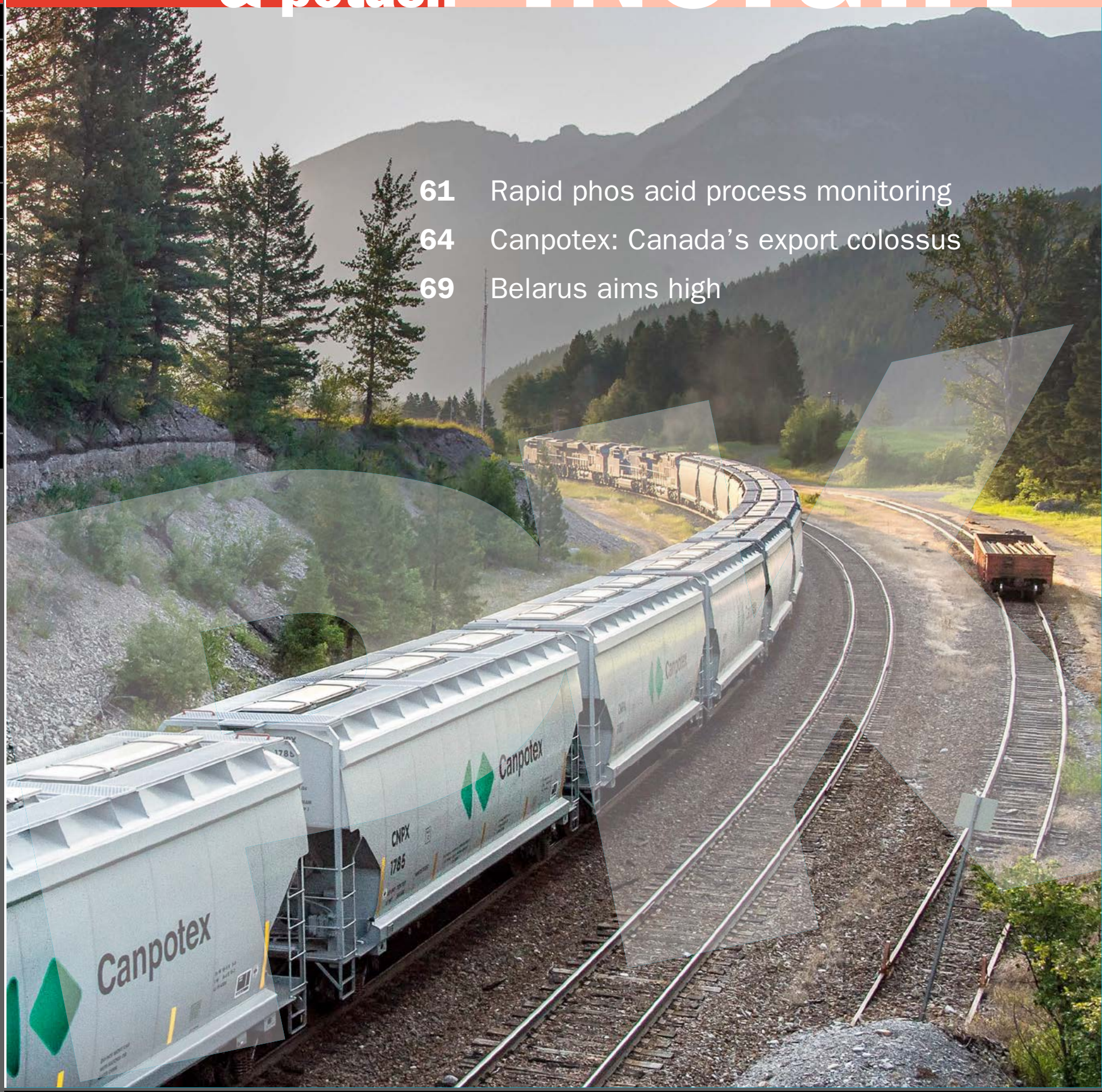
phosphates & potash INSIGHT



Rapid phos acid process monitoring

Incitec Pivot has adopted a new computer-controlled thermal analysis method to monitor the P_2O_5 content of phosphoric acid at its Phosphate Hill plant in Queensland, Australia. The rapid hourly measurements obtained help improve filtration efficiency and reduce co-crystallised losses, explains **Stewart Bache**, Incitec Pivot's chemist at Phosphate Hill.

Thermometric titration is a well-known thermal analysis method. In this article, we describe how this method can rapidly determine P_2O_5 by measuring the exothermic reaction associated with the formation of struvite ($MgNH_4PO_4.6H_2O$). This reaction, by releasing energy as heat, produces a measurable inflection in the titration curve.

We have demonstrated how a computer-controlled thermometric titration system can rapidly and accurately measure the P_2O_5 concentration of phosphoric acid during the production process at an operational hemi-hydrate production plant in Australia.

In a mini laboratory within the plant, operators filter off a small sample of phosphoric acid (38-42% P_2O_5) and weigh the correct amount into the reaction vessel. Reagents and standardised magnesium nitrate are added automatically and the final result is available within three minutes of starting the analysis.

Valuably, the rapid P_2O_5 determinations obtained are used to control cake wash water addition to the plant's filters. The rapidity of the thermometric titration, relative to other methods, makes it possible to improve filtration efficiency of the phosphoric acid plant and reduce co-crystallised losses.

The Phosphate Hill fertiliser plant

Phosphate Hill is an integrated mining and chemical processing plant, located deep in the Australian interior, about 1,000 kilometres west of Queensland's Pacific coast. The remote inland plant is situated some 200 kilometres south of the nearest town, Mount Isa. Most staff including contractors are flown directly to the plant from Townsville. Employees who live in Mount Isa either work at the nearby sulphuric acid plant, which supports the fertiliser plant, or fly to the Phosphate Hill plant. A nearby camp at Phosphate Hill fully supports all employees who work at the fertiliser plant.

The AUD 800 million plant was commissioned in 1999 by WMC Fertilisers Pty Ltd, a subsidiary of WMC Resources. It was subsequently acquired by BHP in 2005, who later sold the plant to Incitec Pivot Limited (IPL), the current owner and operator.

Phosphate rock mined from a number of nearby open pits is chemically processed at the Phosphate Hill plant to produce high-analysis fertilizers. The fertilizer complex comprises of a beneficiation plant, a phosphoric acid plant, an ammonia plant and a granulation plant.

Phosphate Hill manufactures high-quality diammonium phosphate (DAP) and monoammonium phosphate (MAP), as well as nutrient-enriched DAP an MAP products, as required. The plant has the capacity to produce approximately one million tonnes of DAP and MAP annually at full production. Around half of the plant's annual fertilizer output is distributed and sold to Australian farmers and consumed domestically. The remainder is exported.

MAP and DAP products manufactured at Phosphate Hill are widely-applied to Australia's nutrient-poor soils, and provide a valuable source of phosphorus and nitrogen for a range of crops. MAP is an excellent source of phosphorus (22%), and is extensively used in cropping systems and increasingly on pastures.

The DAP fertilizer produced at the Phosphate Hill plant also has one of the lowest cadmium contents in the world. This offers significant environmental benefits, given the global drive towards reducing heavy metal loads, particularly in soils and crops.

Measuring P_2O_5

Before instrument-based techniques were available, the nutrient content of fertilizers was typically measured by gravimetric analysis (weighing). This involved separating solids by filtration and capturing these on a filter paper which was then burned in a furnace. This oxidised phosphorus and other major components, such as potassium and magnesium, into their respective oxide forms.

Gravimetric analysis, therefore, established the practice of measuring phosphorus in the form of P_2O_5. This convention for chemically expressing phosphorus as an oxide was subsequently formalised by the Association of American Plant Food Control. The Association demanded that fertilizer manufacturers specify and guarantee the nutrient content of fertilizers (P_2O_5, K_2O and N) in this way.

Phosphoric acid manufacture at Phosphate Hill

At the Phosphate Hill plant, the overall objective – from a chemical engineering point of view – is to react mined phosphate rock with concentrated sulphuric acid to recover the maximum percentage of P_2O_5 – and to do this as simply and as safely as possible at the lowest achievable cost.

The wet phosphoric acid process produces calcium sulphate (gypsum) waste. The type of calcium sulphate produced is governed by the reaction temperature and phosphoric acid concentration. The

Fig. 1: Apparatus for the rapid determination of P_2O_5 in phosphoric acid by thermometric titration.

Table 1: **Titration parameters**

Parameter	Sample
Sample weight, g	0.96-1.04g
Start Volume	4 mL
Stop Volume	7.5 mL
End point (typical)	5.2 mL
Filter Factor	75
Dosing rate	2 mL/min
300 g/L potassium oxalate volume	5 mL
Ammonia/ ammonium chloride volume	35 mL
Molarity of $Mg(NO_3)_2$	0.98818
Blank	0.2853 mL

Source: Incitec Pivot

Procedure

- Weigh 1 g (+/-0.1 g) of the phosphoric acid sample (~40% P_2O_5), using a top-pan analytical balance, into a clean and dry reaction vessel. Do not add any water or reagent.
- Attach the vessel to the vessel lid and clamp it.
- Enter the sample details into the TIAMO software, including the sample weight.
- Click "Start". The 50 mL Dosino will add 35 mL of the ammonia/ ammonium chloride reagent with stirring. The 10 mL Dosino will add 4 mL of the 1 mol dm^{-3} magnesium nitrate solution which will produce an off-white coloured precipitate in the reaction vessel. After a 30 second delay, the titration continues with rapid addition of the titrant to reach the exothermic end-point.

Phosphate Hill plant uses the hemihydrate process. The plant's operating conditions – a temperature of 96-100°C and a phosphoric acid concentration of 40-50% P_2O_5 – ensure that gypsum crystallises in the hemihydrate ($CaSO_4.½H_2O$) form. Knowing the concentration of P_2O_5 makes it possible to adjust the cake wash flow more accurately and improve filtration efficiency. That makes quick and accurate measurement of the P_2O_5 content of phosphoric acid an important part of process control and overall production efficiency.

Measurement of P_2O_5 in phosphoric acid

Presently, the analytical laboratory at Phosphate Hill determines P_2O_5 in phosphoric acid samples using the AOAC official method (958.1). Measurements are taken every four hours by an ultra-violet/ visible (UV/Vis) spectrophotometer (420 nm) using ammonium vanadomolybdate as a colouring agent.

Other fertilizer operations globally employ different techniques for determining P_2O_5 content. Where instrumentation is not available, these include the classic quimociac gravimetric method. This precipitates soluble phosphate as quinolone molybdophosphoric acid. This is then filtered and dried with the P_2O_5 content being calculated from the weight of dried material. The alkalimetric quinolium molybdophosphate titration method is also used by some laboratories.

These classical methods are time-consuming and keep chemists and technicians at the lab bench for long periods preparing samples for analysis. Even the spectrophotometric method used at the Phosphate Hill laboratory was found to be a limiting factor when it came to controlling P_2O_5 losses during the filtration stage of production. In order to have better control of P_2O_5 losses, it became clear that more frequent sampling and determination of P_2O_5 would be necessary.

Hourly analysis provides better control of the production process but this could not be achieved with the existing spectrophotometric method of analysis. A new, rapid method – thermometric titration – was therefore required to meet the requirement for hourly P_2O_5 analysis at the Phosphate Hill plant.

Thermometric titration

Apparatus used: Metrohm Australia supplied three Dosino dosing pumps, a reaction vessel fitted with a propeller stirrer and a thermoprobe (Figure 1). This apparatus was controlled by Metrohm's TIAMO software via a Titrotherm 859 interface.

Method: The filtered sample (38-42% P_2O_5) was firstly combined with a buffer solution containing ammonia (400 mL) and ammonium chloride (40 g) in two litres of water buffered at around pH 10. A 5 mL volume of potassium oxalate solution was added as a complexing and oxidising agent. Standardised magnesium nitrate solution (1M) was used as the titrant. The blank value was predetermined using the procedure recommended by the apparatus manufacturer. Titration parameters are shown in Table 1.

Dissolved phosphate reacts exothermically to form a magnesium ammonium phosphate hexahydrate precipitate ($MgNH_4PO_4.6H_2O$) in the presence of an ammonia buffer and magnesium nitrate solution. This white, inorganic, crystalline mineral precipitates out at pH 10. The presence of ferrous iron will create an off-white/orange coloured precipitate in alkaline conditions. Potassium oxalate is therefore added prior to titration to oxidise ferrous iron to the ferric form, and complex with calcium, which is known to interfere with the reaction.

Results and discussion

The reaction between phosphate in the sample and magnesium nitrate at pH 10 produces a molar heat of reaction (Δ Hr). This is detected by the apparatus as a measurable change in temperature. In our measurements, Δ Hr values are negative, indicating an exothermic reaction. In thermometric titration, such exothermic readings are expressed as a second-derivative end-point. The software automatically calculates the P_2O_5 content corresponding to the recorded end-point volume (mL).

The thermoprobe used in the new method contains a thermistor which responds quickly to small changes in temperature. Its signal can, however, be prone to minor noise and interference. This can be eliminated by applying a digital filter (filter factor) to smooth out the signal and produce a sharp, symmetrical second-derivative peak.

Where a precipitate is formed, it is well-known analytical chemistry practice to 'seed' the reaction first. This improves precision and ensures that precipitation is more regular during the titration. To achieve this, a small volume of magnesium nitrate titrant (4 mL) was added to condition samples prior to analysis, after the buffer and potassium oxalate solutions had been added.

Table 2: **Comparison of results (% P_2O_5) from the thermometric titration method versus those from the AOAC UV/Vis spectrometric method for an eight hour period**

	Result (% P_2O_5)	
Time	**AOAC spectrometric Method**	**Thermometric titration method**
00:00	40.91	40.77
01:00	40.55	40.79
02:00	40.69	40.70
03:00	40.33	40.75
04:00	40.44	40.75
05:00	40.54	40.57
06:00	39.88	39.97
07:00	39.91	39.88
08:00	39.75	39.88

Source: Incitec Pivot

The thermometric titration method was corroborated by directly comparing measurements obtained from the existing UV/Vis spectrometric AOAC method on identical samples over an eight hour period. Results (% P_2O_5) were found to be sufficient for process control (Table 2). In terms of linearity, the best correlation between both methods was found over a phosphoric acid concentration range of 38-42% P_2O_5 (16.5–18.3% phosphorus, P).

Note

Further information on this novel thermometric titration method and a full reference list are available from the author (stewart.bache@incitecpivot.com.au).

Canpotex: Canada's export colossus

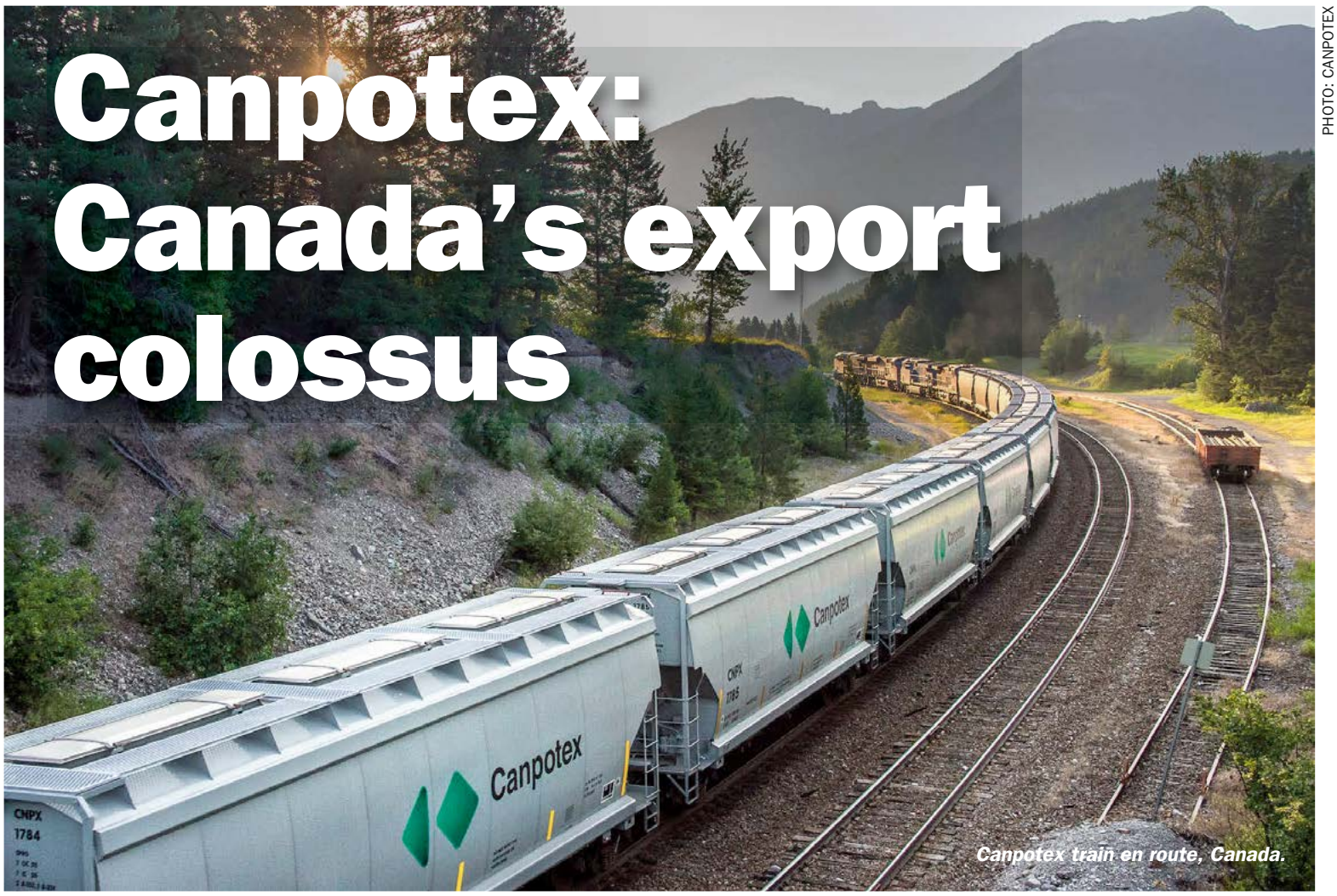


PHOTO: CANPOTEX

Canpotex train en route, Canada.

We profile Canpotex, Canada's export consortium, highlighting its continuing success in Asian and Latin American markets, and reviewing its major transport, terminal and shipping capabilities and investments.

Introduction

Canpotex is the world's premier potash exporter, and has been exclusively marketing and distributing Canadian potash internationally since 1972. The consortium is jointly owned by two North American potash producers, Nutrien Ltd and The Mosaic Company. Collectively, they own and operate 10 Saskatchewan potash mines – the largest concentration of potash capacity anywhere in the world. Over the last five decades, Canpotex has shipped almost 250 million tonnes of potash to more than 60 countries.

Canpotex is able to distribute and deliver massive multi-million tonnages of Canadian potash globally, quickly and efficiently, through a fleet of over 5,000 dedicated railcars, four marine terminals and chartered ocean vessels. The consortium's renowned world-class distribution network is backed by exemplary customer service delivered via five corporate offices in Saskatoon, São Paulo, Shanghai, Singapore and Tokyo.

Inland transportation

The majority of Canpotex's potash is transported long-distance westwards overland by train, from mine sites in Saskatchewan to two Pacific coast ports, one in Vancouver, British Columbia, and the other in Portland, Oregon, a journey of approximately 2,000 kilometres. The consortium also transports a smaller volume of potash eastwards to two ports accessing the Atlantic, namely Thunder Bay, Ontario – for shipment via the Great Lakes and the St Lawrence Seaway – and the Saint John terminal in New Brunswick, an even longer 4,300 kilometre journey.

Every year, Canpotex trains make over 700 individual trips to these four ports, carrying more than 12 million tonnes of potash across Canada's vast prairies and rugged landscape, often under the most extreme weather conditions. The longest trains are made up of 205 railcars and transport over 21,000 tonnes of potash per journey (see photo).

Canpotex has operated its own custom fleet of railcars since 1999. These potash-specific cars were developed in collaboration with Ontario-based National Steel Car. Their unique, larger-volume design effectively doubled the amount of potash that could be transported by rail across Canada, without any increase in the number of train journeys needed. Canpotex has since commissioned 7,000 of these custom railcars from National Steel Car, and in the process has invested hundreds of millions of dollars into the Canadian economy.

Terminals

The millions of tonnes of potash transported across Canada by train end up at one of following four dedicated marine terminals, two on North America's West coast and two on its East Coast:

- Neptune Bulk Terminals, Vancouver, British Columbia
- Portland Bulk Terminals, Portland, Oregon
- Saint John Terminal, Saint John, New Brunswick
- Thunder Bay Terminals, Thunder Bay, Ontario

At these terminals, potash is transferred from railcars into ocean vessels for onward shipment to ports of discharge in final destination countries. Canpotex also has access to modern, high-capacity port-side warehouses. These store various grades of potash in large volumes until they are needed. The ability to maintain an easily-accessible, port-side potash inventory provides Canpotex with operational flexibility and ensures the consortium can move quickly to service customer deliveries, even during periods of peak demand.

Canpotex ships the majority of its potash through **Neptune Bulk Terminals**, a joint venture between affiliate company Canpotex Bulk Terminals Limited and Teck Coal. Neptune has been shipping potash and fertilizers through the Port of Vancouver for more than 40 years and employs modern, state-of-the-art handling equipment. Neptune was established in 1967 and operates under a long-term lease agreement with the Port of Vancouver.

The terminal is sited on 71 acres of land on Vancouver's Burrard Inlet, a location that provides excellent deep water access and sheltered loading for large ocean-going vessels. Two berths (Berth 2 and Berth 3) are dedicated to potash shipments.

On-site rail tracks can accommodate two potash unit trains, or 340 individual railcars. Two enclosed gravity-fed dumper pits can each take four railcars at a time. Neptune's conveyor system can deliver product directly to the vessel or to storage.

Both of Neptune's potash berths can load either red or white potash. Berth 2 is equipped with two, 2,500 t/h capacity quadrant shiploaders able to operate simultaneously. Berth 3 has a single, linear shiploader with a capacity of 2,500 t/h. Cascade chutes are used to gently place potash into vessel holds.

The terminal has two warehouses capable of storing 210,000 tonnes of potash in total. The 110,000-tonne 'A-frame' warehouse can be subdivided into sections, making it ideal for handling and storing different potash grades. Potash is reclaimed from the bottom of the warehouse for delivery to either Berth 2 or Berth 3. Canpotex commissioned a separate 100,000-tonne 'cathedral' warehouse in 1994. This is equipped with a 6,000 t/h portal reclaimer that automatically delivers potash to either Berth 2 or Berth 3.

Portland Bulk Terminals is on the Columbia River in Portland, Oregon, some 177 kilometres from the Pacific Ocean, and has been operative since 1997 (see photo). This dedicated potash terminal is wholly Canpotex-owned and operated by SSA Pacific. Facilities are located at Terminal 5 on 100 acres of land leased the Port of Portland. The terminal can efficiently handle specialty products – particularly white potash – and is an alternative embarkation point for Canpotex potash shipments worldwide. The consortium has invested $150 million in shiploading and rail improvements at Portland Bulk Terminals (see box). The investment has also improved how specialty white potash is managed.

PHOTO: CANPOTEX

Portland Bulk Terminals, Oregon.

Three on-site loop tracks at Portland Bulk Terminals can accommodate three Canpotex unit trains, or 390 individual railcars. The site's enclosed gravity-fed dumper pit can unload four railcars at a time.

Portland's enclosed stainless steel conveyor system minimises dust emissions. The system can deliver products to storage or directly to the vessel. The terminal has a single, covered, linear shiploader with a rated capacity of 6,000 t/h. Delivery to the vessel is computer controlled from the ship's deck. Separate delivery belts and cascade chutes prevent the cross-contamination of red and white potash, and gently deliver products into the vessel or to storage.

The on-site 135,000 tonne warehouse is divided into six bays – four for specialty

INTERVIEW

Ken Seitz, president and CEO of Canpotex, talks exclusively to *Fertilizer International*.

What's the thinking behind the Canpotex's new Brazilian sales office which opened in April?

Brazil is one of Canpotex's most important markets. In fact, almost a quarter of our potash is destined for Brazilian customers, and we're expecting demand to grow. Just look at what's on the horizon. The United Nations projects the world will need to increase food production by 70 percent by 2050, and Brazil is expected to be responsible for 40 percent of this increase in food production. To meet the growing need for potash, opening our sales office in Sao Paulo allows us to stay close to our customers in Brazil, and work directly with distributors to support farmers using Canpotex potash in their crops.

Canpotex has expanded its international farmer education work since the early 1980s. Why is the consortium so committed to this?

It's simple: food security is at the core of what we do. Canpotex's vision is to be a vital link in the pursuit of global food security, inspiring farmers in our export markets to grow and help nourish the world. Part of how we do this is contributing to farmer education in many of our markets. Farmers are shown in practical, hands-on ways the benefits of balanced fertilization and modern farming practices that will improve their crops' yield and help them achieve food security for their families and their communities. Since 1983, we've invested almost $50 million in more than 25 countries on this education. To give you an idea of the scale of this work, in a market like China, approximately 100 million Chinese farmers have received information on balanced fertilization through these education programs.

The expansion of Portland Bulk Terminals was completed in March. What will be the main business benefits of this?

Reliably delivering over 12 million tonnes of potash each year from land-locked Saskatchewan to customers half-way around the world is no easy feat. Since 2000, we've invested approximately $1 billion US in our own supply chain and become a global leader in transportation logistics. The $150 million US expansion of Portland Bulk Terminals is our latest completed project. The improvements we've made – the new shiploader, a new warehouse, and upgraded vessel loading system – has nearly doubled overall terminal capacity. At the end of the day, the efficiencies and the capacity gained means we're enhancing our ability to reliably ship potash overseas and meet our customers' needs.

Canpotex is fully committed until October 2018. What does this say about global demand and current market conditions?

There's a good news story in potash right now. Overall, global demand is robust and the fundamentals in many of our markets are solid. As an illustration, our overseas markets are highly engaged in their potash purchasing, and significantly, farmer affordability for potash – which is a key driver for demand – is favourable.

Looking ahead, as new supply capacity emerges in both Canada and Russia, is Canpotex positive about future potash demand and market growth prospects?

Overseas potash markets are already highly competitive, and Canpotex is well-positioned to serve our overseas markets in the future. There is robust demand in many of our markets, and Canpotex has the customers, the expertise and an unparalleled supply chain to capture much of this growth. ■

white potash and two for red potash. Two separate portal reclaimers each reclaim red and white potash at a rate of 3,000 t/h. A second warehouse currently under construction will give Canpotex up to 100,000 tonnes of additional storage capacity at Portland.

The **Saint John Terminal** is Nutrien-owned but managed by Canpotex Terminals Limited and operated by Furncan Marine. The terminal, located at Port Saint John in New Brunswick, has been in operation since 1982 and can handle up to 2.5 million tonnes of potash annually. This east coast port provides Canpotex with better export access and shorter sea routes to the eastern seaboards of South and Central America, as well as West Africa and Europe.

The Saint John Terminal occupies 30 acres of land leased from Port Saint John, and includes a dolphin structure dock apron, two potash warehouses, and enough track capacity for up to 146 railcars. The terminal's single covered quadrant shiploader has a rated capacity of 2,500 t/h and is able to access three ship holds. A telescopic chute minimises dust generation. Potash is delivered from one of two warehouses. These provide 235,000 tonnes of combined storage capacity.

Canpotex has been shipping potash through **Thunder Bay Terminals** at Port of Thunder Bay, Ontario, via the St. Lawrence Seaway, since 1986. This eastern port provides Canpotex with better access to European customers.

The terminal covers 235 acres of land, can handle three million tonnes of potash annually and has one warehouse for bulk unloading. Trains up to 120 railcars long are accommodated by a dedicated loop track, and there is sufficient on-site capacity for up to 400 railcars at any one time. The 259 metre-length berth is designed to take the largest vessels (eight metres draft) in the St. Lawrence Seaway. Vessels can be directly loaded from railcars at the terminal at an average rate of 3,000 t/h.

Ocean transport

Canpotex currently has 14 ocean-going vessels under long-term charter. These vessels undertake approximately 250 voyages every year, and make a total of almost 750 port calls annually. On any given day, Canpotex is managing more than 50 ocean-going, potash-carrying vessels across the world.

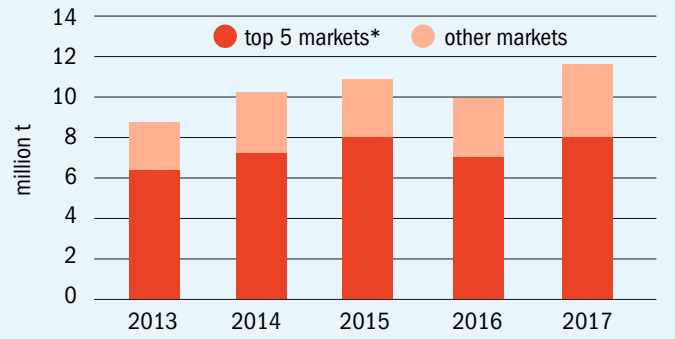
Canpotex's offices, railways and terminals, and its crews on ocean vessels, are all in constant daily communication. This helps ensure that the transit of potash export cargoes is carefully coordinated and closely monitored at all times. A highly-skilled operations team, located in Canpotex's Saskatoon and Singapore offices, manages the long journey made by Canadian potash, over both land and sea. This team tracks the progress of every shipment, from mine to terminal then onwards across the ocean to the final destination port, culminating in the cargo's arrival and eventual discharge.

Main markets

Since its founding, Canpotex has shipped almost 250 million tonnes of potash to more than 60 overseas countries. Its success has turned potash into one of Canada's largest exports and made the consortium Saskatchewan's top overseas exporter. Every year, Canpotex delivers more than 12 million tonnes of potash from

CANPOTEX'S FIVE MAIN MARKETS

Fig. 1: **Canpotex's global potash sales, 2013-2017**



*Brazil, China, India, Indonesia, Malaysia

Source: Canpotex

Brazil

Unsurprisingly, Brazil, as the world's largest potash importer, is also Canpotex's main export market. Brazil's soils are notoriously potassium-deficient and applications of Canpotex potash are vital when it comes to maintaining and increasing the yields of many Brazilian crops – particularly soybean, corn, sugarcane and coffee. Indeed, Canadian-supplied potash has helped ensure the country's soil health and crop productivity since exports to Brazil began 1972. Over the intervening years and decades, total Canpotex potash sales to Brazil have exceeded 35 million tonnes.

China

China is the world's second largest potash importer. Canada was at the vanguard, being one of the first countries to export potash to China in 1972. Supplies began when the late Chinese premier, Zhou Enlai, learnt first-hand about Canadian potash while at a trade exhibition, subsequently placing a 23,000 tonne trial order with Canpotex. Since that modest first delivery, Canpotex has sold and despatched more than 45 million tonnes of potash to China.

Since 1983, Canpotex has invested more than $30 million in educating its Chinese customers about how best to use potash to increase crop yields and improve food production. In 1986, Canpotex and the Canadian government also jointly-funded the first ever bulk blending plant built in China. Decades later, this pilot plant, located in South China, continues to purchase Canadian potash for bending.

India

India is the third largest international potash market. Canpotex has delivered over 20 million tonnes of potash to the country since 1972. Potash is primarily applied to rice, fruits and vegetables, wheat and pulses. Canpotex has run a farmer education programme in India dating back to 1985. This teaches farmers how to apply balanced applications of potash, nitrogen and phosphate to improve soil health and increase crop yields.

Indonesia

Indonesia is the fastest growing potash market in Southeast Asia, and is currently ranked the fourth largest in the world. Canpotex has supplied Indonesia with nearly 20 million tonnes of potash since 1972. The majority of potash in Indonesia – circa 70 percent – is consumed by oil palm growers, with the remainder being applied to a range of crops such as rice, maize, soybean, rubber, fruits and vegetables. Indonesia is the world's largest palm oil producer and the sector remains a central pillar of country's economy. Potash availability has played a key role in the growth of the Indonesian palm oil industry, and its productivity and profitability. High fruit yields on oil palm plantations require an ample supply of potash. Applications also improves plant pest- and disease-resistance.

Malaysia

Malaysia is the fifth largest international potash market and the world's second largest palm oil producer. Canpotex has been a dedicated supplier of potash to the country since 1972, delivering almost 20 million tonnes in total to date. Around 90 percent of Malaysia's potash imports are applied to oil palm, with the remainder applied by the country's rubber, rice, fruit and vegetables growers. Malaysia is a mature potash market with significant labour shortages and limited land for expansion. Canpotex has invested over $2 million in potash education programmes in Malaysia and Indonesia since 1985, working in partnership with IPNI. These offer oil palm plantation owners and smallholders agronomic advice on plantation management best practice. ■

Saskatchewan, Canada, to some 40 overseas countries. Its five largest overseas markets – Brazil, China, India, Indonesia and Malaysia – account for around 75 percent of annual potash exports (see Figure 1 and box).

Farmer education

For more than three decades now, Canpotex has committed itself to educating farmers globally about crop nutrition and the benefits of potash applications – in partnership with the International Plant Nutrition Institute (IPNI) and others. Its first farm education programme began in China in 1983, and has been widely replicated in many other parts of the world since then. To date, Canpotex has invested approximately $50 million in farmer education in more than 25 countries.

The consortium is currently actively involved in education work in 15 countries. Its programmes are tailored to individual market and regional needs. The overall aim is to educate local farmers at a grassroots level about the benefits of balanced fertilization and modern farming practices. The focus is on delivering higher crop yields, boosting farm incomes, and ultimately improving the food security of farming families and local communities. Examples of Canpotex's farmer education work include:

- Field demonstrations for specific crops, highlighting the yield differences obtained from balanced fertilization and the application of potash
- Farmer meetings, seminars and symposiums
- Harvest days and crop tours
- Agronomic advice and educational materials on crop nutrition and fertilizer applications ■

Belarus aims high

Belarus, alongside Canada and Russia, is a front-ranking potash-producing nation. The completion of large-scale projects, financed with the help of foreign investors, could further transform the Belarussian potash industry, reports **Eugene Gerden**.

The potash industry in Belarus is undergoing a major expansion in capacity thanks to two large-scale projects currently under development.

Slavkaliy project now well-advanced

The $2 billion and two million tonne capacity Slavkaliy project is one well-advanced example. The project's Nezhinsky mine and processing plant near Lyuban in the country's Minsk region is due to be completed early in 2019.

Its operational capacity could double to four million t/a after 2020.

The project is located in the eastern part of the Starobinsky potash field. With ore reserves estimated at three billion tonnes, Starobinsky is one of the largest potash deposits in Belarus.

The Slavkaliy project is being implemented by Mikhail Gutseriev, a well-known Russian billionaire and a personal friend of the Belarus President Alexander Lukashenko. China's State Development Bank is providing most of the project finance ($1.4 billion). In return, Slavkaliy has guaranteed to supply China with future production from the plant for a 25-year period.

Originally, the Slavkaliy project was to have been mainly bankrolled by the Russian state-owned bank Sberbank, under its initial investment plan. However, Sberbank subsequently abandoned its role as lead project investor, reportedly because of worries over insufficient returns due to the potash market's low price environment.

The deal between Gutseriev and the Belarus government to construct a new potash mine goes back to the signing of an agreement by both parties in 2011. Implementation has been subject to a series of delays since that time, although the project does now appear to be firmly back on track. If and when it finally does enter production, Slavkaliy will become the second largest potash producer in Belarus, after Belaruskali.

Presidential backing

President Lukashenko has taken a personal interest in the Slavkaliy project and has played a key role in getting the venture up and running. He arranged for project investors to be exempted from all compulsory tax payments, for example.

"This is understandable," says Alexander Avtushko-Sikorsky, a senior analyst at the Belarusian Institute for Strategic Studies (BISS). "Implementation of all large-scale investment projects in Belarus is regulated at the highest level – while their launch is usually confirmed by special presidential decree."

The project will use a special processing method to recover up to 99.7 percent of the ore as usable fertilizer, according to Igor Kozhich, Slavkaliy's general director. Ore processing at Slavkaliy's plant will be carried out by the halurgic method – also used by Uralkali – instead of conventional flotation technology, Kozhich confirmed. This type of production technology is expected to reduce production costs as well as deliver a chemically-pure MOP (muriate of potash, KCl) product.

Overcapacity risks

Russian analysts believe Slavkaliy will increase global potash market competition, if it's commissioned next year as expected.

A spokesman for Russia's Energy Minister, Alexander Novak, said: "The competition in the global potash market will intensify, with many large-scale projects scheduled for commissioning. Because of this, while investors will try to generate returns on their investments, potassium chloride prices may decline this year, if there are no capacity closures or large-scale consolidation among producers. Such closures will most likely not happen, as currency devaluations in CIS countries and Canada still allow the main potash producers to operate profitably."

Belaruskali's expansion plans

Belaruskali, meanwhile, has its own plans to expand capacity this year. A new, under-construction potassium nitrate plant was scheduled for completion in the second quarter of 2018. The new 160,000 t/a capacity plant is located at a Belaruskali production site in the city of Soligorsk. It includes two nitrate production lines, a reloading unit, warehouses and associated infrastructure. As well as potassium nitrate, the plant will also produce 124,000 t/a of mixed NK fertilizers.

Completion of Belaruskali's new potassium nitrate plant and the successful implementation of the Slavkaliy project will create the necessary conditions to transform Belarus' prospects as a world-leading potash producer, according to president Lukashenko's spokesman.

Belaruskali-Uralkali cooperation back on the agenda

The possible resumption of cooperation between Belaruskali and Uralkali could significantly accelerate these plans, according to the same presidential spokesman.

Both companies are continuing to negotiate a possible resumption of joint export trading, with a final agreement potentially being reached as early as September or October this year, according to some sources. As a pre-condition, President Lukashenko is pushing to have the newly-established joint trading company located in Belarus.

Potash production at a record high

Belaruskali exported about 9.5 million tonnes of potash last year, from a record total production output of 11.5 million tonnes. Belaruskali has increased its production capacity by more than four million tonnes over the last five years. Uralkali also exported 11 million tonnes of potash in 2017 and produced 13.1 million tonnes in total for the year.

Dmitry Mazepin, one of Uralkali's major shareholders, sees an upside to resumed potash cooperation between the Russia and Belarus. Optimistically, he believes that active cooperation between the two producers will help unlock the full demand potential of the world potash market. ■

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