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FERTILIZER INTERNATIONAL
ISSUE 480
SEPTEMBER-OCTOBER 2017

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***Cover:*** *US Capitol Building in Autumn, Washington, DC. Orhan Cam/Shutterstock.com*

**Sulphur briefing**

**Young professionals**

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# TFI welcomes you to DC!


> **Fertilizer International will be exhibiting at TFI's 2017 World Fertilizer Conference in Washington this September.**

The Fertilizer Institute (TFI) is hosting this year's World Fertilizer Conference at the Marriott Marquis in Washington, DC. The mid-September 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 have long made the World Fertilizer Conference a must-attend event on the annual calendar. The three-day conference and exhibition opens for registration on Sunday 17th September. In keeping with conference tradition, delegates will hear from two distinguished and entertaining business speakers during breakfast sessions on Monday 18th and Tuesday 19th September.

Fittingly, given this year's prestigious Washington setting, breakfasting delegates will be treated to words of wisdom from **Wilbur L Ross, Jr**, the 39th US Secretary of Commerce. The equally impressive **David Pottruck**, a top faculty member at the Wharton School of Business, will be speaking at the other breakfast session.

Secretary Ross, the principal voice of business in the Trump administration, was sworn in as US Secretary of Commerce in February. He has over 55 years of investment banking and private equity experience, and is the former chairman of WL Ross & Co. During his career, Secretary Ross has been chairman or lead director of more than 100 companies operating in over 20 different countries. He has also helped restructure over $400 billion of industry assets.

Named by Bloomberg Markets as one of the 50 most influential people in global finance, Secretary Ross previously served as privatisation advisor to New York's mayor, Rudy Giuliani. He was also appointed by President Bill Clinton to the board of the US-Russia Investment Fund. South Korea's president, Kim Dae-jung, awarded Secretary Ross a medal for his help during that country's financial crisis. In 2014, he was also awarded The Order of the Rising Sun, Gold and Silver Star, by the Emperor of Japan.

Secretary Ross has also chaired or been a trustee of a wide range of philanthropic organisations. These include the Japan Society, the Brookings Institution (Economic Studies Council), the International Board of the Musée des Arts Décoratifs in Paris, the Blenheim Foundation and the Magritte Museum in Brussels. Secretary Ross is also a Yale University graduate and a former advisory board member of Yale's School of Management. He graduated from Harvard Business School with distinction.

TFI's other breakfast speaker, David Pottruck, is the former CEO of Charles Schwab and the author of the *New York Times* bestsellers *Clicks and Mortar* and *Stacking the Deck*. He currently teaches transformational change to global executives at the Wharton School of Business.

During his 20-year career with Charles Schwab, David Pottruck watched the company's revenues grow from $50 million to $5 billion, and its client assets increase from $25 billion to more than $1 trillion. While at the company, he helped revolutionise the way stocks are bought and sold. In a pioneering move, he also rebuilt Schwab's business model around the internet.

*Smart Money* named David Pottruck one of the three most influential executives in the investment world, while *Institutional Investor* called him the single most influential executive in online finance. David's other business accolades include being named 'CEO of the Year' by *Information Week* and 'Executive of the Year' by the *San Francisco Business Times*.

During his breakfast talk to delegates, David Pottruck will be asking two questions: What does it take to be effective during a time of rapid change? And how do you increase the likelihood you'll be successful at leading breakthrough change at your organisation? David will also discuss how to develop a game plan for success.

Monday evening's closing reception takes place in the Library of Congress, one of Washington's most historic buildings. Founded in 1800, the Library is the nation's oldest federal cultural institution. It serves as the main research arm of the US Congress and also plays host to the US Copyright Office. During the evening, delegates will be treated to a special exhibit highlighting the rich agricultural history of the United States.

As we have done for many years, *Fertilizer International* will be exhibiting at TFI's 2017 World Fertilizer Conference in Washington this September. We are very much looking forward to being in the nation's capital to meet industry friends, both old and new. ■

*Simon Inglethorpe, Editor*







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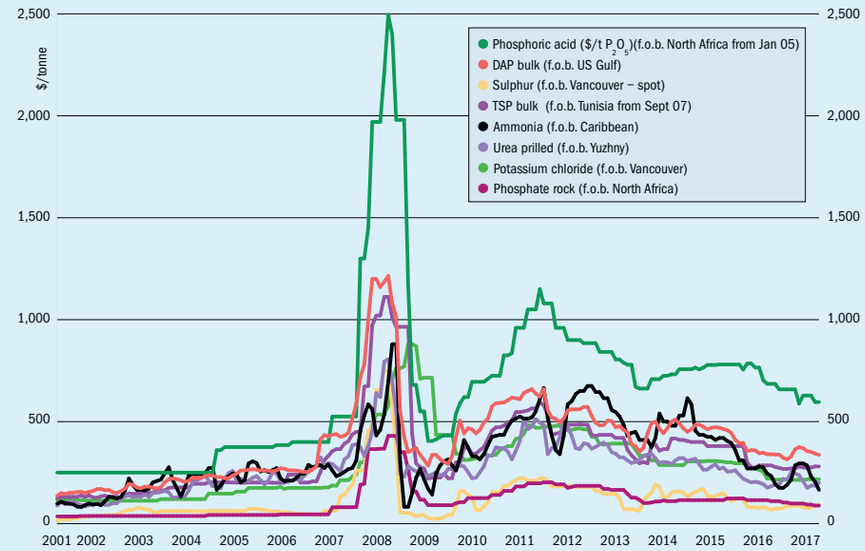
# Market outlook

**Historical price trends** $/tonne




*Source: BCInsight*

**Market insight courtesy of Integer Research**

## AMMONIA

Prices have trended downward throughout the summer, as persistently low demand has left prices subdued. The Yuzhny benchmark fell to a low of $185/t f.o.b. during late July and early August, and remains below $200/t f.o.b. after a slight rebound. Southeast Asia bucked the trend with supply outages pushing up prices from Middle Eastern producers. However, the short-term supply issues currently in play should not be interpreted as a recovery in demand. Indeed, a persistent and lasting supply/demand imbalance will keep the pressure on pricing downwards.

## UREA

The market saw some upward movement across global pricing benchmarks in early August. The Yuzhny urea price rested at $203/t f.o.b. mid-August, following a slight and mainly supply-driven price lift which began in mid-July. The prospect of future demand from India, Europe and Turkey from September onwards also shored-up prices. Although pricing support should continue in the short-term, significant upward gains are unlikely, given that many traders are now reported to be long and remaining on the sidelines. The imminent IPL Indian tender could provide prices with extra support, if Indian purchasing is at its normal level of half a million tonnes or more. A tender volume below this level, in contrast, could provoke more bearish market behaviour.

## PHOSPHATE

The downward movement in DAP pricing continued through July and August. This was despite improved Indian buying sentiment. Falling raw materials prices, combined with competition between exporters, kept a lid on DAP prices. Most of the major benchmarks averaged around $340/t f.o.b. by late August, compared to an average of $360/t f.o.b. during the second quarter. August DAP prices at most major export hubs were still slightly up year-on-year, due in part to better Indian demand growth and tighter Chinese supply. August's North African DAP benchmark was the exception: it fell by $8/t year-on-year to $326/t f.o.b.

## POTASH

Canpotex, Arab Potash Company (APC), Uralkali and ICL have all signed contracts with Chinese suppliers at a price of $230/t for the second half of 2017. Agreed volumes are mostly comparable to that achieved in the equivalent period last year. Belarusian Potash Company (BPC) negotiations are ongoing but, similar to other suppliers, both contract price and volume is likely to be similar to last year. Uralkali has been the first seller to reach a contract agreement with Indian buyers at a price of $240/t cfr. Canpotex, BPC, ICL and APC are expected to follow suit and conclude negotiations with IPL shortly.

MOP prices in Brazil strengthened slightly following contract conclusions with China, increasing by three dollars to $267/t cfr between mid-June and mid-August. Prices in Southeast Asia increased by a similar margin to $253/t cfr over the same period. Elsewhere, weekly Vancouver MOP prices







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increased by $4/t to $229/t f.o.b. between the end of July and mid-August.

## SULPHUR

Global sulphur prices surged to $100/t f.o.b. (Middle East) in August – despite the lack of support from the downstream processed phosphates market. Short-term sulphur market dynamics were behind the run-up in pricing. The three major Middle Eastern producers all posted price increases for August, reflecting a comfortable position vis a vis contract commitments. In China, total sulphur inventories at the nine major ports remained around 1.1 million tonnes due to a tighter local balance. Chinese buyers and traders turned to the sulphur spot market, boosting producer confidence and stimulating delivered prices into the country. August prices in India also rose in line with the increases posted by Middle East producers. Demand for sulphur-based acid increased in Asia, as sulphuric acid from the metallurgical sector has been very tight for several months, adding to the more buoyant pricing trend. Chinese sulphur imports in the first half of 2017 were, however, down 16 percent year-on-year, despite more positive spot trades and pricing.

**Market price summary** $/tonne – End-August 2017

| Nitrogen | Ammonia | Urea | Ammonium Sulphate | Phosphates | DAP | TSP | Phosphoric Acid |
|---|---|---|---|---|---|---|---|
| f.o.b. Caribbean | 175 | n.m. | f.o.b. E. Europe 90-100 | f.o.b. US Gulf | 337 | n.m. | n.m. |
| f.o.b. Yuzhny | 190-195 | 198-205 | - | f.o.b. N. Africa | 345-355 | 263-275 | 492-700 |
| f.o.b. Middle East | 230 | 188-225** | - | cfr India | 355-360 | - | 567-572* |
| **Potash** | KCl Standard | $K_2SO_4$ | **Sulphuric Acid** | | **Sulphur** | | |
| f.o.b. Vancouver | 196-238 | - | cfr US Gulf | 45-55 | f.o.b. Vancouver | 90-100 | |
| f.o.b. Middle East | 192-234 | - | | | f.o.b. Arab Gulf | 105-107 | |
| f.o.b. Western Europe | - | €420-450 | | | cfr North Africa | 78-92 | |
| f.o.b. FSU | 184-226 | | | | cfr India | 118-120+ | |

*Prices are on a bulk, spot basis, unless otherwise stated. (* = contract ** = granular). Phosphoric acid is in terms of $/t $P_2O_5$ for merchant-grade (54% $P_2O_5$) product. Sulphur prices are for dry material. (+ Quotes for product ex-Arab Gulf)* 

## MARKET DRIVERS

- **Ammonia:** Support for upward price movement remains limited. The ammonia market is largely in surplus and this, combined with weak demand, will undoubtedly keep up pricing pressure and prevent significant gains. Southeast Asia is the one bright spot for price support, due to a variety of production outages, both planned and unplanned. Outages may well add support to global price benchmarks over the coming month, especially for Middle Eastern producers. A planned outage at the Malaysian Kerteh plant owned by Petronas, for example, has now been extended until early September. This situation is echoed in Indonesia, where KPI is also extending its planned outage until September due to technical problems.
- **Urea:** Although surpluses have reduced, the global urea market remains imbalanced, preventing a pricing upswing. Chronic oversupply means the price lift that began in July is unlikely to be sustained, particularly as extra volumes from new capacity are poised to enter the market. A new 500,000 t/a granular urea plant from PhosAgro is due to be commissioned in September, while Koch's Enid plant in the US state of Oklahoma is due sometime in October. This new capacity is likely to counter growing seasonal demand from September onwards.
- **Phosphate:** The Chinese domestic market is currently providing better returns for the country's producers than the international market. Efforts by China's largest producers to maintain a minimum export price of $350/t f.o.b. have been undermined by international competition. The recent confirmation of a lower goods and services tax (GST) rate appears to have boosted Indian buying sentiment for DAP. But the country's DAP demand is likely to be negatively affected by the heavy monsoons which have caused severe floods in key farming regions. Integer expects global DAP prices to come under increasing pressure during the year's second half, as low-cost capacity from Saudi Arabia and Morocco ramps-up, increasing supply competition.
- **Potash:** The market could tighten slightly in the third quarter before moving back into moderate oversupply. Several factors are contributing to tighter supply. Canpotex is reported to be sold-out until August and BPC has assigned 90% of its total September and October volumes. Lower Chinese operating rates are also anticipated because of railcar disruption at Qinghai Salt Lake. UK production will also move lower as ICL's Boulby mine shifts from MOP to polyhalite production. Later in the year, the emergence of new greenfield mines is likely to tip the market back into oversupply as they ramp-up to full capacity. K+S Bethune and Turkmenhimya's Garlyk mine are now up and running. EuroChem Usolskiy in Russia is also due to come onstream later this year. These capacity additions will keep any price increases modest. Pricing will also increasingly depend on supplier discipline.
- **Sulphur:** The recent price run-up is unlikely to be supported in coming months, as supply shortages ease and the downward pressure from end-use markets prevails. On the supply front, there have been further setbacks to the Barzan project in Qatar due to technical issues. Its start-up is now expected at the end of 2018 or the start of 2019. Further supply growth means the Middle East is set to maintain its position as the leading sulphur producing region in 2017, with production in Iran and Saudi Arabia continuing to rise. The Kashagan project in Kazakhstan is also expected to produce its first sulphur test cargo for export in September.

  Brazil remains a bright spot in the short-term outlook. Potential cuts in Brazil's domestic sulphur production should keep sulphur trade to the country strong. US and Middle East suppliers are likely to capitalise on this.







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SAUDI ARABIA

## Umm Wu'al phosphate project starts production

The Ma'aden Wa'ad Al-Shamal Phosphate Company (MWSPC) has started producing ammonia, merchant-grade acid and fertilizer from its Umm Wu'al phosphate project.

Fluor, which provided engineering, procurement and management services for the $8 billion project, made the announcement on 10 August. The Mosaic Company later confirmed production of the first tonnes of diammonium phosphate (DAP) at Ras Al Khair on 22 August.

Mosaic holds a 25 percent share in the MWSPC joint venture, alongside partners Ma'aden (60%) and SABIC (15%). The large-scale project enters the market as one of the lowest cost producers of finished phosphates in the world. Investment in the project offers Mosaic and partners improved access to growing agricultural markets, most notably India, now that Umm Wu'al has come to fruition.

MWSPC first began producing ammonia at the Ras Al Khair complex last year. Only one fertilizer production train is currently up and running at Ras Al Khair's granulation plant. But the complex is expected to produce around three million t/a tons of DAP, monoammonium phosphate (MAP) and NPK fertilizers, once all four trains come online later this year.

"After less than four years from the start of the execution phase, we are proud to have partnered with Ma'aden to bring this facility to production," said Tony Morgan, Fluor's mining and metals business president. "We look forward to continuing our partnership with Ma'aden in developing their next phase of mining projects in Saudi Arabia through our recently signed memorandum of understanding."

A workforce of 28,000 from more than 50 nationalities worked on the megaproject at the peak of construction. Fluor, by implementing a world-class safety programme, achieved more than 46 million consecutive work hours without a lost-time incident.

PHOTO: FLUOR

*MWSPC sulphuric acid plant.*

QATAR

### Barzan hit by further delays

The Barzan project is likely to postpone the start-up of its natural gas processing plant due to a continuing gas leak problem. The expected arrival of significant new sulphur supply from the two bcf/d capacity RasGas-owned project will be delayed as a consequence.

The leak in an upstream subsea piping section was originally discovered in October 2016, delaying the plant's commissioning date. The issue, similar to the one which dogged the Kashagan project in Kazakhstan, now puts next year's start-up of the project in doubt.

Barzan is expected to produce natural gas for domestic consumption, ahead of Qatar hosting the World Cup in 2022, as part of a $200 billion infrastructure programme.

The fresh Barzan project delay has emerged during Qatar's escalating rift with its Gulf neighbours, especially Saudi Arabia. An embargo placed on Qatar has restricted air and sea travel to and from the small state, and seen its land border with Saudi Arabia close.

The diplomatic row and accompanying trade embargo has not slowed down the pace of Qatari project announcements. In July, Qatar unveiled plans to expand LNG production by 30 percent, from its present 77 million t/a to 100 million t/a by 2022-24. The gas will come from a new project in a southern sector of the country's North Field. Some 4 bcf/d of this new supply will be earmarked for export.

Major gas expansions will undoubtedly require an increase in Qatar's sulphur output. Enersul says that it has been awarded an equipment supply contract from Doha Petroleum Construction Co. Ltd. for the Qatargas Common Sulphur Project Expansion at Ras Laffan. Enersul will supply two 1,250 t/d *GXM1*™ sulphur granulation units in the second quarter of next year, for a total additional forming capacity of 825,000 t/a.

The supply of gas through the Dolphin pipeline to the UAE has continued uninterrupted since the start of the embargo. LNG exports from Ras Laffan have also been unaffected to date.

UNITED STATES

### Successful molecular-tagging trial

Anti-counterfeiting and anti-theft tagging of fertilizers has been successfully demonstrated by US biotech firm Applied DNA Sciences and its partner Belgian manufacturer Rosier S.A.







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The two companies expect to start making shipments of molecular-tagged fertilizers early next year, once initial customers have been identified. "Our manufacturing partner, Rosier, is well-established, committed and familiar with the markets that will first pull our platform through fertilizer supply chains," commented James Hayward, Applied DNA's president and CEO.

A "substantial" market exists for fertilizer authentication, in Hayward's view. "We believe this is one of the most significant steps the global economy can take toward sustainable agronomy," he said.

Applied DNA first teamed-up with Rosier in September last year. The partners launched a pilot programme to tag and track a shipment of fertilizer pellets using DNA markers. The company's *SigNify* DNA detection technology tracked the fertilizer pellets along a complete supply chain from Europe to their ultimate destination in West Africa.

The aim of the nine-month validation exercise was to "detect the dilution of genuine fertilizer with substandard material within a given batch". The programme, which ended in June and involved both laboratory and field tests, successfully demonstrated that the marked fertilizer shipment had not been adulterated.

The adulteration and counterfeiting of fertilizers is a major problem in some regions. Vietnam's fertilizer association estimates that substandard fertilizers costs that country's economy two billion dollars a year, for example. It is also known to be an issue in the African fertilizer market. Tests in Uganda, for example, have revealed that urea sold to farmers contains one-third less nitrogen than advertised. Two-fifths of fertilizers sold In Tanzania could also be fake, according to some estimates.

"Adulterated fertilizers have become a global supply chain problem of such impact that bankers will no longer finance fertilizer purchases for some farmers," commented Tony Benson, managing director of Applied DNA Europe. "Without necessary funds, farmers cannot purchase fertilizer, leading to poor or failing crop yields and financial disaster for the farmer."

Encouragingly, the success of the West African pilot programme could make banks more willing to lend. "Regional banks expressed a willingness to finance DNA-tagged fertilizers," said Benson. Financiers praised the company's "demonstration of the power of molecular tags to protect fertilizer supply chains against dilution", he added.

Applied DNA Sciences is based at Stony Brook in New York's Suffolk County, and supplies molecular tagging technology to the textiles, leather and luxury car markets. The firm recently landed a major licensing deal with Indian textile manufacturer GHCL Ltd. The US Defense Department has also used Applied DNA's technology to authenticate electronic microcircuits.

## Agrium acquires more US retail outlets

Agrium has bought 20 agricultural retail outlets in Georgia and Florida. The acquisition is part of binding deal between its Crop Production Services arm and Southern States Cooperative, Inc. The latter's cotton ginning business in Statesboro, Georgia, is also included in the deal. Agrium expects these new assets to generate annual revenues in excess of $100 million.

"Agrium remains focused on enhancing our retail distribution network in the US and this acquisition will allow us to further capitalize on our existing presence in these regions," commented Chuck Magro, Agrium's president and CEO. "We would like to extend a warm welcome to the Southern States Ag-retail employees and are enthused to bring the latest in technologically advanced proprietary products and precision-ag services to grower customers in the southeastern US."

Jeff Stroburg, Southern States president and CEO, added: "This agreement will… allow Southern States to… serve our members and customers more efficiently and effectively."

The acquisition is expected to close in September.

## OMAN

## New ammonia plant contract

Canadian engineering firm SNC-Lavalin has secured an engineering, procurement, and construction (EPC) contract for a new ammonia plant in Salalah, Oman.

The contract was awarded by the Salalah Methanol Company (SMC), a subsidiary of the Oman Oil Company (OOC). It covers the construction of a 1,000 t/d ammonia plant, together with utilities and off-site infrastructure.

"We are very excited about this opportunity to pursue our work with SMC," said Etienne Cabanes, senior vice president for SNC-Lavalin's MENA region mining and metallurgy operations.

"SNC-Lavalin is pleased to enter into this next phase of the Salalah ammonia project, which is of great importance for SMC and the Sultanate of Oman," added José J Suárez, SNC-Lavalin's mining and metallurgy president.

Financial closure of the ammonia project is said to be in its final stages.

## GERMANY

## thyssenkrupp wins two nitrogen plant orders

thyssenkrupp Industrial Solutions has secured separate engineering, procurement and construction (EPC) contracts to build two nitrogen fertilizer complexes, one in the US and the other in Brunei.

thyssenkrupp signed an EPC contract with state-owned Brunei Fertilizer Industries on the 26 August. The contract covers the building of an integrated, state-of-the-art nitrogen fertilizer complex with the capacity to produce 2,200 t/d of ammonia and 3,900 t/d of granulated urea.

The new complex will be constructed at the Sungai Liang Industrial Park, next to existing oil and gas industry facilities, and is due to be completed in 2021. Brunei's large natural gas reserves will provide the complex with feedstock. The nitrogen fertilizer produced will mainly be destined for export.

thyssenkrupp will engineer the fertilizer complex, supplying and erecting equipment, supervising construction and commissioning, as well as being responsible for various offsite utility systems.

Peter Feldhaus, CEO of thyssenkrupp Industrial Solutions, said the company was proud to be working with Brunei Fertilizer Industries. "Being selected to develop this lighthouse project is an important milestone for our fertilizer plant business. This major order will further strengthen our market position and growth in the Asia Pacific region."

Brunei is one of the world's largest producers and exporters of natural gas. By adding value to the country's oil and gas production activities, development of the new nitrogen complex supports the government's diversification strategy for Brunei's economy.

Dato Bahrin Abdullah, chairman of Brunei Fertilizer Industries, said: "We have chosen thyssenkrupp for our investment project as the company combines vast experience in engineering, procurement and construction with proven and cost-efficient fertilizer production technology."





On 23 August, Cronus Fertilizers also announced thyssenkrupp Industrial Solutions as the new EPC contractor for its Tuscola, Illinois, fertilizer project in the US. The fixed-price, turnkey contract means the start of construction is now on track for next year, Cronus confirmed.

The planned Tuscola plant will have the capacity to produce 2,300 t/d of ammonia and up to 2,000 t/d of granular urea. Cronus is reported to have instigated a number of project changes, including the replacement of its previous EPC contractor, to ensure the proposed greenfield plant was consistent with current market needs.

According to Cronus, the plant's strategic location will provide farmers with locally-produced fertilizer that can be delivered via pipeline or truck, replacing the need for imported products.

"With this agreement in place, project development will now accelerate," said Erzin Atac, CEO of Cronus Chemicals. "thyssenkrupp Industrial Solutions… is the leading builder of fertilizer projects and will be involved in every aspect of constructing this state-of-the-art facility."

State Senator Chapin Rose, a long-term champion of the project, welcomed the news: "I am very excited and look forward to breaking ground. Cronus Fertilizers will be a great economic 'shot in the arm' for the entire region."

## MEXICO

## Pemex selects Jacobs for ammonia plant rehab

Jacobs Engineering Group has won a project management contract (PMC) from Mexico's Pemex Fertilizantes.

Jacobs is taking on the role of PMC contractor to manage the rehabilitation of the Ammonia IV plant at Pemex's Cosoleacaque Petrochemical Complex in Veracruz, Mexico. It will be responsible for supervising the engineering, procurement and construction (EPC) work on the plant. Pemex is restoring the Ammonia IV plant to its original capacity and specification to reduce the risks of unplanned shutdowns and abnormal operations.

"Building on our outstanding performance as PMC service provider for their Minatitlan Refinery Reconfiguration Project, we are committed to support Pemex in delivering the Ammonia IV rehabilitation project safely and successfully," said Mark Bello, Jacobs senior vice president, petroleum and chemicals downstream.

## Mexichem buys Netafim

Plastic pipe producer Mexichem has bought an 80 percent share in pioneering Israeli drip irrigation firm Netafim for $1.5 billion.

Mexichem is purchasing its stake in Netafim from private equity fund Permira (61.3%), Kibbutz Magal (6%) and Kibbutz Hazerim (33%). Under the terms of the deal, Netafim's production and R&D facilities will remain in Israel for the next 20 years.

Netafim is a leading manufacturer in the drip irrigation market (*Fertilizer International* 475, p33). Drip irrigation is increasingly valued by fertilizer producers as a niche, high-value market. The irrigation market is a particularly attractive segment for speciality fertilizer manufacturers due to fast-growing sales of water-soluble fertilizers used in fertigation.

Netafim has 17 manufacturing plants, operates in over 30 countries and sells to over 100 countries world-wide. Its sales totalled $855 million in 2016. The company and its 29 global subsidiaries employ more than 4,300 workers.

Netafim had announced earlier this year that is was looking for a strategic part-







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ner to develop the business. Ran Maidan, Netafim's CEO, welcomed the partnership with Mexichem: "Together we can ensure the continued growth and prosperity of Netafim," he said

Mexichem is one of the world's biggest producers of plastic pipes and one of the largest petrochemical companies in Latin America. "This is a strategic acquisition that strengthens our unique basket of solutions and products," said Antonio Carrillo Rule, Mexichem's CEO.

Completion of the purchase is expected during the fourth quarter of the year, subject to regulatory approval.

## BRAZIL

### Regulator approves Vale Fertilizantes purchase

Brazilian regulator the Administrative Council for Economic Defence (CADE) has approved Mosaic's acquisition of Vale Fertilizantes.

Mosaic originally agreed to buy Vale Fertilizantes in December last year for $2.5 billion. The deal offers mutual benefits. It consolidates major Brazilian fertilizer production assets under Mosaic's ownership, and makes Vale a significant shareholder in Mosaic. The money raised also helps Vale achieve debt reduction goals.

"This acquisition gives Mosaic the opportunity to benefit from the growing Brazilian agriculture market... For Vale, the deal guarantees an important capital injection and a significant minority position in the global fertilizer business," CADE commented in August, in its deal approval statement.

Vale Fertilizantes' Brazil assets include five phosphate mines, four production plants and a potash project. These assets produce 4.8 million tonnes of phosphate fertilizers. The purchase also provides Mosaic with ownership of the Kronau potash project in Canada and Vale's 40 percent stake in Peru's Miski Mayo phosphate mine.

Vale will own a 11 percent stake in The Mosaic Company and have the right to appoint two directors to Mosaic's board, once the deal is concluded.

## ARGENTINA

### EuroChem buys Emerger Fertilizantes

Swiss-headquartred EuroChem Group has acquired Emerger Fertilizantes S.A., a privately-owned distributor of premium and standard fertilizers in Argentina.

Emerger sells 50,000 tonnes of fertilizer annually. Premium fertilizers, which are popular with the domestic tobacco industry, make up around 60 percent of sales. The remaining sales are to customers in Argentina's North East, Central and Central East regions.

Emerger owns a 12,000-tonne capacity warehouse, eight kilometres from the port of San Nicolas de los Arroyos, northern Argentina. The company, which has 25 employees, also rents three separate retail centres in the country.

The purchase strengthens EuroChem's presence in Latin America, a region that accounts for 11 percent of the company's fertilizer sales. The size of the Argentinian fertilizer market is expected to increase from 3.4 million tonnes in 2016 to 5.5 million tonnes in 2020.

"The acquisition of Emerger, a well-positioned distributor in the Argentinian fertilizer market, is another step to bolster our capabilities in Latin America which is one of the fastest growing fertilizer markets in the world," said Dmitry Strezhnev, EuroChem's CEO. "This reflects our intention to expand sales of premium products in Latin America and we are looking forward to developing the business in Argentina and in neighbouring countries."

Enrique Arambarri, Emerger's former co-owner and CEO, said: "Under EuroChem ownership we will be able to offer a wider range of value-added fertilizers to our customers in Argentina as well as Bolivia, Paraguay and Uruguay."

The purchase of Emerger follows other recent acquisitions by Eurochem in Brazil, Bulgaria, Hungary and Spain. The price and other terms of the Emerger deal have not been disclosed.

## INDIA

### India cuts fertilizer sales tax

India introduced its new Goods and Services Tax (GST) at the start of July. But, in a last minute decision, the Indian government cut the GST rate on fertilizers to five percent, much lower than the rate originally proposed.

The GST is a landmark tax reform. It replaces over a dozen central and state taxes on goods and services with a single national sales tax rate. All goods fall into one of five sales tax brackets, ranging from zero to 28 percent. Precious stones and gold are exempted. The tax change is intended to boost India's GDP by up to 2%.

Fertilizers were initially classed in the 12 percent bracket, but hours before the launch of the reforms the government changed its mind and lowered the GST rate on fertilisers to five percent. The slashed rate was designed to protect farmers' interests by limiting the resulting hike in fertilizer prices.

Prior to the introduction of the GST, fertilizer sales taxes were generally less than six percent. There were particular concerns about the effects of the higher GST rate on retail fertilizer prices in states like Punjab, Haryana and Andhra Pradesh, where soil nutrient products were not taxed previously.

"Regarding the 12% rate of GST (on fertilisers), some felt it may increase the burden on farmers, so the consensus... was to bring the rate down to 5%", explained India's finance minister Arun Jaitley.

## NETHERLANDS

### Louis Dreyfus sells its African fertilizer business

Louis Dreyfus Company (LDC) has announced the sale of its Fertilizers and Inputs Holding B.V. business to private investment firm Helios Investment.

LDC has owned the African-based fertilizer and inputs business since 2011. The company distributes fertilizers, crop protection products, seeds and industrial chemicals throughout West Africa, helping improve agricultural yields and promoting economic development across the region. It generates around $300 million in annual sales.

Gonzalo Ramírez Martiarena, LDC's CEO, said: "Our global fertilizers and inputs business has expanded its reach, sales volumes and customer base in recent years. This transaction... will also allow us to strengthen our focus on forging partnerships in other geographies outside Africa. Through our *Macrofertil* brand, we can continue to deliver a diversified range of fertilizers and inputs products and high-quality services to our customers in the rest of the world."

Closure of the deal is subject to regulatory approval.

## SPAIN

### Cargo ship abandoned after fertilizer fire

Cargo ship MV Cheshire was abandoned off the coast of Gran Canaria in the Canary Islands on 12 August, after a fire broke out in its hold.

The vessel, owned by UK-based Bibby Line, was shipping 42,654 tonnes of ammonium nitrate for Yara from Porsgrunn in Norway to Thailand. All 24 crew were winched to safety by Spanish coastguard helicopters.

The order to abandon ship was given after a steep rise in the temperature of the ammonium nitrate cargo and the risk of an explosion and toxic gas release. The ship had been due to make a fuel stop at Las Palmas on Gran Canaria.

In a statement, Bibby Line said: "The temperature in hold 4 rose to a high enough level to cause damage to the hatch cover. Resolve Marine have been appointed to attend the vessel and deal with the cargo problem. The crew of Cheshire have been evacuated and taken ashore for their own safety. A standby tug from the Spanish Maritime Safety Agency will stay with the vessel. The vessel is drifting in a southerly direction away from any landmass."

On 28 August, the fire was said to have finally petered out, with the vessel, located 50 nautical miles southeast of Gran Canaria, now under tow.

## CANADA

### BHP delays Jansen mine decision

BHP now says the Jansen potash project will not be placed before the company's board for approval during 2018.

The disclosure was made in August as part of the company's end-of-year financial results.

"Board approval will be sought for the project only if it passes our strict capital allocation framework tests," the company added in a statement.

BHP, the largest mining company in the world, also revealed that it may bring a partner on board to dilute its ownership in the Jansen project. It is also looking at options to improve the project's capital efficiency and optimise its design.

The Jansen mine project is located 140 kilometres east of Saskatoon, Saskatchewan, close to the communities of Humboldt and Lanigan. Despite the uncertainty surrounding its ultimate future, BHP is pressing on and developing the Jansen mine, with some 200 workers currently engaged on project construction work.

Seventy per cent of the Jansen project's $2.6 billion shaft sinking phase is now complete, according to BHP. Current construction work at the mine includes the excavation of two shafts and their partial lining to prevent water ingress from the Blairmore aquifer.

However, the final decision on whether the Jansen mine will eventually move to the production stage still requires board-level approval.

The proposed Jansen potash mine is a massive project with an eight million tonne design capacity, equivalent to almost 15 percent of world supply. Taking the project to full production will ultimately require a $12.8 billion capital investment, according to Deutsche Bank. BHP has initially committed $3.8 billion to the project, with $2.6 billion of that allocation being earmarked for surface construction and shaft sinking.

BHP has sent out mixed messages over the Jansen project in recent months. In May, the company signalled an acceleration of the project, saying it could seek board approval for the Jansen project in June 2018, allowing the mine to begin production as early as 2023. Such an early decision now appears to have been ruled out.

BHP also revealed in June that its potash business may eventually grow to match the size of its iron ore division, in certain circumstances. "It's taken us 50 years to create today's iron ore business. It will be another 50 years to create a potash equivalent. So you have to start somewhere," said Andrew Mackenzie, BHP's CEO.

BHP believes potash demand could double by the late 2040s to become a $50 billion market. "That's one of the reasons why we're investing counter-cyclically to give ourselves the option to add it to our diversified portfolio of commodities," said Paul Burnside, BHP's potash principal.

## RUSSIA

### New €160 million Tolyatti urea plant

A joint venture between KuibyshevAzot (68%) and Maire Tecnimont (32%) will develop a new urea plant at Tolyatti in Russia's Samara region.

The two partners unveiled plans to build, finance, maintain and operate the new €160 million fertilizer plant in July.

Maire Tecnimont is participating through its project development company, MET Development, and expects to contribute €11 million in equity. It will act as project developer, technology licensor and EPC contractor.

The 1,500 t/d capacity urea plant will use *Stamicarbon Urea 2000Plus*® pool





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reactor technology. Stamicarbon, which is owned by Maire Tecnimont, will also provide the technology for the plant's granulation unit.

PJSC KuibyshevAzot is one of Russia's leading chemicals and nitrogen producers. The new plant will be integrated within the company's existing large-scale complex at Tolyatti.

Basic engineering and project documentation (BE&PD) work has already started. This is being coordinated by Tecnimont (Maire Tecnimont's EPC contractor) and JSC NIIK. The project's financial closure and the completion of BE&PD work is scheduled for April-June next year. The award of an EPC contract to Tecnimont is then expected to follow.

"A new urea plant project …will allow KuibyshevAzot to attract state-of-the-art technologies to the company's industrial site, increase output of the product demanded by consumers and strengthen the company's position in the mineral fertilizer market," said Aleksandr Gerasimenko, KuibyshevAzot's general director.

"This is a significant step forward in our industrial strategy," said Pierroberto Folgiero, Maire Tecnimont's CEO. "We are very keen to strategically cooperate with a prestigious industry leader such as KuibyshevAzot in one of our core business areas, fertilizers."

### Banks lend Uralkali $850 million

Uralkali has signed a loan agreement for $850 million with 11 international banks. The banks will collectively provide Uralkali, one of the world's largest potash producers, with a five-year pre-export facility. The loan will be used for refinancing Uralkali's existing loans and general corporate purposes.

"The attractive terms of the deal… demonstrates strong commitment from leading international banks to cooperate with the Company," said Anton Vishanenko, Uralkali CFO. "We are grateful to our partners for support and long-term trusting relationships."

The banks involved in the facility include: Commerzbank AG, Credit Agricole Corporate and Investment Bank, ING Bank N.V., Natixis, PJSC Rosbank/ Societe Generale Corporate & Investment Bank and AO UniCredit Bank, Bank of America Merrill Lynch International Limited, ICBC (JSC), AO Raiffeisenbank, Bank of China and IKB Deutsche Industriebank AG.

## ISRAEL

### Haifa Chemicals threatens plant closure

The dispute between Israeli authorities and Haifa Chemicals over the company's Haifa Bay ammonia storage tank has deepened.

In a strongly worded letter to Israeli Prime Minister Benjamin Netanyahu on 2 August, Haifa Chemicals owner Jules Trump said he had decided to shut down the company's operations and layoff 800 workers.

The letter was in response to a Supreme Court ruling ordering the closure of Haifa's ammonia storage tank on safety grounds (*Fertilizer International* 478, p10). "Now we learn that in spite of the unanimous government decision to find a solution for the ammonia crisis… the implementation of a solution is not on the horizon," Trump wrote. "We are forced to close the company and fire its workers."

Trump described the threatened closure of Haifa as a "tragic result". The letter drew attention to the loss of hundreds of millions of shekels from the halt in Haifa's production over the last five months.

However, in a more positive reaction, the letter and its threat to jobs appears to have prompted further action on both sides to resolve the dispute. Following a meeting convened by justice minister Ayelet Shaked and environment protection minister Ze'ev Elkin, the government and Haifa Chemicals concluded that there was a good chance of production resuming at Haifa's southern plant.

The future of the company's northern Haifa Bay plant remains uncertain, however. Subsequent news reports on 22 August described the layoff of the plant's 400 workers as imminent.

New options being pursued by the Israeli government include trucking ammonia overland directly from the dock. The country's Environment Ministry and Home Front Command are said to be looking at the feasibility of this overland trucking option.

Haifa Chemicals, meanwhile, has agreed to resume work at its southern plant, if small ships carrying ammonia are permitted to dock in either Ashdod or Haifa ports, and the ammonia is then sent overland. This solution could apparently be implemented in a matter of weeks. Trump said Haifa would accept any alternative allowing the rapid transfer of ammonia to its plants.

Haifa consumes almost 70 percent of Israel's imported ammonia, using this to produce speciality fertilizers at two plants in the north and the south of the country. Output from these plants is responsible for two percent of Israel's industrial exports. The two plants also directly employ 800 workers and support another 4,500 workers indirectly, according to the company.

## CHINA

### World Bank funds Kingenta retail expansion

IFC, part of World Bank Group, has agreed to provide $200 million in finance to Kingenta, China's leading speciality fertilizer producer.

The agreement will part-fund a Kingenta project to set up hundreds of new crop production service centres across China over the next five years. The new centres, which will go under the name Kingfarm Cooperative, will promote efficient fertilizer usage and promote climate-smart agriculture in China. The project's overall aim is to increase crop yields and boost the income of millions of Chinese farmers.

IFC's finance package includes $70 million in equity, $75 million as a senior loan and $55 million from IFC's managed co-financing portfolio. IFC is also aiming to mobilise a further $80 million in finance from other multilateral lenders.

The new agricultural centres should ensure that Chinese farmers have greater access to training, enhanced efficiency fertilizers (EEFs) and other high-quality inputs in future. The application of EEFs can increase crop yields by 10-40 percent, compared to conventional commodity fertilizers, and deliver higher farm productivity with less environmental impact.

Kingfarm Cooperative's chairman, Li Jiguo, said: "Kingfarm Cooperative – as China's first modern agricultural service platform as well as a group dedicated to farmers – is committed to building an integrated agricultural value chain. We will consolidate resources and different channels in order to deliver comprehensive services for 50 million farmers in China."

Sérgio Pimenta, IFC's director for manufacturing, agribusiness, and services, said: "Kingenta's innovative distribution strategy offers a sustainable solution to increasing farm productivity and encouraging the adoption of climate-smart farming techniques and technology."



# People

*Jeanne Johns*

**Jeanne Johns** will become the new managing director and CEO of Incitec Pivot Limited (IPL) with effect from 15 November, succeeding James Fazzino. The company's board said it was delighted to have recruited Ms Johns to the role.

Ms Johns, an American-born chemical engineer, has over 25 years international business experience. She previously held a range of senior executive positions at BP, including numerous leadership roles in the US, Europe and China. While at BP, she managed multinational businesses and specialised in international strategic business development.

As part of the move to IPL, Ms Johns will be giving up her non-executive board membership of Tate & Lyle and Parsons Corporation.

IPL's chairman Paul Brashe said he was delighted to announce Jeanne's appointment: "She is a truly global executive, having worked, and led teams, in many different countries. Her global experience has provided a deep understanding of the strategic and operational issues facing companies in cyclical and commodity based businesses."

He added: "Jeanne's global experience, leadership and customer focus are strongly aligned to our company strategy and we look forward to her joining IPL."

Jeanne Johns said she was honoured to be joining IPL: "[It is] an exemplary Australian company that has grown into a global diversified industrial chemicals business. I look forward to building upon a proud legacy and creating an exciting future with the people of IPL."

Ms Johns will relocate to Australia in late October. This will allow her to join IPL in a transitional capacity before formally starting work in her new role in mid-November. Mr Fazzino will continue as IPL's MD and CEO until this time.

**Mike Frank** is joining Agrium as president of Agrium Retail on 18 September. Mr Frank will be responsible for Agrium's global retail operations, including Crop Production Services in North America, Landmark in Australia and the company's South American retail operations.

"We are very excited to welcome Mike to Agrium. With almost three decades of experience in agriculture, he is very well known and highly respected across the crop input industry," said Chuck Magro, Agrium's president and CEO. "Mike has a clear mandate to grow our Retail business. He is an exceptional people leader and I look forward to working with him to continue to develop and grow our talent and business to ensure we remain the leading provider of crop inputs and solutions for our global farm customers."

Mike previously held a wide variety of senior positions at Monsanto, most recently as the lead executive planning the company's integration with Bayer. Immediately prior to this, he was the senior VP and Chief Commercial Officer of Monsanto's global business. Mr Frank has served on the boards of CropLife International and CropLife America, as well as World Trade Center St Louis. He holds an agricultural engineering degree from the University of Saskatchewan and an MBA from Northwestern University.

**Karl-Heinz Fiegenbaum**, the managing director of SCHADE Lagertechnik GmbH for the last six years, has retired after a career spanning 47 years. He became managing director of the company in July 2011 with responsibility for the sales and commercial side of the business. Mr Fiegenbaum's successor as managing director will be **Dr Christoph Seifert**, who joined SCHADE as technical managing director in February 2015. **Klaus Paul** also joined SCHADE in March in order to take over the role of technical managing director from Dr Seifert.

**John Eaves** and **Michael Toelle** have been elected to the board of CF Industries as independent directors. Mr Eaves is CEO of Arch Coal while Michael Toelle is the owner of T&T Farms and is the former board chairman of CHS.

Mr Eaves serves on the boards of the National Association of Manufacturers and the National Mining Association. He is a graduate of the Advanced Management Program at Harvard University, and holds a bachelor's degree from the University of Kentucky. Mr Toelle is past chairman of the CHS Foundation and previously served as a director for the Agricultural Council of America and Country Partners Cooperative. He is a member of the National Association of Corporate Directors.

"We are pleased to welcome John and Michael to the CF Industries' Board," said Stephen Furbacher, chairman of the board, CF Industries Holdings, Inc. "John's extensive knowledge of the global coal industry and Michael's deep agricultural experience… will benefit the board and our management team greatly. We look forward to their insights and perspectives as we work together to create long-term value for our stockholders."

# Calendar 2017

## SEPTEMBER

**17-19**
TFI World Fertilizer Conference,
WASHINGTON, DC, USA
Contact: Valerie Sutton
Fax: (202) 962-0577
Email: vsutton@tfi.org

**26-28**
8th GPCA Fertilizer Convention, BAHRAIN
Contact: Ammara Shahiryar
Tel: +9714 4510666, Ext. 10
Email: ammara@gpca.org.ae

## OCTOBER

**9-11**
East and Southern Africa Fertilizer Agribusiness Conference,
MAPUTO, Mozambique
Contact: CRU Events
Tel: +44 (0)20 7903 2444
Email: conferences@crugroup.com

**10-12**
30th AFA Technical Conference,
AMMAN, Jordan
Contact: Arab Fertilizer Association
Tel: +20 2 23054464
Email: afa@arabfertilizer.org

**24-26**
IFA Crossroads Asia-Pacific Conference,
SHANGHAI, China
Contact: IFA Conference Service
Tel: +33 1 53 93 05 25
Email: conference@fertilizer.org
Web: www.fertilizer.org

## NOVEMBER

**6-9**
Sulphur 2017,
ATLANTA, Georgia, USA
Contact: CRU Events
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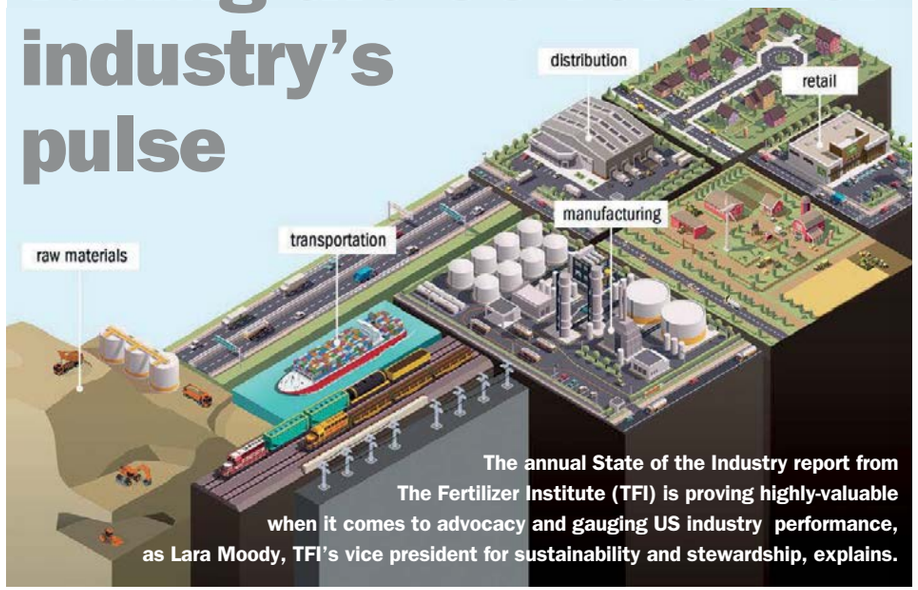
# Taking the US fertilizer industry's pulse




**The annual State of the Industry report from The Fertilizer Institute (TFI) is proving highly-valuable when it comes to advocacy and gauging US industry performance, as Lara Moody, TFI's vice president for sustainability and stewardship, explains.**

The Fertilizer Institute (TFI) can now reveal how well the US fertilizer industry is performing by publishing its annual *State of the Industry* report. This tracks the industry's progress on safety, energy and the environment, and nutrient stewardship every year, using a range of environmental, economic, and social indicators.

## More than just metrics

But the report is much more than a simple narrative about the industry's performance at the production, wholesale and retail levels. Its real value and usefulness is as a tool that the whole industry can access and use in a remarkable variety of different ways.

The *State of the Industry* report is a baseline for internal assessment and a data point to mark progress. It is also a pathway to initiate a sustainability reporting journey, and a roadmap of important industry topics. It uncovers and highlights innovative initiatives, and provides a record of industry actions. Even more importantly, it is how we tell our story, how we bring data to advocacy, and how we present facts that are more than opinions.

From an internal perspective, measuring and evaluating industry efforts is a valuable and constructive way of tracking performance and achieving continuous improvement. The fertilizer industry's future depends on the ability to provide goods and services that help farmers feed the world, while simultaneously improving lives and livelihoods, and protecting the environment. Sustainable growth requires the industry to balance its economic performance with environmental and social responsibilities.

From an external perspective, transparency is a fundamental component of effective stakeholder relations. The ability to influence policy makers and other stakeholders depends on the industry's ability to convey relevant and quantifiable information on its environmental, economic, and social performance. The fertilizer industry is frequently in a defensive position. As we react to policy, evolve and offer solutions, our credibility depends on the ability to substantiate our messages with supporting data. Making assertions without the back-up of dependable, verifiable data and metrics weakens our position.

The *State of the Industry* report assesses economic, environmental, and social impacts to quantify success and track performance. Data submitted for the 2016 report accounted for 93 percent of nitrogen, phosphorus, and potassium fertilizer production capacity in the United States. The industry's wholesale and retail sectors are also represented. The report encompasses product data from TFI member companies. This includes information on fertilizers and associated raw materials manufactured in the United States or imported into the US market. Fertilizer manufacturing sites, crop nutrient wholesalers, and agricultural retail facilities (including blending facilities) all contribute to the report.







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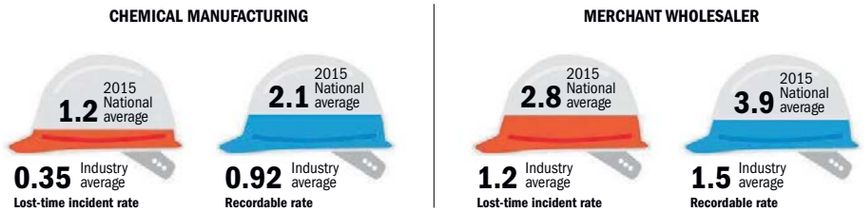



## Internal assessment and progress

It's hard to decide where we're going if we don't know where we've been. Although still in its infancy, industry participation in the *State of the Industry* report is expanding and data from successive years is growing. The 2016 report contained aggregated data from 20 TFI member companies. The goal is to double participation in 2017. Initial reporting efforts yielded a set of benchmarks to create points of reference. In future years, these will yield trends showing stability, change, or improvement.

One key takeaway from the recently-released GlobalScan-SustainAbility Survey was the belief of experts that, a decade from now, leading organizations will be defined by their integrated sustainability strategy, vision, innovation, and transparency. The *State of the Industry* report, by defining metrics for the crucial issues affecting the industry, provides an opportunity for industry members not yet engaged in sustainability assessment and reporting to take steps in that direction. The report tracks progress on sustainability using 21 environmental, economic, and social indicators. Only by measuring and evaluating industry efforts can we identify target areas for improvement.

## Safety

Employee safety is a concern and a focal point for improvement in all industries. There are two common ways to track employee safety: lost time incident rate and recordable rate. Lost time incident rate is defined as the number of employees involved in an injury or illness case (per 100 full-time employees) which resulted in the loss of a day of work. Recordable rate is the number of employees (per 100 full-time employees) involved in a recordable injury or illness. Most individual organisations in the United States track employee safety not only to assess performance, but as a federal requirement.

Safety data reported to the Occupational Health and Safety Administration (OSHA) is collected and made available through nationwide statistics by industry classification. Fertilizer manufactures are considered part of the chemical manufacturing sector, while wholesalers and agricultural retailers are classed as merchant wholesalers.

The *State of the Industry* report therefore allowed a specific comparison between the fertilizer industry and the broader chemical manufacturing and merchant wholesaler sectors. As it turns out, in 2016, the fertilizer industry experienced fewer than one-half the safety incidents compared to national averages (see above). While this information is important for industry advocacy, it also allows industry members to assess their performance against their peers. And, for individual companies or the industry collectively, these data serve as a benchmark for future targets.


SAFETY STUDY

### PotashCorp

A fresh set of eyes is always valuable, and PotashCorp is using that theory in its new 'SIF in the Routine' (SIF) safety initiative. The goal is to discover when workers are unintentionally putting themselves at risk of a serious injury or fatality as they perform routine jobs.

"We want to find potential dangers that exist in our everyday tasks, before they can lead to harm," said Rob Bubnick, PotashCorp's Vice President of Safety, Health, and Environment.

Small teams observe their colleagues as they complete common tasks, paying special attention to when their gut feelings tell them that something may not be right.

"We're looking for those moments when the person observing the work begins to feel uneasy about the task," said Bubnick. "That's our cue that we need to look a little deeper at how the work is being done. People familiar with the task won't see the SIF exposure the same way the person with a fresh set of eyes will."

The audits are a blend of investigation, conversation, and observation.

"We're not looking to find fault. Sometimes people develop more efficient ways to do a task, and they're still being safe and that's great," explained Bubnick. "In other cases, maybe we need to redesign the system in which people are required to work, instead of just asking them to work safer."





## Reporting materiality

The term 'materiality' has been adopted in financial reporting to refer to the threshold at which a factor may affect future earnings – and therefore influence the economic decisions of investors. TFI also reports on materiality, but has defined it more broadly to encompass economic, social, and environmental impacts. This required us to consider issues from the perspective of all our stakeholders, including member companies, regulators and governments, communities and NGOs.

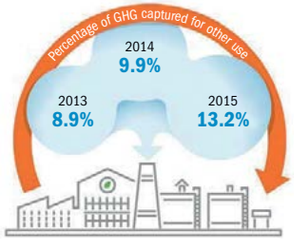
TFI's materiality assessment with member companies identified topics that could significantly impact business performance across the fertilizer industry, now and into the future. As far as possible, the goal was to ensure that the report and its metrics fully-captured the key strategic issues affecting member companies. The materiality data reported are based on metrics covering people and communities, environment and energy, fertilizer transportation, and fertilizer on the farm.

## Capturing greenhouse gases

From an environment and energy viewpoint, all industries must carefully manage their greenhouse gas (GHG) emissions. The US fertilizer industry is responsible for only a small portion of the country's total GHG emissions. But it is often the focal point of discussions by food value chain stakeholders engaged in tracking and reducing GHG emissions.

The capture of carbon dioxide ($CO_2$) during the production process is a valid part of these GHG discussions. High purity $CO_2$ is obtained during ammonia production. Manufacturers are able to capture this as a by-product, instead of emitting it, and use it for downstream processing of urea fertilizer, for which $CO_2$ is a necessary ingredient. It is also sold to other industrial operations for enhanced oil recovery and soft drink carbonisation.

The US Environmental Protection Agency's (EPA) GHG Reporting Program (GHGRP) requires industry members to report emissions from production, manufacturing, and stationary combustion sources. EPA reporting does not, however, account for $CO_2$ captured as a by-product. The *State of the Industry* report, in contrast, does allow us to see that the percentage of GHGs captured as $CO_2$, and how this has increased steadily over the past three years. The report therefore provides accurate data on a positive action that would otherwise not be available.




## Recognising innovation and success

Our industry is not always recognised for its innovation. That's not because fertilizer companies aren't innovative. Rather, as with many in the agricultural sector, we can be modest to a fault. In addition, concerns about competitive advantage may prevent companies sharing information that can lead to industry-wide progress.

The *State of the Industry* report therefore offers an important opportunity to celebrate innovation and success. It also offers insights into those actions which are positively influencing the industry's performance, as shown by the report's indicators and metrics. Valuably, the report also provides an opportunity for companies to highlight their own activities.

The process of creating fertilizer products necessarily involves the consumption of energy. Based on 2015 data, nine companies reported using a direct and indirect energy total of 134.1 million gigajoules (GJ). This is equivalent to 10.6 GJ per nutrient ton produced. However, some manufacturers cogenerate their energy, or use renewable energy or recycled energy sources such as solar power or steam from waste heat. Such steps contribute to sustainability goals by reducing the industry's overall energy footprint. For the 2016 report, companies reported capturing more than 107 million GJ of waste heat in 2015. The thermal energy captured was used for steam production, heating, and electricity generation. This represents energy that otherwise would have had to be purchased or supplied by fuel combustion.

For TFI to advocate effectively on behalf of the industry, we need to relay the industry's success stories. The above figures on waste energy capture represent a positive success for the industry. But to a local planning commissioner, a state legislator, or a Congressman, these numbers need

CASE STUDY

### Research Innovation For 4R Nutrient Stewardship

In 2013, the 4R Research Fund was created by the fertilizer industry. The aim was to expand the implementation of 4R nutrient stewardship across North America by establishing sustainability indicators and environmental impact data. The fund provides much-needed resource support, and focusses on measuring and documenting the economic, social, and environmental impacts of 4R nutrient stewardship.

The US fertilizer industry is committed to providing growers with the tools they need to remain profitable while protecting the environment. In 2015, the industry contributed $1,006,000 to the research fund. Four US projects totalling $366,365 were also awarded to university researchers.

The 4R Research Fund is maintained by the Foundation for Agronomic Research (FAR), a non-profit 501(c)(3) research and education foundation managed by the International Plant Nutrition Institute (IPNI). Funded projects are reviewed and recommended by a multi-stakeholder technical advisory group before final approval by an industry fund management committee.






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PHOTO: TFI

some real-life context. The *State of the Industry* report allows us to do this by identifying member actions and highlighting success.

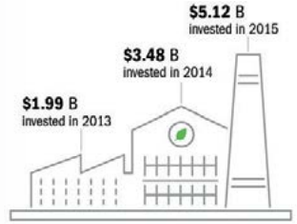
Action taken by TFI member Willard Agri-Service in Maryland provides a great example of industry innovation – one that we would be unaware of without the company's participation in the report. Bob Willard began exploring the possibility of bringing solar power to Willard Agri-Service to reduce electricity costs at one of their agricultural retail facilities. Willard applied for and received a rural small business grant from the United States Department of Agriculture. The grant, along with a combination of federal and state tax credits, put the solar power project on a strong financial path. The installation of the 64-kW system (above) began immediately and it subsequently came online in 2014. As a result, Willard has virtually eliminated the facility's electricity costs by generating solar power and selling solar credits. In the short time the system has been in operation, $CO_2$ emissions have also been reduced by more than 179 tons.

## Presenting the facts for advocacy

Being a good advocate for the fertilizer industry relies on the ability to convey facts and rebut perceived fictions. Any statement not supported by data is simply anecdotal opinion. Specifically, when presenting on an issue or addressing policy, the ability to support a position with hard data is paramount. Additionally, buy-in and support comes from understanding why a requested action matters to the industry as much as it does to stakeholders.

When it comes to advocacy, the *State of the Industry* report is a new tool in TFI's armoury. Data on jobs and capital investment provide concrete insights into the value the industry brings to the communities we serve and work with. With Congress as a primary audience for advocacy, these details are invaluable in showing how our industry creates value in their districts.

The US fertilizer industry is one of the world's largest. The United States is the fourth-largest producer of nitrogen-based fertilizers in the world and the second largest producer of phosphate. The industry generates more than $155 billion in economic benefit and provides 89,000 direct jobs and 406,000 indirect jobs. In 2015, the fertilizer industry collectively made capital investments worth $5.12 billion. Whether purchasing equipment, building a new plant, or improving an existing facility, these investments do more than help companies operate. Each dollar spent strengthens the US economy and the financial well-being of individual communities. What's more, investments that improve infrastructure often have a positive impact on safety, environmental, and energy performance.




Strong irrefutable datasets strengthen and back-up the industry's position when advocating on specific topics. For example, the US fertilizer distribution network is essential for the efficient on-time delivery of fertilizers to farm customers. When logistical challenges arise, data on the key modes of transport, together with an annual assessment of distribution needs, is enormously beneficial during discussions and consideration of potential actions.

Marine, rail, and road are all prominent modes of fertilizer transport. Using data submitted for the *State of the Industry* report, truck shipments seemed most significant, based on an assessment of total tons of material transported. After more detailed scrutiny of the data, truck transport becomes even more important, as each ton of fertilizer is moved by a motor vehicle at least once, and often several times, during its journey.

In contrast, when the transportation data is weighted by distance travelled (ton-miles), the importance of rail stands out. It emerges that 56 percent of all fertilizer is moved by rail on a ton-mile basis. Marine vessels also carry a significant amount of fertilizer, and motor transport is critical on shorter hauls, particularly as the product gets closer to farm customers. Transportation data in the report shows that shipment volumes by rail, marine and pipeline remain relatively steady from quarter-to-quarter, confirming there is no seasonality of shipping needs.

## Reporting for the Future

As in other industries, it is today's actions which will shape future outcomes for the fertilizer sector. Using the *State of the Industry* report, TFI is able to track and assess these actions across the industry as they occur. The report enables the Institute to identify benchmarks, document trends and measure success. Industry-wide participation in reporting is essential for accurate and complete datasets. The data gathered, as well as strengthening and underpinning advocacy by the industry, can also be widely shared through outreach to extend its usefulness.

The *State of the Industry* report is not claiming to be unique. Yet few industry sectors have attempted sustainability reporting at this scale. And the report is certainly pioneering and a pathfinder for agricultural sector transparency. Its compelling and positive narrative, based on authoritative industry data, also puts the fertilizer industry very much on the front foot when it comes to external engagement and outreach. The report is already helping the US Industry steer through a fast-changing landscape. Its usefulness as a guiding tool can therefore only improve, as participation grows and the reporting process evolves. ■

### Further reading

The *2016 State of the Fertilizer Industry Report* is available as a free download from The Fertilizer Institute's tfi.org website.

**CASE STUDY**

## Investment by GROWMARK

PHOTO: TFI

New Century FS, a retail division of GROWMARK, expanded its facilities in Melbourne, Iowa, which serves six of the nine counties in which New Century FS does business. The new facility increases customer service and safety.

The new site features a dry fertilizer shed with a total storage capacity of 11,500 tons, accommodating eight products. State-of-the-art blending capabilities ensure growers get exactly what they ordered, underscoring how New Century FS is helping farmers carefully manage their inputs. The indoor loading scale takes precision a step further by allowing the fast loading of up to 200 tons of product per hour.

The plant's capacity and accurate measurement abilities were its most impressive features, according to Scott Schmidt, a customer from the Grinnell area. "Its size, volume, and technology mean these guys can deliver exactly what they recommend for my fields, and do it safely and accurately. My job is to put it into the ground. Theirs is to tell me exactly what I need," he said.

Safety is a priority for GROWMARK, and the Melbourne facility has several new features that confirm this. The anhydrous loading station features a safety shut-off system capable of being remotely triggered. Additionally, the ag chemical blending building, with its drive-through loading, is designed to protect the environment. The building complex, including the new shop and warehouse, also feature safety curbs able to contain any spills. ■





NORTH AMERICA REPORT





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# North American sulphur market briefing

New Wales sulphur melter.

PHOTO: DEVCO

A shake-up in the North American sulphur and phosphates markets is expected. Sulphur demand in the region has declined, correlating with a downtrend in phosphoric acid production, while sulphur supply has firmed, primarily on an increase in US refining capacity. **Fiona Boyd** of Acuity Commodities reports on recent developments and the outlook for the North American sulphur market.

## Entwined fortunes

Sulphur is consumed in large quantities as a raw material in the manufacture of phosphate fertilizers. Unsurprisingly, given the closeness of this supply chain relationship, the relative fortunes of the sulphur and phosphates markets are intimately entwined, with developments in one impacting on the other.

North America is no exception to this. Further merger and acquisition activity is likely in the North American phosphates industry by the year's end, continuing a trend for rationalisation stretching back 30 years. At the same time, the continued growth in global phosphates production capacity, most notably in Morocco and Saudi Arabia, could also have ramifications for North America's phosphate operators. US-based producer The Mosaic Company, in particular, owns substantial stakes in offshore assets in Saudi Arabia, Brazil and elsewhere.

So, what does all this mean for the sulphur outlook in North America, a region that was the largest sulphur producer on a global basis until it was overtaken recently by the Middle East (*Fertilizer International* 477, p22).

## Downward pressure on supply

Looking forward, Acuity does not expect the upward trend in US sulphur production over the last five years (see box) to continue. Some refiners will take advantage of the US shale boom of recent years and become more inclined towards a lighter crude slate. Acuity expects this to counterbalance other refineries planning to use more heavy crude, with a few projects currently underway, most notably in the Midwest. Meanwhile, we expect sulphur production from natural gas processing to be under downward pressure. US sour gas reserves are not being replaced as they are worked through, owing to the shale gas boom, with a similar trend apparent in Canada.

## Canadian production pressures

Indeed, Canadian sulphur production is under more significant downward pressure than the US, as sulphur recovery from natural gas processing in Canada makes up a greater proportion of supply. Last year, for example, around 45 percent (2.1 million tonnes) of the 4.7 million tonnes of sulphur produced in Canada was derived from natural gas processing. That compares to the 3.8 million tonnes of natural gas-derived sulphur produced in 2011, a loss of around 1.7 million tonnes. While there has been growth in sulphur supply from oil sands upgrading – rising to 2.6 million tonnes in 2016 from just under 2.4 million tonnes in 2011 – this has not been enough to outstrip the decline in supply from natural gas. Although new sources of supply, such as the Sturgeon refinery in Alberta will become operational next year, the outlook for Canadian sulphur production is one of overall decline linked to natural gas trends.

Despite this, companies in Canada are investing in infrastructure to enable the movement of solid sulphur out of Vancouver. This is primarily occurring because existing forming capacity – required to convert liquid sulphur to a solid form suitable for long-haul transport – is geographically mismatched with production. There is no forming capacity, for example, within or nearby the Fort McMurray region, where growth in sulphur production is occurring, albeit slower than expected. Instead, existing forming capacity is located at natural gas plants throughout Canada, where their utilisation is declining due to the previously mentioned production downtrend.

The push for more forming capacity also comes from the desire of Canadian suppliers to move away from the US molten market. Canada has long sent molten sulphur across the border, mostly by rail, to support US phosphate fertilizer operations. Sulphur supplied by rail freight from northern Alberta to the southeast US region, however, is often the most expensive.

These tonnages, because of the transport expense involved, were seen as the most vulnerable when Mosaic began to build its solid sulphur melter at New Wales in Florida. With the looming possibility that it might be more economical for Mosaic to import solid sulphur by ship from offshore

## Phosphates rationalisation

### Many sites, more producers

Before 1990, there were at least 20 active phosphate fertilizer production sites in the US. Many of these were operated by companies that no longer exist – these having been acquired by and subsumed within fertilizer majors. One example is the former operations of Texasgulf, now owned and operated by PotashCorp (PCS).

The structure of the US phosphate industry prior to 1990, and associated high production levels, created a strong demand for sulphur. This was needed to support the production of large volumes of sulphuric acid, which in turn was necessary for the large-scale manufacture of phosphoric acid from phosphate rock.

### Long-term consumption decline

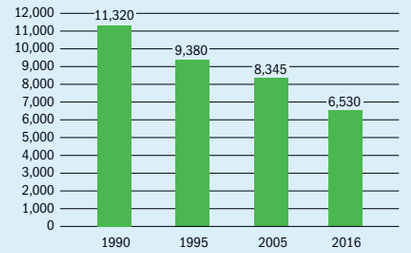
Acuity estimates that a sulphur consumption level of 11 million t/a was needed in the late 1980s to support phosphate production at the time. The two-fifths decline in phosphates industry consumption over the last 25 years has been highly significant for the sulphur market.

Annual sulphur consumption had declined to 9.4 million tonnes by 1995. This was linked to merger and acquisition activity, such as NuWest being folded into Agrium, and closures, including Farmland Industries in Florida.

By 2005, consumption had declined further to an estimated 8.6 million tonnes. Other than the four present day producers, Mosaic, PCS, Agrium and Simplot, only three other US phosphate fertilizer companies remained active: CF Industries, MississippiPhosphates and US Agri-Chem. This was not the end of rationalisation, however. The phosphate fertilizer production assets of CF Industries were acquired by Mosaic in 2013, while the other two operators eventually ceased production prompting further site closures.

The level of US sulphur consumption required to support phosphoric acid production has declined further over the last decade, dropping by around 2 million t/a to 6.6 million tonnes by 2016. This fall was driven by Mosaic's rationalisation of its central Florida operations, PCS scaling-back solids production in favour of liquids at its White Springs, Florida, plant. The 2014 closure of MississippiPhosphates, which had been operative since the 1950s, was a further blow to demand.

Fig. 1: **US sulphur consumption for phosphate production, '000 t/a**




*Source: Acuity*

### Phosphoric acid production downturn

Data from North American trade body The Fertilizer Institute (TFI) confirms the down trend. US phosphoric acid production fell from around 10.4 million tonnes in 2005 to 7.4 million tonnes in 2015, according to TFI, a capacity loss of 3 million t/a over the decade. This is highly significant given that phosphoric acid manufacture consumes around one tonne of sulphur for every tonne of acid produced.



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markets such as Russia, Canadians began to discuss reducing their exposure to the US molten market.

The volume of molten sulphur sent by Canada to the US declined to 1.4 million tonnes last year, down from 1.8 million tonnes in 2015. However, it is not entirely fair to correlate this decline with the ramp-up of Mosaic's New Wales melter, as Canadian wild fires last summer caused notable supply disruption. Molten sulphur shipments from Canada in 2017 have also been affected by unplanned operational issues. Acuity still expects 1.4 million t/a of sulphur to move into the US from Canada in the medium-term, although this volume will be impacted by Mosaic's utilisation of its New Wales melter.

## The fall in Mexican supply

Interestingly, the impact of the New Wales sulphur melter on North American suppliers has been offset by an unexpected decline in imports from Mexico, another molten sulphur supplier to the US.

On paper, the US market should be relatively balanced in terms of sulphur production and consumption. However, exports from the US Gulf Coast have been necessary to balance the market. US sulphur production has been increasing in recent years, at a time when Canadian supply has continued to push into the US, while consumption was trending down. The sulphur trade balance has been further complicated by molten imports from Mexico and Venezuela, and long-standing exports from the US West Coast.

Sulphur production in Mexico first began to decline in the second half of 2015, linked to gas and crude oil contamination, then intensified last year as a result of crude and gas economics. Mexico is importing higher volumes of refined products currently, leading to lower utilisation of its sulphur-producing assets. Some of these assets are also in need of major investment to keep them operating efficiently.

The overall result was that Mexico delivered a lowly 86,000 tonnes of sulphur to the US in 2016, versus the 484,000 tonnes it exported as recently as 2013. The volume shipped from Mexico last year was mostly destined for Mosaic and PCS who, as a consequence, lost several hundred thousand tonnes of supply. The decline from Mexico has therefore shored-up demand for domestically-produced sulphur. Nevertheless, Mosaic still imported an estimated 300,000 tonnes of sulphur last year, versus 100,000 tonnes in 2015. So far this year, Mosaic is also on track to import around 400,000 tonnes of solid sulphur in 2017.

## Offshore exposure

Offshore sulphur export activity out of the US Gulf Coast has been on the increase. This has been driven by the wariness of North American sulphur suppliers over their significant exposure to domestic phosphate fertilizer producers, and an awareness of the need to balance the market. However, a shift to sulphur exports may not be the ideal solution for suppliers, as these also carry significant exposure to developments in the international phosphate fertilizer market.

The primary markets served by the US Gulf Coast are Morocco and Brazil. Encouragingly, the sulphur consumption requirements of large Moroccan buyer OCP continue to grow, as the company adds substantial additional phosphate fertilizer production capacity. The downside for US suppliers is that, as global sulphur production increases, large consumers such as OCP will also benefit from greater sulphur availability and supply choice.

Vale is the largest sulphur consumer in Brazil, importing at least 1.2 million t/a, accounting for around 60 percent of the country's historic imports. Market participants are currently readying themselves for the ramifications of Mosaic's pending acquisition of Vale's Brazilian fertilizer assets. The deal, which is expected to close by the end of the year, means that Mosaic, already the largest sulphur consumer in North America, will also assume sulphur purchasing responsibility for Vale's former Brazilian operations. In the past, these have mainly been supplied out of the US Gulf Coast. The impact of this acquisition on sulphur sourcing strategies and pricing mechanisms has been at the centre of market discussions, as has the lack of diversification that will result.

## Potential for further rationalisation

Given the relatively stable production outlook, sulphur producers naturally remain nervous about the potential for further rationalisation in the North American phosphates industry (see box). Domestic phosphate producers are still the largest consumer of sulphur produced in the US. Mosaic alone consumes around 4.5 million t/a of sulphur to support its US operations, a volume that equates to just under half of total US sulphur consumption.

Such concerns intensified when Canada's PCS and Agrium announced a 'merger of equals' at the end of 2016. This is expected to close late in the third quarter of 2017, at the time of writing. The potential to rationalise phosphoric acid production capacity at Agrium's Redwater, Alberta, plant – Canada's only active phosphate site – was specifically identified as part of the merger. The planned rationalisation involves PCS supplying its excess phosphoric acid to the merged company's Canadian operations, instead of supplying offshore markets such as India, as it does at present. Acuity estimates this would result in the loss of around 300,000 t/a of sulphur consumption in Canada, if Redwater were to close as a result of the merger. The main consequence of this would be increased sulphur availability for export out of Vancouver.

## Phosphates production growth outside the US

There is also potential for more phosphate sector rationalisation in the US over the longer term, especially as lower-cost offshore phosphate fertilizer production continues to grow rapidly. Morocco and Saudi Arabia is where most growth is occurring currently, as previously mentioned. These two countries will increase their supply to major fertilizer import markets such as India. This is making the phosphate fertilizer export business more competitive, as the market has already seen this year. Greater competition could ultimately result in the rationalisation of vulnerable higher-cost US phosphate operations.

Furthermore, Mosaic has a 25 percent ownership stake in the Wa'ad Al Shamal project in Saudi Arabia which began to ramp up in the second quarter. Both its Saudi JV and the pending takeover of Vale's assets could impact on Mosaic's operations in the US. Both these non-domestic production centres have an assumed lower cost of production, and are also closer to markets currently served by US exports, such as Brazil and India.

The US market is already being affected by the growth in offshore phosphates production, as is shown by the surge in US finished phosphates imports from markets such as Morocco in recent years. Long-term rationalisation also appears to be increasingly likely once the preservation of domestic phosphate reserves is factored in.

## Global increase in sulphur recovery

The above domestic developments are happening at the same time as an anticipated increase in sulphur recovery from the oil and gas industry globally. The worldwide demand for sulphur, particularly from the phosphate fertilizer sector, should rise over the long-term. Acuity does, however, expect the sulphur market to be in a net surplus for the next couple of years, as growth in supply continues to outstrip rises in demand.

Changing trade routes elsewhere could also affect North American market dynamics. When Kashagan in Kazakhstan starts exporting sulphur in the final quarter of 2017, for example, its potential destinations include the US as well as Morocco. This project alone has the potential to disrupt current US sulphur trade flows, both out of the US Gulf Coast and into Florida. ■

# Sulphur supply shifts

At the same time as domestic demand for sulphur came under pressure from phosphates industry consolidation, equally significant shifts in US sulphur production and supply were occurring.

### Decline in Frasch mining

The US produced some 11.8 million tonnes of sulphur in 1995, according to the United States Geological Survey (USGS). Of that total, around one-quarter (3.1 million tonnes) was produced 'on purpose' by Frasch mining, being destined for the phosphates sector. One of the major Frasch operations, for example, was the Freeport McMoRan's Main Pass sulphur mine (5,500 long tons/day capacity) which began operating in 1982.

Energy-intensive Frasch mining subsequently declined due to its high costs and the increased availability of lower-cost sulphur produced as a by-product from oil refineries and natural gas plants. By 2005, US sulphur production had declined to 9.5 million tonnes, with no contribution from Frasch mining and more than 90 percent of this volume sourced from refining and natural gas processing.

### Sulphur production firms

US sulphur production fell-back to just over 8.2 million tonnes in 2011, but has since rebounded and grown by almost one million tonnes over the last five years. In 2016, the US produced just under 9.1 million tonnes, around 91 percent of this being derived from crude refining with the balance from natural gas processing.

The rise in US sulphur supply over the last five years largely reflects the growth in production from refining. US sulphur production from crude refining rose from 7.1 million tonnes in 2011 to just under 8.3 million tonnes last year. The appetite for heavy crude has increased, while new coking capacity has also been added, most notably in the Midwest and US Gulf Coast regions. These developments also anticipated an increase in heavy crude supply from Canada. ■





SULPHUR REPORT





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*Koch's Enid, Oklahoma, nitrogen complex.*

PHOTO: KOCH

# Growing the market with new tech

New technology is allowing urea manufacturers to join the fast-growing enhanced efficiency fertilizer (EEF) segment, as **Christopher Muehling**, director for Global Technology Licensing at Koch Agronomic Services, explains.

## Industry moving to EEFs

In a competitive selling environment, urea manufacturers see product differentiation as a way to maintain or increase market share and profitability. Customers are demanding enhanced efficiency fertilizers (EEFs) and value-added products that offer functional efficiency. Farmers are interested in improving nutrient use efficiency and reducing nitrogen losses. This is in part due to pressure from consumers concerned about how their food is produced and its impact on the environment.

With this economic backdrop, adding a production capability for enhanced efficiency fertilizers to existing urea plants is a viable and strategic business option. Projects to achieve this can be successfully implemented, and the risks minimised, by working with capable and reputable partners with a proven track record of installing and operating world-scale, value-added urea production facilities.

Koch Agronomic Services (Koch) is leading the way in helping commodity urea manufacturers move to higher-value products with its innovative *N-TEGRATION™ Technology*.

*N-TEGRATION™ Technology* is a branded platform that allows proprietary Koch additives such as the *AGROTAIN®* nitrogen stabiliser to be integrated directly into granular or prilled urea – ensuring uniform distribution throughout each and every granule. The result: a consistent and higher-value product that can boost both demand and profit for the manufacturer.

## Project design and implementation

Adding a new chemical to the product stream, or modifying processes in an existing operation, is not without risks. The transition from commodity to higher-value production therefore requires careful planning to avoid negative consequences to the base operation. As a first step, Koch begins the *N-TEGRATION™ Technology* analysis via an initial facility assessment. This is followed by the delivery of a process design package and supporting technical services. The overall aim is to ensure a successful and smooth transition at all project stages – from detailed design to implementation and commissioning to the eventual start-up of new, value-added production capabilities.

The Koch team starts with a thorough assessment of the potential licensee's facility, focusing on the areas of the urea plant that could be impacted, as well as understanding product and chemical flows and concentrations. The assessment also determines acceptable levels of risk and identifies ways to protect against chemical interactions, corrosion, product quality changes, and contamination of recycle streams. Storage segregation, changes in transportation, and product handling are also considered.

## The manufacturing process

The *N-TEGRATION™ Technology* platform has a critical, key advantage: it simply bolts-on to an existing facility, working seamlessly with urea manufacturing processes, and doesn't interfere with urea production. In fact, the manufacturing of new value-added products starts with the raw materials which are already on hand.

*N-TEGRATION™ Technology* works with existing granulation or prilling processes to produce homogenous granules that require no additional coating. Proprietary urease and/or nitrification inhibitors from Koch are added to the granules, being specifically engineered to remain active throughout the manufacturing process. The result is a powerful new 46 percent nitrogen fertilizer that requires no additional treatment and is ready to use on-farm. And, because the active ingredients are dispersed throughout the interior of the granule, the technology allows other, additional treatments to be applied to the granule's exterior.

Manufacturers can also easily switch back to production of commodity urea from production of the enhanced efficiency product. The system operator simply stops the flow of proprietary additives, which allows the plant to transition back to commodity-grade urea in a relatively short time. Indeed, the technology is specifically designed to help minimize the changeover time between products.

"*N-TEGRATION™ Technology* allows us to quickly switch between traditional commodity urea production, and value-added EEF technology based on the needs of our customers," said Paul Liddle, plant manager of Koch's affiliate-owned plant in Brandon, Manitoba, Canada. "That production flexibility is key to our ability to provide growers with the products that will provide the most benefit in any situation."

From an agronomic standpoint, incorporated fertilizers can provide multiple benefits. *SUPERU®* fertilizer from Koch, for example, incorporates both urease and nitrification inhibitors. This provides both above- and below-ground protection against nitrogen loss in one easy-to-apply granule. *SUPERU®* fertilizer also allows for broader and more even spread patterns, enabling applicators and growers to cover more acres in less time. Since they are completely soluble, the granules are readily available to the plant.

Koch produces *SUPERU®* fertilizer made with *N-TEGRATION™ Technology* through its affiliate-owned urea plant in Manitoba, Canada, and at its speciality plant in St. Louis, Missouri. Additionally, the company will soon produce *SUPERU®* fertilizer through another affiliate-owned plant in Enid, Oklahoma, as part of a $1.3 billion expansion of that production site.

## Business benefits

The enhanced efficiency fertilizer market offers significant growth opportunities, with worldwide sales forecast to reach nearly $20 billion by 2020, up from approximately $13 billion in 2014. Commodity urea manufacturers can leverage *N-TEGRATION™ Technology* to increase their profits and capture a lucrative share of this dynamic global market with flexible, proven and effective incorporated fertilizers.

For more information on *N-TEGRATION® Technology*, please visit the n-tegration.com website.





ENHANCED EFFICIENCY FERTILIZERS





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# State of the enhanced efficiency fertilizer market

Slow-release, controlled-release and stabilised fertilizers occupy a relatively small but fast-growing and high-value segment of the overall fertilizer market. Production and consumption of these enhanced efficiency fertilizers is accelerating. This trend is unsurprising given that their higher costs can be offset by better use efficiency and lower application rates. We explore the state of the market, regionally and globally, including its major players. The range of products available, and their key advantages over conventional commodity fertilizers, are also described.

Enhanced efficiency fertilizers (EEFs) are a niche but fast-growing and high-value group of plant nutrient products. They include slow- and controlled-release and stabilised fertilizers – hence the label SCRSFs, the other widely-used term for these products.

The Association of American Plant Food Control Officials (AAPFCO) defines EEFs as: "Fertilizer products with characteristics that allow increased plant nutrient availability and reduce potential of nutrient losses to the environment when compared to an appropriate reference product."

To date, a relatively high cost-to-benefit ratio has largely restricted the application of EEFs to turf and ornamental applications, horticulture and high-value cash crops. This is beginning to change. EEFs are increasingly being applied to broadacre crops, as larger sales volumes bring down production costs, and understanding of their benefits becomes more widely understood.

## $20 billion end-of-decade market

From a baseline of $12.9 billion in 2014, the value of the world market for EEFs could grow by as much as eight percent per annum to reach $19.9 billion by the end of this decade, according to some forecasts. Turf and ornamental applications are expected to be the fastest growing segment globally over this period. The Asia-Pacific region, specifically China followed by India, is likely to be the pacesetter for the growth in EEF consumption out to 2020.

EEFs offer farmers distinct cost advantages over conventional commodity fertilizers. They achieve this by delivering significant savings in inputs, labour, energy and time, alongside potential yield improvements. Beneficially, they also increase both nutrient and water use efficiency, and reduce the environmental impacts of applying fertilizers to land.

EEFs benefit crops by avoiding excess and potentially toxic levels of soil nutrients that occur when fertilizers dissolve too rapidly. They also moderate the environmental effects of fertilizer use by reducing nutrient losses, preventing nitrate leaching and NOx emissions, and curbing the volatilisation of ammonia.

To obtain the desired properties, such as slower or regulated nutrient release, the fertilizer content of EEF products is either modified chemically or physically encapsulated within a coating. EEFs are sub-divided into three main product types: slow-release fertilizers, controlled-release fertilizers and stabilised fertilizers, as described below.

[Note: a large number of acronyms and abbreviations are used for different types of enhanced efficiency fertilizers. To help the reader, we have included a list of these at the end of the article.]

## Slow-release fertilizers

Slow-release fertilizers (SRFs) regulate nutrient release to plants using compounds which limit or lower water solubility. They are usually made by reacting urea with aldehydes to form one of three compounds: urea formaldehyde, methylene urea and isobutylidine diurea. This gives SRFs their other name – **urea reaction products**.

Slow-release fertilizers function by either delaying the initial availability of nutrients or extending the time period over which nutrients are released. Slow-release behaviour is primarily determined by the relative proportions of three components: water soluble nitrogen; water insoluble nitrogen (WIN); and slowly-available water soluble nitrogen.

The primary market for **isobutylidene urea (IBDU)** is turf, horticulture and nurseries. Around 90 percent of the nitrogen content (31-32%) present in IBDUs is water insoluble. Nitrogen is typically released over a three month period.

IBDUs can be applied straight or as part of NPK blends. The latter are commonly used for turf, golf courses and sports fields, and are frequently enriched with micronutrients. NPK granules containing IBDU are used to fertilize potted and flowering plants in nurseries, for example, and last for up to a year. IBDU







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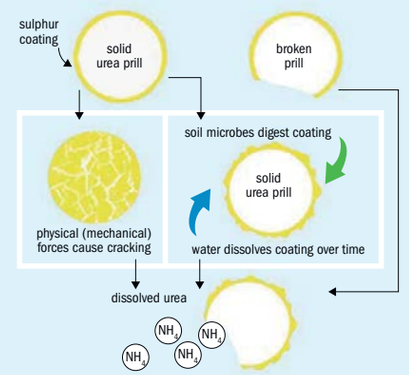
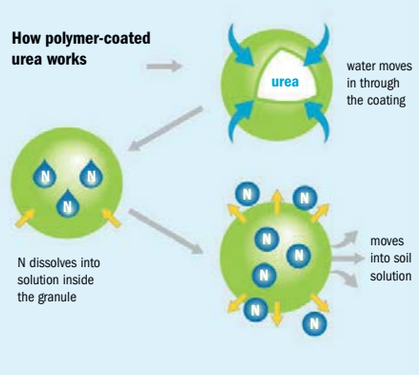
Fig. 1: **Sulphur-coated urea: nutrient release**




*Source: Butzen (2016)*

Fig. 2: **Polymer-coated urea: nutrient release**




*Source: Butzen (2016)*

briquettes provide a slow-release source of nutrients for trees grown for fruit, rubber and timber over an 18 month to three year period.

Commercial IBDU products include the *Floranid* NPK and micronutrient granular fertilizer line offered by European market-leader COMPO Expert. This incorporates the proprietary *Isodur* IBDU technology.

**Urea formaldehyde (UF)** products are used straight and incorporated in NPK blends. Around 60 percent of UF's nitrogen content (38%) is insoluble, and they generally release nitrogen over a three to four month period. UF decomposes bacterially in soils, releasing ammonia and carbon dioxide. The rate of nitrogen release is temperature-controlled and peaks at 20-30°C. Temperature is not the only factor: the chain length of methylene urea molecules within UF products also varies, affecting solubility and nutrient release characteristics.

UF products are sold as straight fertilizers for turf, and can supply nitrogen for up to a year. UF can also be used to produce high-nitrogen formulations, when combined with other nitrogen sources, and NPK blends. These are marketed for cereals, turf, vegetables and fruit. Blends often contain additional nutrients (Ca, Mg and S supplemented by micronutrients such as B and Zn) and humic acids. UF manufacturers include:

- **Koch Turf & Ornamantal:** solid *Nitroform* UF fertilizer
- **Helena Chemical:** *CoRoN* liquid UF formulations

**Methylene urea (MU)** has a high nitrogen content (39%) and is primarily used in turf and horticultural markets. It is used as a straight nitrogen fertilizer in the turf market, being commonly applied on sports fields, golf fairways and domestic lawns. MU is also blended to produce NPK granules and tablets for the horticultural market. These blends, which often incorporate micronutrients, are used by plant nurseries and others for growing ornamental trees, cut flowers, vegetables, potted plants, seedlings and shrubs. MU tablets are used to top dress pot plants and last 4-5 months. Larger MU tablets are designed for forestry and landscaping applications and are capable of providing nutrients for 1-3 years. Commercial MU products include:

- **Aglukon:** *Azolon* liquid and granular fertilizer for turf and horticulture; *Plantodur* and *Plantosan* tablets for tree plantations, tree nurseries and ornamental applications
- **Everris (ICL):** microgranular *SierraformGT* slow-release NK range of turf fertilizers
- **Koch Turf & Ornamantal:** *Nitamin* foliar liquid MU for application on turf, row crops, vegetables and fruits, and granular *Nutralene* product for turf
- **LebanonTurf:** The MU-ammonium sulphate granular turf fertilizers *Meth-Ex 40* MU and *MESA*

## Controlled-release fertilizers (CRFs)

Controlled-release fertilizers (CRFs) use an external physical coating to regulate the release of nutrients. CRFs are suitable for landscaping, plantations, horticulture and open-field arable crops.

There is uncertainty over whether sulphur-coated products fall within the CRF category or should be grouped with SRFs instead. This is because their nutrient release, being heavily influenced by soil conditions, is hard to predict and relatively poorly controlled. For this reason, the International Fertilizer Association (IFA) classifies sulphur-coated products as slow-release, for example. Others such as the AAPFCO classify SRFs and CRFs together so avoiding this distinction.

Sulphur-coated products such as **sulphur-coated urea (SCU)** are primarily targeted at the turf market. They consists of a core of urea coated in sulphur (Figure 1). A wax sealant is generally applied to prevent the damage of brittle sulphur coatings during handling. Nitrogen (30-40%) and sulphur content both vary with sulphur coating thickness. As well as being a cheap and effective coating material, sulphur is increasingly valued as a crop nutrient in its own right (*Fertilizer International* 476, p19).

SCU products typically release nutrients over 6-16 weeks. The rate of nitrogen release depends on coating thickness and uniformity, as well as soil temperature, pH, wetness and bacterial activity. Nitrogen is released quickly from SCU products once their coating fails. Consumption of the wax sealant by soil bacteria degrades sulphur coatings and contributes to their eventual failure.

Leading SCU producers and brands include Kingenta (*Syncote*) and Hanfeng Evergreen in China, and Sun Agro (*S-Coat*) in Japan. Several manufacturers have begun producing sulphur-coated NPKs as well as SCUs.

**Polymer-coated fertilizers (PCFs)** are a more advanced type of CRF product. They release nutrients via a polymer coating which acts as an impermeable or semi-permeable barrier (Figure 2). Release rates are primarily a function of temperature and are therefore more predictable than those of sulphur-coated products. Having a dependable rate of nutrient release allows PCFs to match plant nutrient requirements much more closely over the growing season.

The cost of polymers makes PCF products a more expensive option than suphur-coated equivalents. Their higher price is, however, offset by higher nutrient content (polymer coatings are thinner), greater labour efficiency and lower environmental impact.

**Polymer coated urea (PCU)** products release nitrogen (42-44%) for up to three months. Applications include conventional crops (corn, barley, potato, wheat, rice, cotton etc.) as well as leaf vegetables, tree fruits, melons and vines. PCU products are also targeted at the turf market.

Table 1: **Polymer-coated fertilizers, producers and products**

| Country | Company | Product/brand |
|---|---|---|
| Germany | SQM Vitas/Aglukon | *Plantacote* |
| Germany | COMPO Expert/XIO | *Basacote* |
| Netherlands | Kingenta/Ekompany | *Ekote* |
| Netherlands | ICL/Everris | *Osmocote* |
| Netherlands | Mivena | *Granucote* |
| Canada | Agrium | *ESN* |
| US | Simplot/Florikan | *Gal-XE-One (APEX)* |
| US/France | Haifa Group | *Multicote* |
| US/Japan | Florikan/Chisso-asahi | *Nutricote* |
| China | Kingenta | *Syncote* |
| China | Moith | *Semecote* |
| China | LGAGRO | *Supocote* |
| S Korea | Farm Hannong | *Long Star* |
| Malaysia | SK Specialities | *SK Cote* |

Table 2: **Nitrification inhibitors: Key players, brands and stabilising agents**

| Stabilising agent | Company | Brand |
|---|---|---|
| Nitrapyrin | Dow Agrosciences, US | *N-Serve* |
| (2-chloro-6-trichloromethyl pyridine) | Zhejiang Aofutuo Chemical, China | *NMAX* |
| DCD/DDA (dicyandiamide) | Koch, US | *SuperU** |
| | Solvay | *Agro N-Protect** |
| | SKW Piesterlitz, Germany | *Azlon, Didin, Ensan* |
| | Crisso-asahi, Japan | *Yodel* |
| DMPP (3,4-dimethylpyrazolphosphate) | COMPO Expert, Germany | *NovaTec* |
| DMPP | BASF/EuroChem Agro, Germany | *Entec* |

**Also contains the urease inhibitor NBPT*

The irregular nutrient release of SCU has spurred the development of hybrid **polymer-coated sulphur-coated urea (PCSCU)** products. These use a thin outer polymer-coating to seal the underlying sulphur coating. They typically contain 38-42% nitrogen and 11-15% sulphur, together with less than 2% polymer sealant.

PCSCU products attempt to combine the quality of a polymer-coated fertilizer with the lower cost of sulphur coating, and typically release nutrients over 6-10 weeks. They are generally applied to turf as either a straight nitrogen fertilizer or within NK and NPK blends. Koch's *XCU* and *Poly-S* from Everris/ICL are two notable PCSCU products on the market. XCU has the highest nitrogen content (43%) and lowest sulphur content (4%) of any commercial PCSCU product, according to Koch.

Polymer-coated fertilizers have proliferated in recent years in response to demand. The wide range of CRF products on the market (Table 1) reflects differences in the compostion of coatings and their manufacture.

The *Polyon* range from **Koch Agronomic Services** are manufactured using a proprietary reactive layer coating (RLC) process. This encapsulate fertilizers within an ultra-thin polyurethane coating. The process can be applied to a various substrates including urea, monoammonium phosphate (MAP), muriate of potash (MOP), sulphate of potash (SOP) and NPKs.

Haifa Group's *Multicote* technology and *Plantacote* from SQM Vitas also use a polyurethane coating material. Chisso-asahi's *Nutricote* technology, in contrast, is polyethylene-based, whereas alkyd resin coatings form the basis of the *Osmocote* technology used by ICL/Everris.

## Stabilised fertilizers (SFs)

Stabilised fertilizers (SFs) are a group of plant nutrient products that incorporate a stabilising agent, usually for nitrogen. Stabilisation agents fall into one of two types:

- **Nitrification inhibitors (NI):** these inhibit the bacterial oxidation of the ammonium form of nitrogen into nitrates. This helps prevent nitrate leaching and subsequent $N_2O$ emissions from soil.
- **Urease inhibitors (UI):** these inhibit the hydrolysis of urea and urea ammonium nitrate (UAN) into ammonia and $CO_2$, a reaction catalysed by the urease enzyme. This helps prevent ammonia volatilisation and the nitrogen losses associated with this.



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The nitrogen present in urea, anhydrous ammonia and UAN fertilizers is released into the soil in ammonium form. **Nitrification inhibitors (NIs)** work by preventing nitrifying bacteria from converting this ammonium into easily-leachable nitrates. By doing so, they also prevent subsequent conversion of nitrates into gaseous nitrogen oxides (NOx) by de-nitrifying bacteria. NI stabilised fertilizers function best when applied to wet or poorly drained soils in high rainfall areas. They are generally recommended for fall/autumn application and no-till systems.

Key players in the global NI market and the main brands of stabilising agents are listed in Table 2.

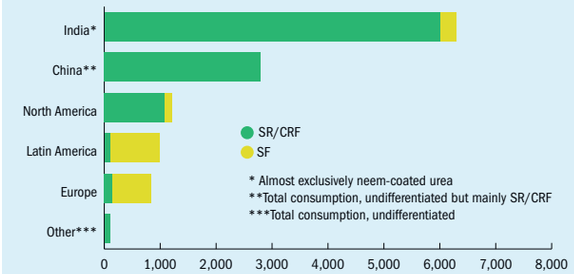
Biochemical processes on the surface of soils can convert urea and UAN into ammonia gas (ammonia volatilisation), carbon dioxide and water. This reaction, known as hydrolysis, is aided by the urease enzyme, a naturally-occurring soil catalyst. The function of **urease inhibitors (UIs)** is to block this enzyme and so stop hydrolysis when urea and UAN are first applied. This prevents volatilisation of ammonia and provides time for fertilizers to sift downwards into the soil profile.

Urease inhibitors are effective for both solid urea and liquid UAN fertilizers. They deliver the most benefit for surface applications in no-till or reduced tillage systems. While urea can be incorporated within soil prior to the seeding of spring crops, such as corn and barley, this is not possible for winter cereals, winter oilseed rape and pasture, which require surface application of fertilizers instead.

While mainly recommended for pre-planting surface applications, fertilizers stabilised with UI can be applied post-planting and pre-emergence in side- or top-dressings. As well as being recommended for soils with high ammonia losses, UIs also provide farmers with greater flexibility on application timings. These type of stabilised fertilizers were originally designed for relatively hot and arid growing conditions found in parts of the US. They are generally less effective in wetter and warmer weather, as soils replenish more rapidly with the urease enzyme under these conditions.

Leading global urease inhibitor brands, such as Koch's *Agrotain,* Solvay's *Agro N-Protect* and BASF's *Limus* products are based on the stabilisation agent NBPT (N-(N-butyl)thiophosphoric triamide) – although *Limus* also contains another UI agent, NPPT (N-(2-nitrophenyl)phosphoric triamide). Solvay's *N-Protect* and Koch's *Super-U* are innovative in that they both incorporate a nitrification inhibitor (DCD) and urease inhibitor together in a single stabilised fertilizer product.

Fig. 3: **Estimated EEF consumption by main region/country, 2014**




*Source: Apostolopoulou (2016)*

## Market overview

The production of EEFs is accelerating rapidly globally, albeit from a relatively low starting baseline. Installed production capacity almost doubled between 2011 and 2014, increasing from around 6.5 million t/a to 12 million t/a over this period[1].

Production is relatively concentrated, both geographically and commercially, with four companies, Koch and Agrium in North America and Kingenta and Hanfeng Evergreen in China, leading the way in terms of production plants and the scale of their output[1]. Other large global players include Israel's Haifa Group, COMPO Expert in Germany, and SQM Vitas, the latter a joint venture between France's Roullier Group and SQM of Chile[2].

Large global chemical manufacturers have also been instrumental in the development of innovative nitrogen stabilisation agents. These include Belgium's Solvay, BASF and SKW Piesterlitz in Germany, Japan's Chisso-asahi and Dow Agrosciences in the US (see Table 2).

That said, smaller players have been equally innovative. In North America, for example, Agrotain International and Pursell were responsible for some of the key breakthrough developments in EEF technology, which were later acquired by major fertilizer producers. Eco Agro Resources (see page 40) and Pursell Agri Tech are continuing the tradition in the EEF sector for technological breakthrough by innovative new companies.

The market for EEFs is potentially large, as consumption growth is mainly constrained by availability and affordability. South Asia and East Asia dominate the global market place.

Controlled- and slow-release products predominate, accounting for more than four-fifths of global EEF demand (12.2 million t/a, excluding Japan). This largely reflects market preferences in China and the US, and India's large-scale consumption of neem-coated urea (Figure 3).

China and India collectively account for almost three-quarters of total world consumption of EEFs. China has emerged strongly as the world's largest producer and consumer of EEFs (2.8 million tonnes). India, meanwhile, is consuming neem-coated urea in ever greater quantities (6.3 million t/a), driven upwards by government mandate[1].

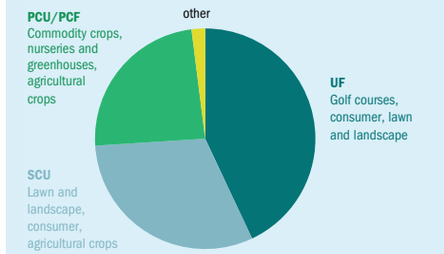
Chinese consumption doubled from 1.4 million tonnes in 2007 to 2.8 million tonnes in 2014. Sulphur-coated urea products have the largest EEF market share in China, and are being increasingly applied to wheat, rice and corn. The use of stabilised fertilizers in China, in contrast, remains in its infancy[1].

The global EEF market outside of China and India amounts to about 3.6 million tonnes, split almost 50:50 between stabilised fertilizers and SRF/CRF products. North America consumes around 1.2 million t/a of EEFs, with SRFs and CRFs accounting for about 90 percent of the market. Latin American consumes EEFs in similar amounts (1.0 million t/a), although the market there is overwhelmingly for stabilised products (900,000 t/a), which account for more than nine-tenths of consumption[1].



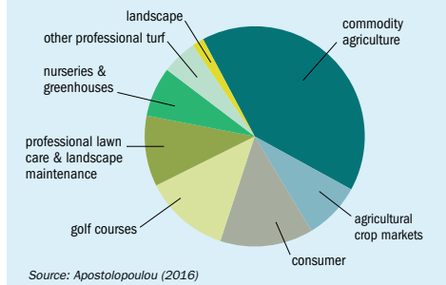


Fig. 4: **US market for SRFs & CRFs, by product type**



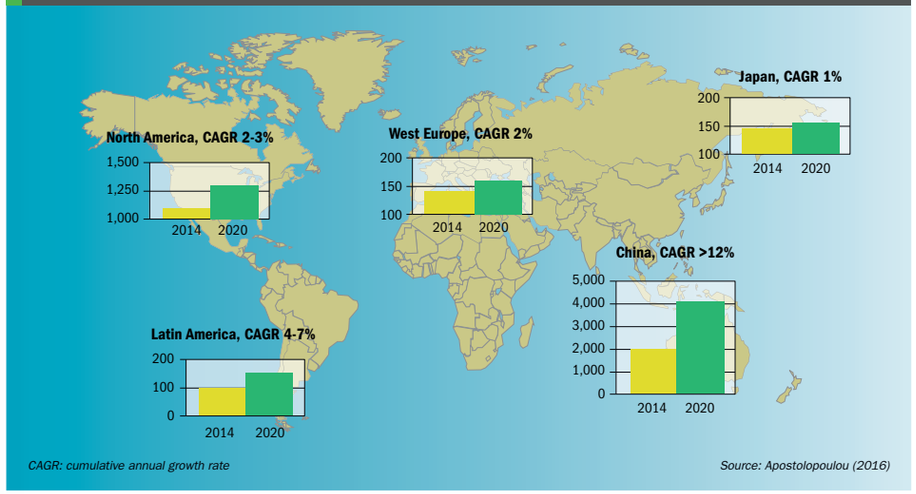

*Source: Apostolopoulou (2016)*

Fig. 5: **US market for SRFs & CRFs, by end-use**




*Source: Apostolopoulou (2016)*

Fig. 6: **Market outlook for SRFs and CRFs, 2014-2020**




*CAGR: cumulative annual growth rate*

*Source: Apostolopoulou (2016)*

The large SRF/CRF market in the US divides fairly evenly between turf & ornamental and agricultural applications, with urea-formaldehyde and sulphur-coated urea having a particularly strong market presence (Figures 4 and 5). Coated products in particular have been the fastest-growing segment in both the US and Japan in recent years.

Western European consumption of EEFs (840,000 t/a) is slightly lower than in Latin and North American markets. Europe is the largest regional consumer of stabilised fertilizers (700,000 t/a) after Latin America – Europe's demand for SFs being 4-5 times higher than for SRFs/CRFs. Slow- and controlled-release fertilizer use in Europe (just 140,000 t/a) is spread relatively equally between four market segments: horticulture (28%), turf (26%), agricultural (24%) and home gardening (22%). EEF consumption in other regions such as the Middle East, Africa (80,000 t/a) and Central Europe (20,000 t/a) remains minor currently[1].

China and Latin America are setting the pace on EEF market expansion, with annual growth rates of 12 percent and up to 7 percent, respectively, forecast between now and the end of the decade (Figure 6). Moderate growth (2-3% p.a.) is also expected in Europe and North America out to 2020.

## Kingenta continues to rise

Kingenta of China is currently the largest and fastest-growing global producer of EEFs. The company markets a wide range of SCUs, PCUs and PCSCUs, together with polymer-coated NPK-based controlled release fertilizers[2].

Supportive government policies have helped China become the largest global producer and consumer of EEFs. Kingenta has played a key role in this emergence. The company is China's largest EEF manufacturer with production plants in Shandong, Henan and Liaoning. Kingenta's production capacity for coated PCSCU,





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PCUs and bulk-blended NPKs stood at 1.8 million tonnes in 2015, equivalent to a 61 percent share of China's total EEF production capability (2.95 million tonnes).

In July, Kingenta confirmed plans to set up hundreds of new crop production service centres across China over the next five years, assisted by a $200 million finance package from the IFC, The World Bank's investment arm (*Fertilizer International* 478, p13). The new centres will promote climate-smart agriculture in China and encourage the country's 50 million farmers to switch from commodity fertilizers to EEFs.

## North America: innovation, acquisition & expansion

The story of the North American EEF market has been one of innovation M&A activity, and growth. **Koch Agronomic Services**, formed in 2010, acquired the *Nitamin 30L* and *Nitamin Nfusion* product lines from Georgia-Pacific Chemicals in 2011. Both products are triazone-containing MU polymers. Koch's purchase of Agrotain International's urease inhibitor technology later that year, provided the company with a strong stabilised fertiliser portfolio and market presence.

Koch further strengthened its market position by buying Agrium's turf and ornamental business for $85 million in 2014. The purchase included market-leading coated CRF products previously offered by Agrium Advanced Technologies. Notably, the deal gave Koch the ownership of production facilities in Sylacauga, Alabama, previously operated by Pursell until their sale to Agrium in 2006, and control of the *Polyon* polymer-coated urea brand. Agrium had been the only company in the North America supplying polymer-coated fertilisers for commodity crops at this point[1].

**Agrium** remains a strong player in the CRF market through its well-established polymer-coated urea *ESN* (environmentally smart nitrogen) brand. The company successfully markets and sells *ESN* on a large scale, targeting maize, winter wheat and forage crops in North America. The company owns two *ESN* plants, one in New Madrid, Missouri, and another in Carseland, Alberta.

**Everris**, a Netherlands-headquartered business owned by ICL, operates three EEF production sites in the US. ICL acquired Scotts' Global Professional $270 million in 2011, renaming it Everris. The company, which also supplies the Middle East, Africa, Malaysia and Indonesia, markets the following products:

- The *Osmocote* and *Peters* brands for container nursery and bedding plants
- *Sierraform, Sierrablen* and *ProTurf* for sport fields, golf and landscape
- *Agroblen* for vegetables, fruits and arable crops

Other US players include Haifa Nutritech, Helena Chemical, John Deere, Momentive, Morral Companies, Tessenderlo, JR Simplot Weatherly Consumer Products and Yara.

## Europe: diverse producers

Europe has strengths in both CRF and stabilised fertilizer production. Everris in the Netherlands, COMPO Expert in Germany and Haifa Group in France are major suppliers of coated products. Germany's BASF and Belgium's Solvay are major manufacturers of nitrogen stabilisation agents. BASF makes the *Entec* nitrification inhibitor for EuroChem Agro and IBDU for COMPO Expert.

Europe's market has also consolidated in recent years as a result of the following mergers and acquisitions:

- ICL's purchase of Everris in 2011
- The sale of German producer Aglukon's *Plantacote* CRF product range and Dusseldorf production plant to SQM Vitas in 2013
- COMPO Expert's acquisition by London-headquartered investment group XIO in 2015, having invested €65 million in its slow-release production plant at Krefeld, Germany
- The purchase of Netherlands manufacturer Ekompany and its *Ekote* PCF brand by Kingenta in 2016

**Haifa Group** started producing polymer-coated fertilizers from a new plant in Lunel Ville in the south of France in 2014. The state-of-the-art, 16,000 t/a capacity plant manufactures the company's *Multicote* and *CoteN* CRF product lines. As part of its global expansion plans, Haifa followed this by opening a similar 20,000 t/a capacity CRF plant in Savannah, Georgia, in the US in 2016. Haifa has customised its *Multicote* range to supply different segments of the market:

- *Multicote*: nurseries and ornamentals
- *Multicote Agri* and *Multigro*: agriculture
- *CoteN* for arable crops
- *Multicote Turf* and *Multigreen*: professional turf and domestic lawns

Sadepan Chimica is Europe's leading producer of urea-reaction products, operating plants in Belgium and Italy. Lanxess in Germany produces CRFs based on ion-exchange resins. Greek company Sulfur Hellas is the EU's sole producer of suphur-coated urea[1].

## Japan: a self-sufficient producer

Japan is another important centre for EEF production, particularly for coated products. The country boasts eight main EEF manufacturers and is largely self-sufficient, with the exception of UF imports. **JCAM AGRI**, which brings together Chisso-Asahi and Mitsubishi Chemical, is Japan's leading producer. The company produces CDU and PCU products and is Japan's only IBDU producer. Other Japanese EEF producers include[1]:

- Co-op Chemical Co Ltd: polymer-coated NPKs
- Central Chemical: alkyd-coated complex fertilizer and alkyd resin-coated urea
- Katakurra Chikkarin Co Ltd: PCU and coated NPKs
- MC Ferticom Co Ltd: PCU
- Sumitomo Chemical Co Ltd: PCU
- Sun Agro Co Ltd: UF, PCU and SCU products
- Taki Chemical Co Ltd: PCU

## Conclusions

Enhanced efficiency fertilizers, although traditionally strong in the turf & ornamental market, are starting to displace the use of commodity fertilizers in agriculture.

"Use of slow and controlled release fertilizers has been previously confined to the high-end horticulture, amenity and golf course markets where end-users generally have bigger budgets to support the higher costs but equally realise the advantages of the better performance," comments Integer Research[2]. "However their use is now beginning to spread into the broad-acre crops such as maize and potatoes, particularly in Asia."

Stabilised fertilizers incorporating nitrification inhibitors are currently applied to 1.82 million hectares in the US and 200,000 hectares in Europe, for example – although this is still equivalent to just 1.16 percent and 0.29%, respectively, of total cropped area[1].

Rising sales and growth in consumption should bring down production costs, enabling EEFs to be priced more competitively. This, in turn, should stimulate demand, pricing being one of the main limits on consumption at present. The scaling-up of production is being given a helping hand by companies such as Koch Agronomic Services. Koch is encouraging third-party producers of commodity urea to switch to EEF production by licensing its *N-TEGRATION* technology (see feature p28).

Although their higher cost can be prohibitive, the use of EEF products is advantageous and warranted in specific circumstances[3]. These include:

- The cultivation of high-value crops
- When surface fertilizer applications are necessary and incorporation is not an option
- In foliar/remedial fertilizer applications
- Applications on soils associated with high nitrogen losses
- Light-textured, leachable soils
- Low-lying, heavy soils at risk of ponding and denitrification losses
- Applications within environmentally-regulated watersheds
- Applications on fields bordering streams, rivers and lakes
- When weather, field and crop conditions (or labour and equipment restrictions) limit the opportunity for repeat applications

The indirect economic costs of inefficient nitrogen use are a multibillion dollar problem globally. Nitrogen losses equate to the wastage of around a quarter of global urea production, a staggering 38 million tonnes, according to some estimates (*Fertilizer International* 477, p39).

Farmers and the environment currently pay the price for widespread inefficiencies in nitrogen fertilizer use. Nitrogen losses also represent a major waste of public subsidies in some markets such as India. Unsurprisingly, nutrient use efficiency is rising up the political agenda, both nationally and internationally. In particular, China's aim of zero growth in fertilizer use by 2020 and the new UN sustainable development goals (SDGs) should give enhanced efficiency fertilizers a sharp policy push, as neither can be delivered without a step-change in use efficiency. ■

### Common abbreviations/acronyms

CDU Crotonylidene diurea
CRF Controlled-release fertilizer
EEF Enhanced efficiency fertilizer
IBDU Isobutylidene diurea
MU Methylene urea
NCU Neem-coated urea
NI Nitrification inhibitor
PCF Polymer-coated fertilizers
PCSCU Polymer-coated sulphur-coated urea
PCU Polymer-coated urea
SF Stabilised fertilizer
SCRSF Slow- and controlled-release and stabilised fertilizer
SCU Sulphur-coated urea
SRF Slow-release fertilizer, also known as urea reaction products
UF Urea-formaldehyde
UI Urease inhibitor

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# Eco Agro: taking inhibitors to the next level

Developing enhanced efficiency fertilizers (EEFs) and bringing these products to market requires companies and individuals with an entrepreneurial spirit. Our US correspondent **Mark Evans** profiles Florida-based Eco Agro Resources, a pioneering company led by entrepreneurs with a successful track record in fertilizer innovation.

While the classic commodity market for fertilizers such as urea is a mature one, in terms of manufacturing and distribution technologies, the desire to make fertilizers perform with greater efficiency has galvanised many within the industry. Two such people are David McKnight and Ray Perkins of Florida-based Eco Agro.

PHOTO: ECOAGRO

*Farmer group listening to EcoAgro experts.*

## Inhibitors 2.0

David and Ray are proven innovators. Previously, they supplied key raw materials to help support growth at Agrotain International, the former owners of the urease inhibitor *Agrotain*. They also happen to share a common vision about how to advance both urease and nitrification inhibitors to the next level – so making nitrogen fertilizers increasingly effective and more affordable to farmers. In effect, David and Ray were looking to develop and promote 'inhibitors 2.0'.

Eco Agro, founded in 2013, is the vehicle they chose to achieve this goal. The US-based nutrient efficiency company has a simple yet highly ambitious mission. It wants to bring to market innovative fertilizer technologies that will help the world's farmers become more productive.

Andrew Semple is a third key member of Eco Agro's management team. He joined the company at an early stage, having previously played a pivotal role in the worldwide promotion of *Agrotain*, also during its period of ownership under Agrotain International.

Andrew's expertise in 70 countries helped create Eco Agro's global distribution network and company infrastructure. Eco Agro's business ethos is based on a responsible economic and agronomic approach. This has helped the company successfully bring to market innovative, quality products in the increasingly competitive agricultural nutrients sector.

As a company, Eco Agro brings together extensive advanced technology expertise, along with training skills. It is also completely committed to the success of its global partners. Eco Agro has grown fast over the last three to four years. Today, it comprises 18 team members, is conducting business in 26 countries, and has 32 research initiatives.

Impressively, Eco Agro products have been applied to crops grown on more than 3.55 million acres. The company now has offices in Florida, North Carolina, Canada and Brazil. Ray Perkins and Andrew Semple helm the business, as the presidents of Eco Agro and Eco International, respectively, while David McKnight acts as chief technology officer.

## Serial innovators

Eco Agro markets two nitrogen stabiliser products for urea granules and urea ammonium nitrate (UAN), both incorporat-







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ing its proprietary *PENXCEL* technology. Its innovative urease inhibitor (UI), *N YIELD*, blocks the urease enzyme and improves plant take-up of nitrogen by reducing volatilisation losses. Sister product *N-BOUND* contains a nitrification inhibitor (NI) which blocks the microbial oxidation of ammonium to nitrate in soil, reducing leaching and denitrification losses.

Eco Agro has a track record of bringing new types of enhanced efficiency fertilizer products to market. In 2015, the company focussed its attention on a novel phosphate fertilizer additive, *PHOS GAIN*. Last year saw Eco Agro introduce the *NEON* family of products, the latest innovation to incorporate *PENXCEL* technology.

## The expanding *PENXCEL* portfolio

The *PENXCEL* technology developed by Eco Agro improves the nutrient efficiency of nitrogen and phosphate fertilizers. Eco Agro has used *PENXCEL* as a launch pad for a full range of innovative new products. As well as enhancing nutrient efficiency, *PENXCEL*-treated products have superior blending and handling properties.

*PENXCEL* technology has lower viscosity, making applications in colder weather easier. It penetrates deeper into the urea prill, coating faster and more consistently than earlier urease inhibitor products. The treatment process can be finished up to 25 percent faster than was possible previously.

Tests by West Texas A&M University have shown that *PENXCEL* performed particularly well in challenging Texan field conditions. The innovative inhibitor provided consistent results that are amplified under tougher conditions. The better activity of the product was attributed to its more consistent coating ability and its deeper penetration into urea prills. "Our *PENXCEL* technologies are showing tremendous results in field and plot trials," says Luciano Lucero, Eco Agro's business development and research director. "We also utilise field days, on-farm testing, and cooperation with well-respected research institutions, to show our technology's value."

## *N YIELD* and *N-BOUND* inhibitor products

The *N YIELD CX* urease inhibitor, the inaugural product in the *PENXCEL* range, was quickly followed by two more products: the *N-BOUND* nitrification inhibitor and *PHOS GAIN* phosphate enhancer.

*N-BOUND*, which incorporates the proven DCD (dicyandiamide) nitrification inhibitor as an active ingredient, has been successfully marketed for three years. It is immediately ready-to-use, going into suspension instantly in UAN fertilizers. The product obviates the need to empty bags into inductors, or hoist bags onto the top of a tank. Its use eliminates the need to add dusty, powdered products that float or do not blend well.

*N-BOUND*'s active DCD ingredient is essentially a non-toxic and water-soluble compound. It is biodegradable in soil leaving no lingering residues, as it simply decomposes into $CO_2$, ammonia and water.

Brazil's Rio Grande do Sul Federal University undertook extensive tests on *N YIELD* and *N-BOUND* in 2015/16. Trials on corn compared the application of 241 lb/acre of untreated urea against similar applications of:

- Urea treated with *N YIELD*
- Urea treated with *N-BOUND*
- Urea treated with both *N YIELD* and *N-BOUND*

Crop yield and quality were both enhanced considerably by the application of treated urea products, especially by the combined *N YIELD* and *N-BOUND* treatment. Corn yield was 176 bushels/acre with the untreated urea. This increased to 184 bu/acre with the *N-BOUND* treatment, and to 195 bu/acre with *N YIELD*. The combination of *N YIELD* and *N-BOUND* yielded an impressive 219 bu/acre.

## Enhancement using *PHOS GAIN*

Eco Agro's *PHOS GAIN* is an innovative phosphorus enhancer that protects phosphate fertilizers. Phosphorus can often become locked-up in soil by the metals present, such as aluminium, iron and magnesium. The presence of calcium and soil pH also influence P availability. *PHOS GAIN* functions by preventing phosphorus from being tied-up by metals present in the soil. Its use as an enhancer helps to ensure that phosphate fertilizers are plant-available and therefore more effective.

*PHOS GAIN* has been a game-changing innovation, according Andrew Semple: "Perfecting the formulation and specific molecular weight of *PHOS GAIN* allows it to change the rules of the game for P in the soil. It works on granular and liquid fertilizer."

Other currently-available phosphate enhancers are water-based – and less effective because of this. *PENXCEL* technology overcomes this problem, as its water-free formulation doesn't interfere with the soil reactions being controlled. "The technology in *PHOS GAIN* was first used to enhance performance of oilfields. But we developed a unique, water-free formulation that allows the active ingredients to work more efficiency in protecting phosphorus," explains Andrew Semple.

In the past, coverage has been a problem with fertilizers such as diammonium phosphate (DAP) and monoammonium phosphate (MAP). Previous inhibitors were difficult to apply on phosphate fertilizer granules. Too little would render the inhibitor ineffective, whereas too much would make the blend soggy. "Our formulation is rather forgiving," says Andrew Semple. "It minimises the hassle of application and supplies consistent coverage, so you and the fertilizer aren't left exposed."

## The new *NEON* product family

The *NEON* family of nitrogen stabilisers is the latest innovation to use *PENXCEL* technology. *NEON Air*, *NEON Surface* and *NEON Soil* products are combination technologies. Each is designed to protect against volatilisation, nitrification and leaching in one product, depending on soil and climatic conditions. They all incorporate the proven urease inhibitor NBPT and the nitrification inhibitor DCD.

Combining the Greek word Neo (new) with N, the chemical symbol for nitrogen, Eco Agro believes its new product range represents a new era for nitrogen fertilization.

The *NEON* family, by combining two inhibitors in each product, offers triple-action control of nitrogen loss, as the technology prevents volatilisation, denitrification and leaching. Combining key inhibiting functions in a single product also reduces the amount of liquid added to urea by two quarts/acre, compared to adding the same inhibitors separately. This keeps urea granules drier, reduces blending time and improves cold weather performance.

Eco Agro offers three distinct *NEON* formulations for specific uses with urea:

- *NEON Air* is designed for use primarily against nitrogen loss to the air
- *NEON Surface* is a balanced blend formulated for protection against nitrogen losses to the air and in the soil
- *NEON Soil* is built for the protection of nitrogen where leaching in the soil is the primary concern

All three products are also suitable for use on UAN.

*NEON Air* has been formulated with the highest concentration of NBPT, the world's leading urease inhibitor. It is primarily for use on the soil surface, where volatilisation is the challenge. The active ingredient content is 45%, comprising NBPT (30%) and DCD (15%).

*NEON Surface* has been designed for surface applications where residue, rainfall or irrigation are significant. The content of active ingredients is 42.5%.

*NEON Soil* has been formulated for use in soil where leaching is the principal problem. The product protects against surface losses for a short time before rain or irrigation takes nitrogen down into the soil. A typical application rate of four quarts/acre reduces urea wetness. *Neon Soil*'s breakthrough formulation allows the application of significant quantity of DCD to urea. The active ingredient content is 35%, comprising 5% NBPT and 30% DCD.

Using urea treated with Eco Agro's next-generation of inhibitors holds considerable promise for a wide-range of value-added crops, including rice (upland, lowland and flooded crops), corn, wheat, cotton, lettuce, broccoli, carrots, as well as sugar cane and pasture crops. Researchers are also evaluating the performance of the new combined inhibitor products on citrus crops.

"This is a significant and exciting step forward in nitrogen efficiency. We will keep pushing the envelope with new technologies in the entire enhanced efficiency segment," said Eco Agro's David McKnight, whose team led the development of *NEON* technology.

The US Patent and Trademark Office issued patent number 9-367-420 covering the *NEON* product range in January this year. The patent covers over 100 possible combinations of different active ingredients.

"It is important to understand the massive capabilities of these patents. Now a combination of widely used NBPT urease inhibitors alongside the most used nitrification inhibitors can be applied *onto* fertilizers," emphasised Andrew Semple. "This is another breakthrough for the developing enhanced efficiency fertilizer (EEF) industry. With these *NEON* products, fertilizer can now be protected from both above- and below-ground losses, while being treated in one single stage at a fertilizer dealer." Before this breakthrough, combining inhibitors at this scale could only be done at the nitrogen plant prior to distribution.

## Moving to inhibitors 3.0

The fertilizer industry has frequently attracted criticism for its slowness in developing and embracing new technologies. Only last year, for example, a speaker at the Green Markets Specialty Fertilizer Conference commented on the absence of new fertilizer patents. Similar comments were also made by a speaker at the International Fertiliser Society's Technical Conference in London in June.

Eco Agro is one company helping to reverse the industry's reputation for technological stagnation. By announcing three new patents, and helping move the market away from commodity fertilizers, it is proving the naysayers wrong. The pace of change in the added-value market is rapid. "We are moving fast from inhibitors 2.0 to inhibitors 3.0," said Ray Perkins.

Combining the functions of urease inhibitors and nitrification inhibitors together in single products should help overcome cost barriers preventing the widespread production and application of enhanced efficiency fertilizers. The fact that the latest generation of inhibitors can be applied at local-level, after fertilizer production, also removes a significant barrier to greater wholesale adoption. ■





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ifa INTERNATIONAL FERTILIZER ASSOCIATION

The International Fertilizer Association (IFA) is helping to fully develop the career potential of younger employees through the recently-launched Young Professional 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 young industry professionals. These highlight the wide range of attractive and rewarding career options available to young people in the fertilizer sector. In the first of the series, Grace Chilande of the International Fertilizer Development Center (IFDC) in Nairobi, Kenya, talks to us about her career so far. ■

PHOTO: IFA

# Young professionals

## Grace Chilande, 26 fertilizer market specialist

**How did your career in the industry start?**
My first break was purely by chance. I started out as an intern working on agricultural value chains. A couple of months in, there was an opportunity to work on fertilizer market analysis. Since then, I've never looked back.

**What achievement are you most proud of?**
Well, being part of a team of analysts and assessing the Sub-Saharan African fertilizer market is highly satisfying. I've also been lucky enough to attend international conferences in Paris, Cape Town and Marrakech on behalf of IFDC. Seeing my market presentations being well received at those events– that's what I'm most proud of.

**What do you find most rewarding about your job?**
It has to be communicating my knowledge about the African market, and earning respect for my expertise. Foreign travel has allowed me to interact with lots of industry professionals who, one way or another, are all interested in Africa. The continent is the next market that international players want to expand into. The crucial, fundamental assessments that I put together bridge big knowledge gaps – and that's very much appreciated by all investors.

**What hurdles have you had to overcome?**
Being a young African woman, in an industry that is still patriarchal and hierarchical, means I have needed to work much harder to earn my place. Fortunately, I have been lucky enough to receive strong support at IFDC from day one. But I still feel there is a big need for dedicated mentorship of young people, especially in Africa.

**How do you get the best from yourself and colleagues?**
I have three people reporting to me. Maintaining an open door policy is important. My colleagues all know they can come and talk to me. I do like a friendly office where people are free to discuss work-related or personal issues over a coffee.

**Has mentoring been important to you?**
I am where I am because of mentoring. For any young professional, it is key – without mentorship people would drown. I started with no background in this field. Yet someone took the time to support me, help me do my job competently, satisfying customers and working professionally with colleagues.

**Will your job and the industry change in future?**
Yes, the industry will change. Food security will continue to be a problem in coming years. Population growth and climate change will ultimately require more efficient use of African agricultural land. My job will change as well. For strategic analysis of fertilizer markets, you do need to stay relevant and keep up-to-date.

**Would you recommend a career in the sector to others?**
Yes, because the industry is at an exciting stage currently – especially the African fertilizer scene! It's actually a cool industry, a dynamic sector. Whether it's fertilizer or seeds, working for an NGO, or as part of the private sector, there are so many opportunities for women and men now, up and down the value chain. ■





# Small-scale ammonia production

The co-location of small-scale ammonia plants could help avoid transport risks and costs. We explore the safety advantages, technology options and the economic viability of small-scale ammonia production.

Table 1: **Reference small-scale plants with GHR**

| Location | Product | Design capacity | Operation |
|---|---|---|---|
| Severnside, UK | ammonia | 2 x 450 t/d | 1988 – 2008 |
| Yazoo, USA / Moranbah, Australia | ammonia | 450 t/d | 1998 – 2004<br>2012 – today |
| Laverton, Australia | methanol | 162 t/d | 1994 – today |
| New Zealand / Trinidad | demonstration plant (methanol) | 36 t/d | 2002 – 2004<br>2011 – 2013 |

*Source: thyssenkrupp/Johnson Matthey*

Eighty percent of global ammonia production is earmarked for the fertilizer market. This includes the use of ammonia as a feedstock for the manufacture of nitrogen fertilizers, such as urea, and the direct injection of ammonia into soils. Large quantities of ammonia are also consumed during diammonium phosphate (DAP) and monoammonium phosphate (MAP) production, and by ammonium nitrate and nitric acid plants. Other important industrial ammonia users include wastewater treatment, refrigeration and power plants, nylon manufacturers and pollution control systems.

Many industrial consumers import ammonia by railcar or truck, and may have relatively small requirements individually. Collectively, however, ammonia is shipped by road and rail on a large scale globally. Some 1.4 million tons of anhydrous ammonia was transported by railcar in the United States in 2014, for example, in comparison to dry fertilizer shipments of 9.9 million tons in that year.

For a number of reasons, the transport of ammonia in the US has fallen by more than two million tons since 2005. Railroad companies have reacted to accidental derailments by seeking to avoid or minimise the transport of ammonia – a hazardous material that is toxic if inhaled. They have also sought to cover their exposure to such risks by raising their transport rates and by passing the liabilities associated with ammonia transport onto shippers and receivers.

## Johnson Matthey/thyssenkrupp small-scale concept

One way of avoiding transport risks and associated costs is co-locating the production and consumption of ammonia on a single site. Because of this, interest in the co-location of small-scale ammonia plants (less than 600 t/d capacity) is on the rise. This is in marked contrast to the general nitrogen industry trend for ever larger capacities in ammonia and urea production, driven by economies of scale.

In response to renewed interest in production at lower capacity, Johnson Matthey and thyssenkrupp Industrial Solutions have joined forces to develop a competitive small-scale ammonia plant (270 to 550 t/d). This features a gas heated reformer (GHR), pressure swing adsorption (PSA) and a low-pressure ammonia synthesis loop. The technology is well-proven having been operative in a number of plants in the UK, the US and Australia for 20 years. The two partners are currently developing the concept further and modularising construction to lower costs.

The economics and process requirements for ammonia production at small-scale differ from those of conventional, large-scale manufacture in a number of key ways. As a general rule, the capital cost (per tonne of capacity) of reformers rises as ammonia plant capacity falls. Although production is not generally economic at a scale of less than 600 t/d. the capital cost disadvantage of small-scale production can be overcome by adopting a gas heated reformer (GHR). This avoids the need for external firing and associated waste heat recovery and combustion systems.

Importantly, the separation and recovery of high purity $CO_2$ from synthesis gas is not usually necessary in small-scale ammonia production, as urea manufacture is not generally the target market. This allows pressure swing adsorption (PSA) to be selected, thereby improving small plant economics. Slightly lower process efficiencies may also be acceptable in smaller plants – if ammonia is produced for higher-value markets and not straight urea production.

## Small-scale GHR reference plants

Five small-scale GHR reference plants have been built to date, although only two of these are currently operational (Table 1). Three of these references are 450 t/d ammonia plants based on ICI's Leading Concept Ammonia (LCA). Two of these were operated at the Severnside Works in the UK between 1988 and 2008 (Figure 1). The LCA units replaced two, less efficient original plants built in the 1960s. Severn-

*Fig. 1: The two LCA plants at Severnside (shutdown 2008).*





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# The thyssenkrupp/Johnson Matthey small-scale process

Table 2: **Main features of the small-scale ammonia process**

| Problem | Solution |
|---|---|
| Scale-down of steam reformer not cost-effective | Gas heated reformer (GHR) |
| Wet $CO_2$ removal expensive | Pressure swing adsorption (PSA) |
| Low volumetric flow rates impede use of centrifugal compressors | Low synthesis pressure to allow for centrifugal compressors |
| Machinery with low shaft power | Generator turbine for consumption of excess steam, electric motor drives for all process compressors |

*Source: thyssenkrupp/Johnson Matthey*

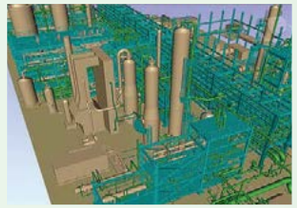
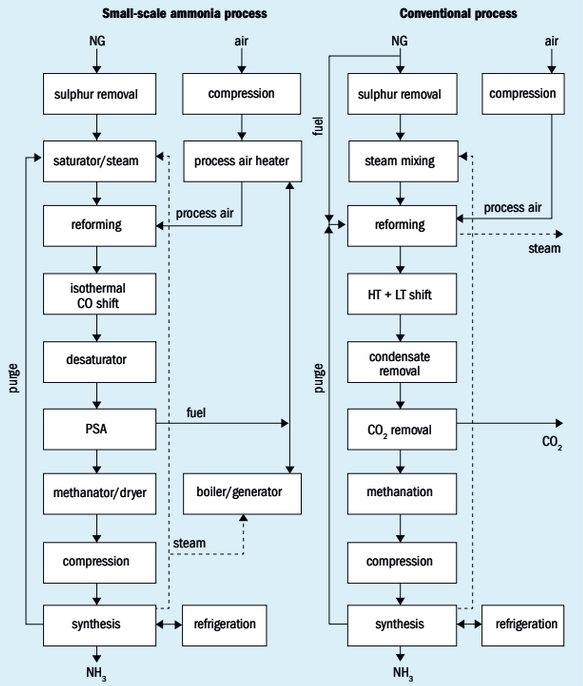


*Fig. 3: 3D model of modularised small-scale ammonia plant.*

The key features of this small-scale ammonia production process are listed in Table 2. Process steps are shown schematically in Figure 2. The small-scale process is commercially available, being offered by thyssenkrupp Industrial Solution and Johnson Matthey in the 270-550 t/d capacity range.

Fig. 2: **Block diagram of small-scale ammonia plant and conventional process**




*Source: thyssenkrupp/Johnson Matthey*

## Layout

The plant has a compact layout and is designed to be pre-fabricated in modules to lower the construction cost (Figure 3). Construction costs can vary, according to both site and local labour costs, and the plant is therefore also marketed in stick-built form.

## Gas heated reformer (GHR)

The GHR is essentially a shell and tube heat exchanger and consists of refractory-lined vessel with an external water jacket (Figure 4). The GHR system is the outcome of an extensive research and development programme and has been proven on the Coogee plant over many years (Figure 5). The GHR's reformer tubes are only designed for the pressure drop across the reformer. This is unlike the design of conventional steam reformer in which the reformer tubes need to withstand the full process pressure. The *KATALCO$_{JM}$™ 23-4Q* catalyst filling inside the tubes initiates strongly endothermic reforming of methane with steam. In the secondary reformer, the combustion of methane over a bed of *KATALCO$_{JM}$ 23-8Q* catalyst allows the endothermic reforming to proceed further (Figure 6).

## Isothermal CO-shift converter

This is a single, tubular isothermal shift reactor with a circulating water system to recover heat (Figure 7). The system dispenses with the need for an HTS catalyst – a Johnson Matthey's *KATALCO$_{JM}$ 83-5* catalyst is used instead. This makes it possible to operate the reformer at a low steam-to-carbon ratio. The water circuit permits near isothermal operation, allowing the catalyst volume to be reduced.

## Ammonia converter

The ammonia converter is an Uhde 3-bed radial type with radial flow from the outside to the inside of all three catalyst beds. Indirect cooling is provided by two heat exchangers between the catalyst beds (Figure 8). A specially developed catalyst, *KATALCO$_{JM}$ 74-1*, provides high activity at low synthesis pressure (80 bar). Sufficient references exist from other applications at low pressure.

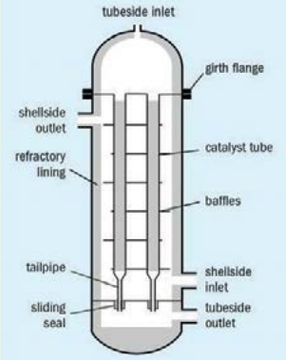
## Waste heat boiler

Process gas passes through a U-tube bundle In the vertical Uhde waste heat boiler (Figure 8). The design and configuration takes up less floor space and avoids the need for an additional steam drum and connecting piping.

## Steam system

Steam is generated by both a waste heat boiler in the synthesis loop and in an auxiliary boiler (Figure 2). Saturated steam from the synthesis loop is partly used as process steam. The rest is superheated in the auxiliary boiler. The steam pressure is 60 bar and the temperature of the superheated steam is 460°C. The auxiliary boiler burns combustible PSA off-gases. (These also fuel the process air preheater upstream). Special burners are required to run off low calorific PSA off-gas. All of the superheated steam generated in the auxiliary boiler is used to generate electricity in a turbo alternator. This delivers the electric power needed to drive the natural gas, process air, synthesis gas and refrigeration compressors. On top of this, a 325 t/d ammonia plant will require net electric power import of around 4 MW. ■

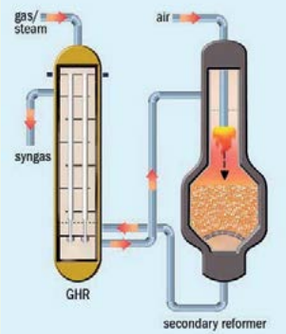
Fig. 4: **Gas heated reformer**




*Source: thyssenkrupp/Johnson Matthey*

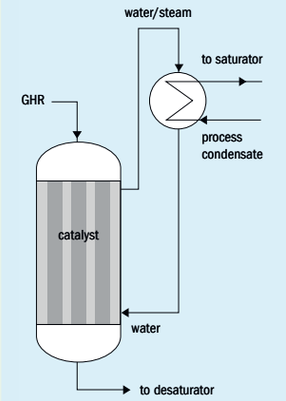
*Fig. 5: Gas heated reformer (GHR) and secondary reformer at Coogee, Australia.*

Fig. 6: **Gas heated reformer (GHR) and secondary reformer**



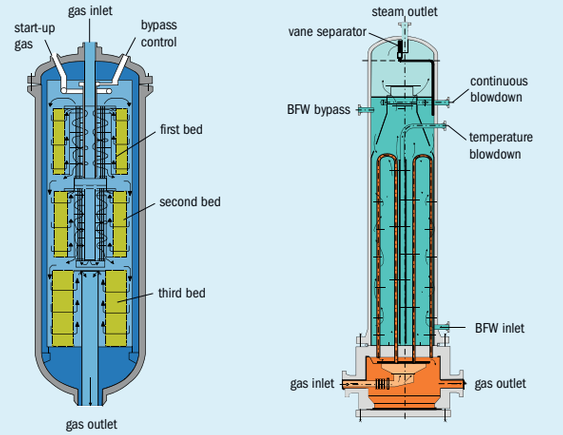

*Source: thyssenkrupp/Johnson Matthey*

Fig. 7: **Isothermal CO-shift converter and water circuit**




*Source: thyssenkrupp/Johnson Matthey*

Fig. 8: **Uhde 3-bed radial ammonia converter (left) and waste heat boiler (right)**




*Source: thyssenkrupp/Johnson Matthey*



NITROGEN TECHNOLOGY





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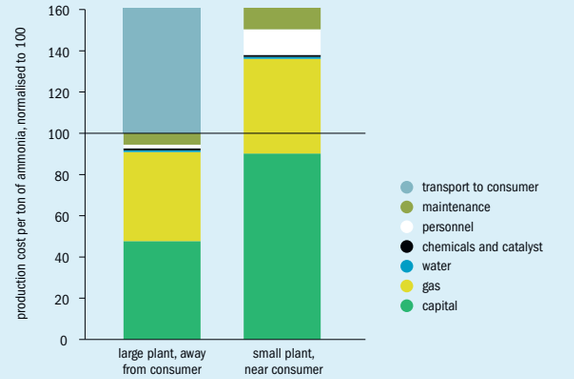
Fig. 9: **Comparison of production costs per ton of ammonia**




*Source: thyssenkrupp/Johnson Matthey*

side was an integrated fertilizer complex producing ammonium nitrate (500,000 t/a) and granulated compound fertilizers (200,000 t/a), but closed in 2008 due to UK market conditions.

Dyno Nobel have been operating the third LCA plant at Moranbah, Queensland, Australia, since 2012. The plant runs on coal bed methane supplied by local mines. The Moranbah plant was originally operated by Mississippi Chemical at Yazoo City in the US between 1998 and 2004, before being relocated and recommissioned by Dyno Nobel, a subsidiary of Incitec Pivot, in 2012.

Also in Australia, Coogee's GHR methanol plant in Laverton, Victoria, has been in production since 1994. The plant has a 165 t/d design capacity, although it has operated at methanol production rates of 225 t/d and above. This type of GHR needs to operate on pure oxygen, instead of air, as methanol production requires a nitrogen-free synthesis gas.

The GHR concept has also been tested in Johnson Matthey's materials demonstration unit (MDU). This operated in Trinidad between 2011 and 2013, after being relocated from New Zealand where the MDU was originally built and operated from 2002 to 2004. The GHR in the MDU is fitted with full-size tubes, each coupled to a secondary reformer and associated equipment. Valuably, experimental results from the MDU demonstrated the suitability and stability of catalyst and carbon-resistant materials at very low steam-to-carbon ratios.

## Economics

By incorporating special equipment (see box), the design of the Johnson Matthey/thyssenkrupp Industrial Solutions small-scale ammonia plant helps eliminate the economy of scale disadvantages of smaller plants. Indeed, an analysis carried out by the two partners suggests that small-scale ammonia plants (300 to 600 t/d) can be competitive with modern, world-scale plants of 2,000 to 3,300 t/d capacity in some circumstances. However, for their economics to work, small-scale ammonia plants need to dedicate output to the on-site manufacture of chemical intermediates (for largely non-fertilizer products). By avoiding merchant sales and the onward shipment of ammonia, transport costs are eliminated, helping offset higher production costs.

> **"Some industry analysts remain sceptical about the viability of small-scale nitrogen production.**

A production cost comparison (capex plus opex) between a conventional large-scale ammonia plant (2,200 t/d) and a small-scale plant of (325 t/d) is shown in Figure 9. This assumes:

- A typical North American location
- Payback over 10 years at five percent interest
- A natural gas price of $4/MMBtu

As might be expected, a lower per tonne capex cost allows the large-scale plant to operate at a much lower overall production cost. Opex costs, in contrast, are broadly similar, although the specific energy consumption of the small-scale plant is marginally higher. Importantly, this comparison reveals that the small-scale ammonia plant becomes competitive, once the transport cost of the large-scale plant exceeds 60% of production cost. This threshold is relatively insensitive to energy price, as energy cost increases will affect opex at both large- and small-scale plants to a similar degree.

Ammonia freight rates between US Gulf Coast producers and consumers in the northern US have been reported at $180/t previously. For transport costs at that level, local production at a small-scale could become economically feasible for Gulf Coast ammonia prices above $300/t. (Major global ammonia benchmarks have been below this level for the last 18 months, however, with prices currently languishing at closer to $200/t.)

Other factors also help improve the cost-effectiveness of local, small-scale production. Ammonia plant integration generally reduces or avoids the need for unloading and storage, for example. Freight rates are also expected to outpace energy price rises in future, as a result of higher rail safety standards and insurance costs. Additionally, there is significant potential to cut small-scale plant capex costs by adopting modular construction. Other benefits, such as security of supply and the avoidance of price volatility, can also make the co-location of small-scale ammonia plants an attractive proposition.

## Discussion

Transport restrictions and regulations are becoming more stringent and, as a consequence, freight rates for ammonia are increasing. The co-location of ammonia production and consumption can certainly avoid these transport costs and mitigate transport risks. Beneficially, small-scale ammonia production could also help exploit stranded energy sources.

Capital costs for ammonia plants can vary by a factor of two or more. Capex levels for US plants are typically around $1,000-1,500/t, based on recent investments, although installation costs of $2,000/t or more are not abnormal. Capital costs for ammonia plants built in other parts of the world are likely to be broadly similar to these North American capex levels[1].

The capex of smaller-scale ammonia plants in contrast, can be as high as $3,000/t (4,000 t/a capacity) or as low as $1,250/t (20,000 t/a), according to developer Proton Ventures[1]. The innovative Netherlands-based engineering company specialises in small-scale ammonia production units for both fertilizer manufacture and energy storage. These are designed to exploit stranded sources of flared gas, renewable energy and hydrogen – and convert these into ammonia.

Proton Ventures believes there is a "credible economic case" for ammonia production at a small-scale, based on lower operating costs and the avoidance of storage and transport costs. Operating costs as low as $50/t are achievable, in its view, either by exploiting flared gas, low cost gas ($1-2/MMBtu) or cheap renewable electricity ($0.02-0.03/kWh). Directly supplying ammonia locally can also avoid between $50-100/t in transport and storage costs, it calculates[1].

However, in today's competitive market, Proton Ventures accepts that small-scale ammonia units dedicated to fertilizer manufacture will struggle to match the economics of standard, large-scale production, at least in the short-term, without tax breaks or carbon credits[1].

Some industry analysts remain sceptical about the viability of small-scale nitrogen production. This view has been reinforced by the recent closure of US biomass gasification technology firm BioNitrogen. The company, which ceased operating in June, had ambitious plans to build innovative, small-scale urea plants in Florida and Louisiana, prior to a nationwide roll-out of the technology.

"We have long-considered small-scale projects as being difficult to justify – and that is reflected in our capacity projections," comments Laura Cross, nitrogen research manager at London-based Integer Research. "The main disadvantage for small projects are diseconomies of scale on capital costs, which outweighs gains from being located close to the market."

The exponential increase in capital costs per tonne, as plant capacity is scaled-down, remains a barrier to the commercialisation of smaller scale ammonia/urea production units, in Integer's view. It believes that market economics still favour either brownfield expansions or mega projects currently. "The low probability of reaching commercial production with small-scale units becomes clear when compared with the relatively low capex per tonne for expansions at existing facilities or very large-scale new facilities – of which the nitrogen market has plenty for now," comments Laura Cross.


### Acknowledgement

This article is partly based on the feature 'Small-scale production of ammonia', by B. Keil and K. Noelker of thyssenkrupp Industrial Solutions and J. Pach of Johnson Matthey, in the September/October 2016 issue of *Nitrogen+Syngas* magazine (*Nitrogen+Syngas* 343, p52).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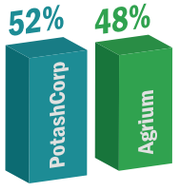
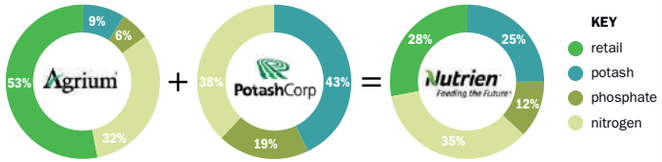
# The Agrium-PotashCorp merger

## SHAREHOLDING SPLIT

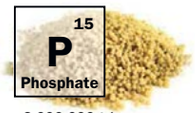



## NUTRIEN: BALANCED EARNINGS

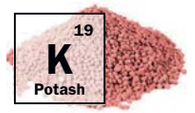



## NUTRIEN: PRODUCTION MIGHT & RETAIL STRENGTH


~19,000,000 t/a




~8,000,000 t/a




~3,000,000 t/a


## TWO BECOME ONE: NUTRIEN IN NUMBERS

The world's **LARGEST** crop nutrient company

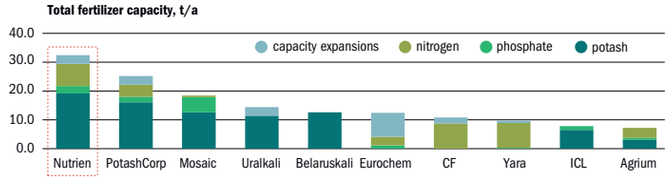
**$36 billion** Enterprise value

**$20.6 billion** 2015 Pro forma revenue

Close to **20,000** employees

**$500 million** Expected in annual operation synergies

## NUTRIEN: A NEW GLOBAL GIANT




*Source: All information Agrium/ PotashCorp, as of September 2016.*

Our infographic this issue shines the spotlight on the proposed merger of Agrium and PotashCorp. This is timely as the merger is expected to close during the third quarter of 2017, subject to regulatory approval in the US and Canada.

The two companies announced plans to join forces in "a merger of equals" in September last year (*Fertilizer International* 475, p16). If successful, Agrium and PotashCorp's integration will create **Nutrien**, the world's largest crop nutrient company. The deal has the unanimous approval of the boards of directors of both companies. Their respective shareholders also overwhelming backed the merger in a vote last November.

The merger has clear mutual benefits. Retail access to the Americas and international markets – via Agrium's network of more than 1,400 outlets in the US, Canada, Australia and South America – has obvious attractions for PotashCorp. For Agrium, joining forces with PotashCorp beefs-up its manufacturing might by bringing together around 29 million t/a of production capacity.

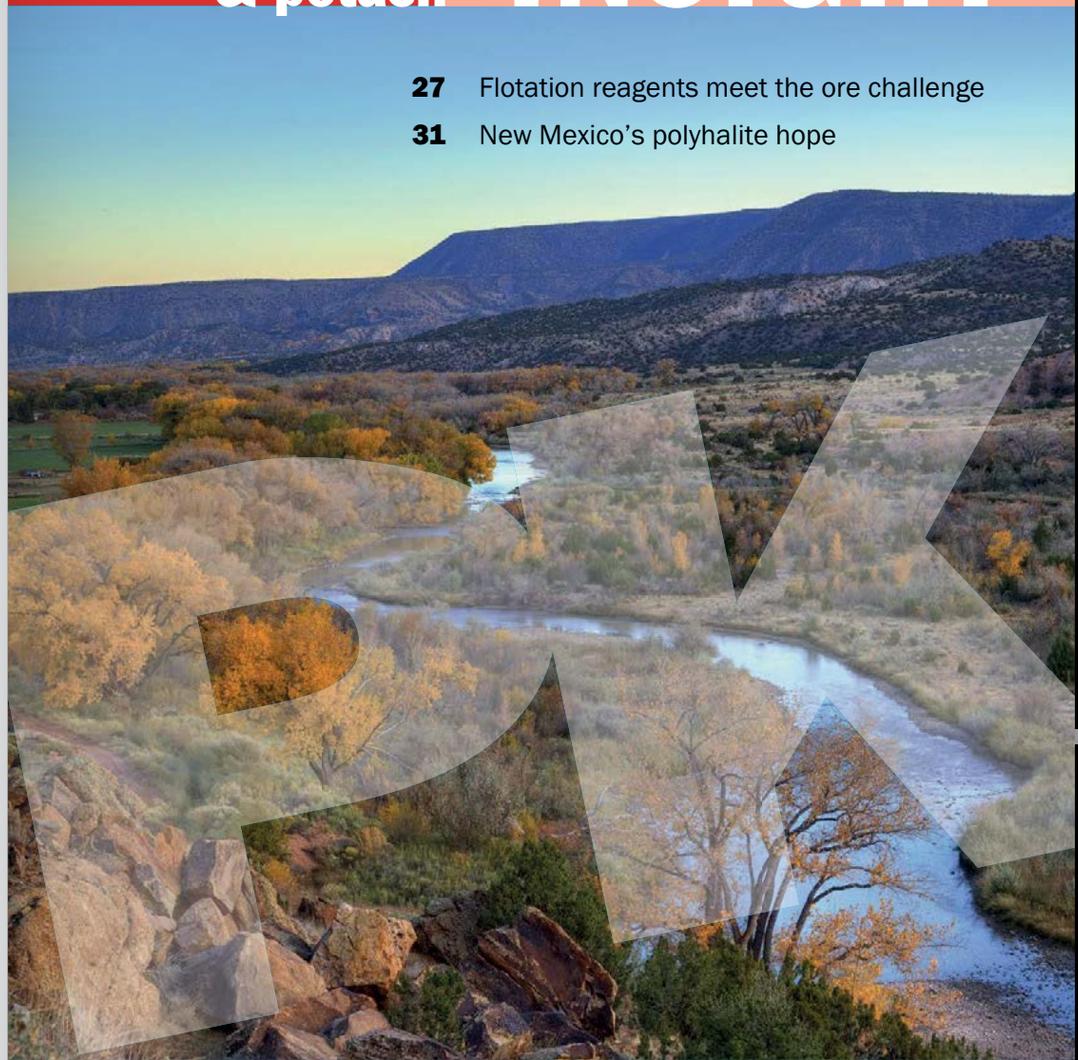
The merged company would have close to 20,000 employees. Although North American in character, Nutrien would have a widespread international presence, through operational ownership and investment holdings in some 18 countries across the globe. ■



September-October 2017

# phosphates & potash INSIGHT







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# Flotation reagents meet the ore challenge

Froth flotation has been widely-adopted globally as the most effective beneficiation method for phosphate rock. The rapid depletion of accessible, high-grade deposits is, however, increasing the demand for innovative flotation reagents. These are needed to produce high-quality phosphate concentrates from challenging ores with high levels of silica and carbonate gangue. We look at novel collectors, modifiers and depressants capable of improving flotation selectivity, and phosphate grade and recovery, in difficult-to-float ores.

Mined phosphate rock generally needs to be processed and upgraded to meet the downstream requirements of phosphoric acid production and fertilizer manufacture. The industry requires rock concentrates with a high phosphate content and low levels of gangue minerals (silicates, carbonates and clays).

Froth flotation has become widely-adopted globally as the most effective beneficiation method for phosphate rock, since its adoption commercially in the first half of the last century. More than half of the world's marketable phosphate, and two-thirds of Florida phosphate rock, is upgraded by froth flotation, according to some estimates[1].

A range of different collector, modifier and depressant reagents are used in the direct and reverse flotation of phosphate ore (see box overleaf). These aid or supress mineral flotation behaviour and enhance separation efficiency. Anionic fatty acids and cationic amines are commonly used as collectors in direct and reverse phosphate flotation, respectively (see box below).

## Flotation flowsheets

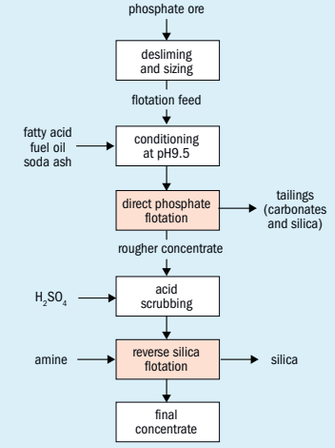
There are three main approaches to phosphate flotation:

- **Direct flotation:** phosphate minerals are floated at basic pH, usually using anionic collectors together with a depressant/modifier for gangue minerals
- **Reverse cationic flotation:** siliceous gangue materials are floated from phosphate ore at close to neutral pH using a cationic amine collector
- **Reverse anionic flotation:** carbonate minerals are floated by an anionic collector at acid pH, while phosphate minerals are depressed using an effective depressant

In process flowsheets, these can be combined in a number of different 'rougher' and 'cleaner' flotation steps[1]. The beneficiation method developed in the 1940s to upgrade the siliceous phosphates of Central Florida, the Crago 'double float' process, has two flotation steps (Figure 1), for example. Based on Arthur Crago's 1942 US patent, the commercial adoption of the Crago process was a significant innovation, and contributed to the major expansion of the phosphates industry during the last century.

The Crago process combines a direct 'rougher' anionic flotation with a reverse cationic 'cleaner' flotation. Phosphate (apatite) is firstly separated from silica and carbonates in the rougher step. Deslimed and sized ore is conditioned with an anionic fatty acid collector and a fuel oil extender at a pH of 9.0-9.5. The rougher concentrate obtained is then scrubbed with sulphuric acid to remove the collector from the surface of apatite particles. It then undergoes a cleaner flotation step using a cationic amine collector at a pH of 7. Silica is floated in this reverse flotation step, leaving the final phosphate concentrate as the sink fraction.

Fig. 1: **Beneficiation of Florida phosphate ores with Crago double float proess**




*Source: Sis & Chander (2003)*





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## New carbonate collectors

High levels of carbonate minerals are found in many phosphate deposits. Indeed, they affect a greater proportion of ore reserves globally than silica gangue. These abundant high carbonate ores will need to be mined eventually, as easier-to-process phosphate reserves become depleted. The presence of the carbonate mineral dolomite in phosphate ores is particularly undesirable because of the magnesium it contains. High MgO levels create problems in downstream production, such as high phosphoric acid viscosity, acid filtration problems and build-up on pipework.

Unfortunately, unlike silica, separating carbonate minerals from phosphate by flotation can be problematic due to their similar surface properties. Phosphates and carbonates respond similarly during conventional fatty acid flotation as they are both oxide minerals and contain the same or similar cations.

Nevertheless, there has been significant progress in developing successful carbonate flotation reagents in recent years. **ArrMaz**, a leading global supplier of flotation reagents, has made great strides in this field, having developed and trialled collectors on a wide range of different carbonate-rich phosphate deposits. Some of these reagents have been applied at full-scale commercial plants, while others have been demonstrated at pilot scale[2].

There is no universal reagent scheme or flowsheet for phosphate flotation. ArrMaz therefore recommends an individually-tailored approach, given that every ore is different. The company also advises developing the reagent scheme and the process flowsheet together from the outset.

Recent flotation results obtained by ArrMaz for US, Chinese and North African ores are summarised below. These illustrate how collector technology and flowsheet design can be married together – and tailored to individual ore characteristics to optimise the removal of dolomite and other impurities, and enhance phosphate grade and recovery.

## Florida's dolomitic pebble problem

Florida's phosphate rock output has been in long-term, slow decline as high-grade, easy-to-process, siliceous reserves that are low in dolomite have become depleted. In the future, as phosphate mining moves southwards from central Florida, lower-grade phosphate rock with higher MgO levels is likely to be encountered; the ore matrix having a lower $P_2O_5$ content and containing more dolomite.

ArrMaz has developed several carbonate flotation collectors (*CustoFloat® and CustAmine®*) to recover phosphate from Florida dolomitic pebble[3].

The current phosphate flotation practice in Florida, the direct-reverse Crago process, is generally unable to handle MgO pebble (-19mm to +1.19 mm size) which accounts for around 30-60% of total phosphate resources. Pebble can be blended with flotation concentrates for phosphoric acid production, as long as $P_2O_5$ is 23-28% and MgO <1.5%. Any pebble with >1.5% MgO, in contrast, is currently discarded as waste.

## Flotation reagents: the basics

Anionic fatty acids and cationic amines are the most common types of collectors used in phosphate ore flotation – and are applied in direct and reverse flotation, respectively. Oily collectors such as fuel oil are typically used as collectors/extenders to reduce collector consumption and excess foaming.

### Anionic collectors

Long-chain **fatty acids** and their salts, especially **oleic acid** and its soap, **sodium oleate**, are the most extensively used types of anionic collector. Fatty acids are used as collectors in the **direct flotation of phosphate** (apatite), oxides and sparingly soluble minerals. They are almost always derived from tall oil, a paper industry by-product. Fatty acid collectors are, however, sensitive to high temperature, slimes, dissolved ions and variations in pH. They can also be costly due to the high dosages required. **Sulphosuccinate** and **sulphosuccinamate** can potentially float apatite minerals faster than sodium oleate. High flotation efficiency and excellent selectivity has also been achieved in the flotation of Florida phosphate ore using **hydroxamate** as a collector.

Anionic compounds such as **fatty acids** and **sulphonated fatty acids** can also be effective carbonate collectors in reverse flotation. **Phosphoric esters** are reported to be very efficient for floating carbonates from sedimentary ores at acid pH, using sulphuric acid or fluorosilicic acid as a depressant.

### Cationic and amphoteric collectors

Cationic amines and amphoteric reagents are typically applied in **reverse flotation** to float **dolomite**, **calcite** and **silica** from phosphate ore. The cationic collector **tallow amine acetate**, mixed with kerosene, has also been used to float phosphate. The amphoteric surfactant **N-sarcosine** is used industrially to float carbonate minerals from the Siilinjärvi phosphate ore in Finland. Another amphoteric surfactant **carboxyethyl imidazoline** is reportedly a selective collector for dolomite.

### Modifiers

Using a collector (ionic surfactants) in combination with a modifier (typically non-ionic surfactants) can enhance flotation performance. Combining ionic and non-ionic surfactants improves froth properties and the emulsification of oil. Modifiers also ensure that the collector is evenly adsorbed on mineral surfaces, as well as protecting the collector from harmful dissolved ions. **Alkylphenol ethoxylates** (APEOs) and **fuel oil** are commonly used as fatty acid modifiers. APEOs are also used in combination with sodium sarcosinate collectors. **Nonylphenol ethoxylates** (NPEOs) and **sulphosuccinate/sulphosuccinamate** are used as modifiers with the collector sodium oleate.

### Depressants

**Phosphoric acid** and derivatives, such as diphosphonic acid, are widely used as depressants for apatite in the reverse flotation of phosphate ore. **Sodium silicate** and **gum arabic** are used as depressants for gangue minerals in the direct flotation of phosphate. ■







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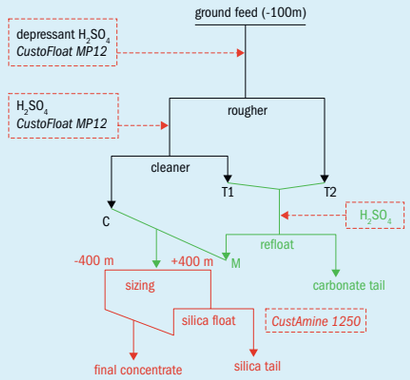
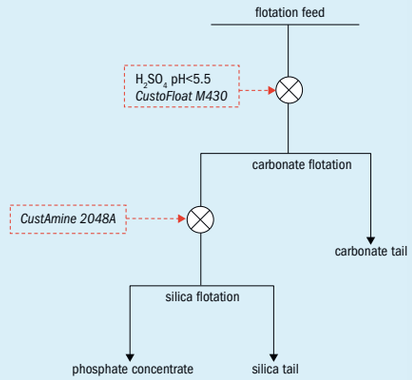
Fig. 2: **Florida MgO pebble flotation flowsheet**




*Source: Wang (2015)*

Fig. 3: **North African ore flotation flowsheet**




*Source: Wang (2015)*

ArrMaz has proposed a fine-particle flotation process without de-sliming as an R&D solution for Florida MgO pebble (Figure 2). The pebble is ground to less than 100 mesh and processed in three main steps:

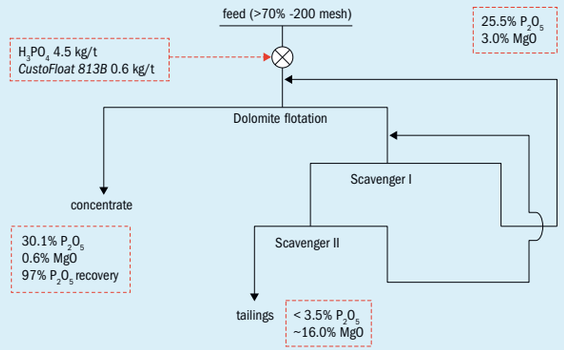
- **Rougher and cleaner float open circuit:** depressant $H_2SO_4$ and *CustoFloat MP12* collector reagents
- **Tailings refloat:** carbonate tail removed as a float fraction
- **Sizing step and silica float (+400 mesh):** *CustAmine 1250* collector, silica tail removed as a float fraction

Good concentrate grades (>31% $P_2O_5$) with low MgO levels (<1%) at high overall $P_2O_5$ recoveries (>86%) have been obtained using this approach. The reagent scheme is able to compensate for the presence of slimes and delivers a recovery advantage[3].

## North African ore challenge

ArrMaz has also developed two collectors to remove carbonate and silica from North African ore – the anionic collector *CustoFloat M430* and the cationic collector *CustAmine 2048A*, respectively[2].

Fig. 4: **Hubei ore, China, flotation flowsheet**




*Source: Wang (2015)*

This reagent scheme was combined with a double reverse flotation flowsheet (Figure 3). This was designed to separate fluorapatite (58%) from dolomite (17%), calcite (15%) and silica (6-7%) gangue. The feed assay for this ore was 24.5% $P_2O_5$, 3.8% MgO and 6.1% insoluble material ($SiO_2$).

Phosphate recovery and grade were successfully improved using this flowsheet, while MgO and insolubles were reduced. Laboratory results demonstrated that good concentrate grades (31.7% $P_2O_5$) can be obtained, with low levels of MgO (0.4%) and insolubles (3.0%), at an excellent overall $P_2O_5$ recovery (90.6%). The new reagent scheme for double reverse flotation has the following benefits[2]:

- Can be easily adopted into the current plant set-up
- Is more tolerant to changes in ore characteristics, such as slimy feeds and low grade feeds
- Has no foaming issues

ArrMaz has also found similar benefits using *CustoFloat 714* for dolomite flotation and *CustAmine 2060A* for silica flotation in more recent double reverse flotation trials on another North African ore.

## Ore challenges in China

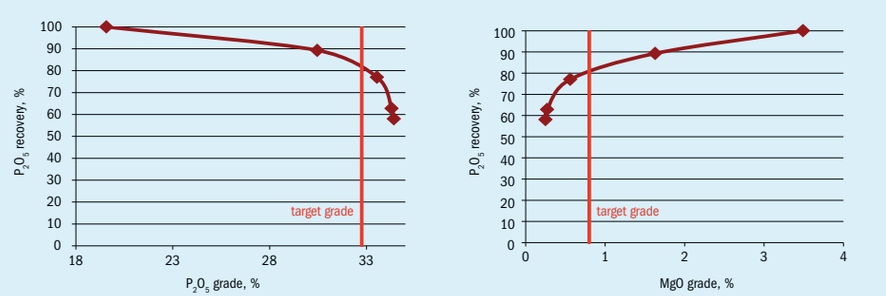
Other new collectors developed by ArrMaz, the *CustoFloat 813* series, are suitable for separating dolomite from phosphate by reverse flotation at acid pH. Satisfactory results were achieved for different ores from several phosphate mines in China[4]. Chinese ores can have a number challenging characteristics, including low $P_2O_5$ grade and high levels of finely disseminated impurities.

Trials with *CustoFloat 813B* included full-scale tests at a 1.2 million t/a output beneficiation plant in Hubei Province. The plant consumes a blended ore containing 24.5-27.0% $P_2O_5$ and 3.5-4.5% MgO. The quality of phosphate concentrate produced by the mine needed improving to meet the low magnesium (<0.6% MgO) requirements of the site's diammonium phosphate (DAP) plant.

The Hubei flowsheet includes one rougher and two scavenger flotation steps (Figure 4). Encouragingly, a 30% $P_2O_5$ grade concentrate containing less than 0.5% MgO was obtained, at an overall recovery of 97% or higher, for a collector dosage of less than 0.7 kg/t[4].

Further trials were also carried out at a beneficiation plant in Yunnan Province and another plant in North China. Overall, all three trials demonstrated that *CustoFloat 813* collectors are highly selective carbonate collectors able to achieve high $P_2O_5$ recoveries for different types of high MgO ore during plant operation. Most notably, because they are strong collectors with a fast flotation rate, *CustoFloat 813* collectors are capable of yielding high quality concentrates at a relatively low dosage. They can also tolerate phosphate ores from different sources while still delivering satisfactory flotation performance[4].

Fig. 5: **Clariant flotation trials: grade vs recovery curves for Hinda phosphate ore**




*Source: Dopico (2015)*

## Specialised collectors

**Clariant** offers the *Flotinor* and *Flotigam* range of collectors for direct and reverse flotation of phosphate ores. The company's *Flotigam 3135* proprietary reagent – an ether propyl di-amine – has long been used as a standard collector by a leading global sedimentary phosphate mine. This mine produces nearly four million tonnes of concentrate by processing around six million tonnes of ore feed using multiple flotation cells. For 30 years, the high production mine has used *Flotigam 3135* as its benchmark collector due to its ability to deliver consistently high-grade concentrates (≥32% $P_2O_5$ and <3% $SiO_2$) at recovery rates in excess of 80%.

Clariant, through its global network of mining laboratories, is developing specialised anionic and cationic collectors capable of increasing phosphate recovery and grade. The company is highly active globally, having successfully conducted direct and reverse flotation trials on a wide range of different phosphate ores from Africa and North and South America[5].

High-grade phosphate ores which are most amenable to fatty acid flotation are becoming exhausted. As a consequence, reverse flotation using amines and specialised anionic collectors will become increasingly necessary in some parts of the world, suggests Clariant, particularly for difficult-to-float ores where carbonates are present as gangue. This is true in Florida, where ores are becoming more dolomite-rich as extraction moves southwards. High levels of carbonate minerals are also present in new South American and African phosphate deposits[5].

In recent case studies, Clariant has been able to demonstrate how difficult-to-float ores – which do not respond to conventional low-cost anionic collectors – can be effectively beneficiated with new anionic and cationic collectors[5]. Clariant says its expertise in reverse collectors for phosphate is helping to make these reagents the preferred choice for ores with high carbonate contents.

Collectors developed by the company have proved to be highly effective during recent flotation trials on ore from Cominco's Hinda project in the Republic of Congo. Hinda ore is a sedimentary phosphate (19% $P_2O_5$) containing dolomite (3.5% MgO) and silica (24.8%) gangue. Reverse flotation successfully achieved beneficiation target grades of 32% $P_2O_5$ and <0.8% MgO at a phosphate recovery of 77% (Figure 5).

Reverse flotation (one rougher and three cleaner steps) was carried out on feed ground to 80% passing 190 microns. A phosphate depressant (sodium tripolyphosphate) was used together with sequential treatments of an anionic collector (*Flotinor 7463*) and two cationic collectors (*Flotigam 7457* and *Flotigam 7510*). Flotation was regulated at pH 5.5 with sulphuric acid, with additional reagent doses for each of the three reverse cleaner steps. The target grades were achieved after the rougher and first cleaner stage alone.

Clariant has also published recent case study results for four other phosphate ores globally[5].

- **North American sedimentary ore (a):** Direct flotation with *Flotinor 7474*



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achieved recoveries as high as 99%, using the first step of the Crago process

- **North American sedimentary ore (b):** Reverse flotation with *Flotigam 7516* and *Flotigam 7454* amine collectors reduced $SiO_2$ levels in ore (6.6%) to 1.8% and 2.5%, respectively, at 98-99% $P_2O_5$ recoveries
- **North African phosphate** with a 22.3% $P_2O_5$, 6.4% MgO and 6.9% $SiO_2$ feed: Reverse flotation with anionic *Flotinor 7466* and cationic *Flotigam 7470* collectors reduced MgO levels to less than 0.65% at 76% $P_2O_5$ recovery
- **African igneous ore (pyroxenite):** upgraded from <6.5% $P_2O_5$ to <84% $P_2O_5$ by direct flotation with *Flotinor 7496* at a recovery of 84.7%
- **South American igneous ore:** In direct flotation with various *Flotinor* reagents (7493, 7487, 7498 and 7505), high-grade concentrates (>35% $P_2O_5$ typical) were obtained at recoveries above 90%, in contrast to the 61% $P_2O_5$ recovery and 33% $P_2O_5$ grade achieved with low-cost fatty acids collectors

The above case studies demonstrate that Clariant's range of anionic and cationic collectors perform well on ores that are considered difficult to float using conventional flotation reagents.

## Safe, biodegradable modifiers

The demand for flotation reagents capable of improving selectivity and recovery during phosphate ore processing is becoming more widespread, as high-grade deposits have become depleted. The use of additives to modify fatty acid collector systems is one area where significant advances have been made in recent years. These secondary collectors/modifiers – typically anionic or non-ionic surfactants – have a critical effect on flotation performance, especially in acidic reverse carbonate flotation.

*Lupromin FP A 105* from **BASF Mining Solutions** is a non-ionic modifier for standard fatty acid collectors. It is recommended for the direct flotation of both oxidised and un-oxidised igneous phosphate ores. *Lupromin FP A 105* also improves selectivity and increases recovery compared to conventional APEO modifiers (see box).

> **Improvements in selectivity and recovery are necessary as high-grade deposits become depleted.**

The modifier compliments BASF's range of *Lupromin FP A* anionic collectors:

- *Lupromin FP A 711* and *Lupromin FP A 721-A* are recommended for apatite flotation for ores with the high $SiO_2/P_2O_5$ or high $CaO/P_2O_5$ ratios
- *Lupromin FP A 212* is a fatty acid based collector applied in oxidised phosphate ore flotation

Since the mid-1990s, BASF Mining Solutions has developed and introduced a range of non-ionic modifiers in mineral processing applications as non-toxic alternatives for alkylphenol ethoxylates (APEOs) and nonylphenol ethoxylates (NPEOs)[6].

The use of non-ionic modifiers in phosphate flotation originally dates back to the mid-1970s. APEOs were first introduced for sedimentary phosphate flotation around this time, and used in combination with fatty acid collectors. APEO/oleic acid reagent systems were subsequently adopted in igneous phosphate flotation during the mid-1990s.

APEO modifiers are strongly emulsifying. They act to improve the apatite/carbonate selectivity of fatty acid collectors during phosphate flotation. They generally do this by emulsifying the fatty acids at low pH and making them more soluble.

However, the use of APEOs can have environmentally-damaging consequences as they degrade into alkylphenol (AP), a hazardous compound that provokes an oestrogen response in animals and fish. The use of nonylphenols (NPs) and NPEOs in the EU is restricted by REACH regulations, with a complete phase-out of these chemicals scheduled by 2018. Other key economies and jurisdictions globally are likely to follow suit[6].

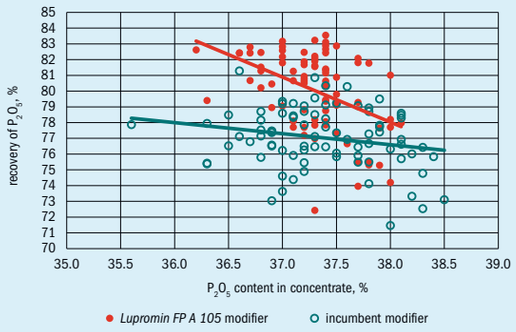
*Lupromin FP A 105*, in contrast, is an environmentally-safe and biodegradable non-ionic modifier. It is suitable for all the typical mineral processing applications of NPEO reagents – including use as a phosphate flotation modifier. *Lupromin FP A 105* also has functional advantages. Its hydrophilic-lipophilic balance (HLB) in particular has a "massive impact on flotation performance", according to BASF. Having the correct blend of high HLB and low HLB components is important when it comes to maximising performance of fatty acid collector schemes[6].

*Lupromin FP A 105* has been successfully trialled on igneous phosphate ore from a mine in Northern Europe. The modifier was used to optimise the mine's existing flotation reagent scheme (tall oil fatty acids, NPEO modifier and frother) used in the direct flotation of its carbonate-bearing ore (8-13% $P_2O_5$, 7.5-22% $CO_3$).

Initial lab-scale flotation tests with *Lupromin FP A* demonstrated significant grade and recover improvements. This was linked to the "combination effect" of the modifier's high HLB and low HLB components. *Lupromin FP A 105* was subsequently applied at the mine's full scale flotation plant for a 30 day period, with the following positive results[6]:

- $P_2O_5$ recovery increased by 2.5% at a constant 37.5% grade (Figure 6)
- Modifier dose reduced by 37% (*Lupromin FP A 105* dosage of 147 g/t vs. dosage of 235 g/t for the incumbent NPEO modifier)
- Unlike NPEO, the new modifier is biodegradable and non-toxic, being free of AP derivatives

Fig. 6: **North European igneous phosphate ore: effects of BASF's *Lupromin FPA105* modifier on grade and recovery**




*Source: Michailovski (2017)*

## Reducing depressant dosages

Phosphoric acid and its derivatives have long been used as depressants for apatite in phosphate flotation. Although an effective reagent, dosage levels are normally quite high (1-5 kg/t) making the use of phosphoric acid a costly option. This depressant is also usually sourced from downstream phosphoric acid production, leaving less $P_2O_5$ for onward fertilizer manufacture.

**Nalco Water** recently trialled a new depressant reagent which, says the company, should help phosphate process engineers maximise $P_2O_5$ recovery and increasing profitability[7]. Test results show that the new reagent can cut phosphoric acid dosage requirements by as much as 50%, and increase phosphate recovery by as much as 3%, without any decline in concentrate grade.

In reverse flotation experiments, the addition of a 50-150 g/t dose of the Nalco depressant can substitute for as much as 1-2.4 kg/t of phosphoric acid ($P_2O_5$ basis), while maintaining or slightly improving flotation performance.

Four cost-saving phosphate flotation scenarios are possible by adjusting the relative dosages of the Nalco depressant and phosphoric acid: the minimisation of phosphoric acid consumption, or its elimination, and the option of maximising either grade or recovery[7]. ■

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# New Mexico's polyhalite hope

PHOTO: A.V.LEY/SHUTTERSTOCK.COM

PHOTO: ICP

*Above left: Chama River, New Mexico. Above right: Project test drilling.*

Plans to develop a two million tonne capacity polyhalite mine in the United States are being stepped up, following a change of ownership of the New Mexico based Ochoa project. The US, Brazil and Mexico offer potentially strong markets for polyhalite – a direct-application, multi-nutrient fertilizer. We profile the Ochoa project and report on its technical and economic feasibility.

Intercontinental Potash Corp (ICP) is a Toronto stock exchange listed mining junior. The Canadian company, through the Ochoa project, has been championing the development of a polyhalite mine in Eddy and Lea counties, New Mexico. The project combines an underground mine with a surface processing plant and a separately-located rail loadout facility.

ICP had bold plans to mine and market polyhalite as a direct-application fertilizer, both domestically and internationally, but has now decided to exit the project completely. Private equity firm Cartesian Capital Group will now drive the Ochoa project forward instead, having recently gained control of the venture. In August, ICP announced it was selling its share in Ochoa to Cartesian for $15 million, subject to shareholder approval.

"It has not been possible for us to continue to maintain the company's financial interest in the project," said Mehdi Azodi, ICP's president and CEO. "The company has determined that the sale of its interest in the project is the best option… under present circumstances."

Having taken control, Cartesian Capital Group now wants to speed-up development of the project.

"This transaction will enable us to accelerate the development of the Ochoa project and build a world-class producer of specialty fertilizer," commented Peter Yu, managing partner at Cartesian. "We are grateful to our partners at ICP… for all of their efforts in developing this important resource."

## Well-placed with good fundamentals

The Ochoa project is well-placed to become the third operating polyhalite mine globally. ICL Fertilizers is already dedicating output from its Boulby mine in the UK to the production of the polyhalite product *Polysulphate*, after making a strategic decision to phase-out potash mining at this site. Developer Sirius Minerals will also begin shaft sinking at the nearby Woodsmith mine property in the UK later this year, having successfully raised the initial finance required. If all goes to plan, the first tonnes of the polyhalite product *POLY4* should emerge from the new Woodsmith mine towards the end of 2021.

The Ochoa project has good fundamentals and is well-advanced. The project, ranked as one of the best mining ventures in New Mexico, is fully-permitted and completed a preliminary economic assessment (PEA) last November[1].

Conscious efforts have also been made to keep the project's capital and operating costs to a minimum. Polyhalite ore will be extracted by conventional room-and-pillar mining, for example. Products will also be







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prepared using simple mechanical crushing and granulation methods, avoiding the need for chemical processing.

The Ochoa project can also draw on a skilled local labour force, a nearby water supply and electrical and natural gas utilities. It also has relatively easy access to ports on North America's Atlantic seaboard, such as Galveston, through existing road and rail infrastructure.

The Ochoa project also benefits from a long-standing partnership with Yara International, a leading global fertilizer producer and distributor. Yara agreed to make a strategic investment of around CAD 40 million in the project in 2012. Yara bought more than 30 million shares in ICP, giving it a stake of almost 20 percent in the venture. The Norwegian fertilizer giant also entered into an offtake arrangement for 30 percent of Ochoa's output for 15 years.

Although not taking an active role, Yara's strategic interest in the project remains unchanged. This is despite recent ownership changes, and the decision last year to change Ochoa from a sulphate of potash (SOP) to a polyhalite project.

"Yara has not made any changes in its shareholding since 2013," a Yara spokesman said. "We maintain passive ownership and no new decisions have been made related to Yara's strategy."

Yara also confirmed that its offtake agreement is unaffected by ICP's exit from the project.

## Ownership and history

Although now controlled by Cartesian Capital Group (see above), the Ochoa project's ownership and history are complex. Until recently, parent company IC Potash owned an 81.4 percent interest in Ochoa. This was held through an indirect investment by its Canadian subsidiary ICP in the US affiliate company developing the project, Intercontinental Potash Corp USA, known as ICP (USA).

Cartesian Capital Group became a major strategic investor in Ochoa three years ago. This provided Cartesian with a say in how the project was run – the terms of its investment allowing it to appoint two of the five directors of ICP (USA).

Cartesian bought into the project by purchasing $10 million of preferred ICP (USA) shares in November 2014. The group subsequently committed to a strategic project investment of up to $45 million at the end of 2015. This resulted in two project drawn downs of $2.5 million each during 2016 (*Fertilizer International* 474, p9).

Fig. 1: **Ochoa project: location map**


## New business strategy

Until last year, IC Potash planned to develop and bring the Ochoa project to market via a sulphate of potash (SOP) production route involving chemical processing.

In 2014, a project feasibility study by Agapito Associates and SNC-Lavalin proposed producing 650,000 t/a of SOP from polyhalite using a five-stage process: crushing/washing, calcination, leaching, crystallisation/evaporation and granulation. The company also received mining authorisation from the US Bureau of Land Management for the project in 2014. This covered the construction and operation of Ochoa's mine, mill and processing facilities.

However, ICP subsequently commissioned a preliminary economic assessment (PEA) from Golder Associates to look at the feasibility of mining and marketing two million t/a of polyhalite as a direct-application fertilizer. On publication of the PEA last November, the company signalled it no longer planned to produce SOP – and announced that the Ochoa project would now focus on polyhalite mining instead.

"IC Potash has revised the project to consider direct application of polyhalite as a crop nutrient product rather than producing SOP through a chemical processing plant," the company said in a statement. "The resulting project has a reduced capital cost, a shorter ramp-up time and improved financial metrics."

Switching from SOP to polyhalite production also reduces the project's execution risk, according to the company. Although now on the backburner, pursuing SOP production at a later date remains a possible future option for the project.

## Resources, mining and processing

The Ochoa project is located some 60 miles east of Carlsbad, New Mexico, less than 20 miles west of the Texas/New Mexico state line. The project's mineral rights cover more than 86,027 acres. They comprise of 26 US Bureau of Land Management prospecting permits (58,223 acres) together with 18 New Mexico State Land Office potash mining leases (27,804 acres).

Ochoa's polyhalite resources are estimated at 330 million short tons (measured and inferred) and have a mean grade of 89.3 percent (polyhalite, $K_2Ca_2Mg(SO_4)\cdot 2H_2O$). Potash mineralisation in this part of New Mexico occurs within the Permian-age Delaware Basin. The flat-lying, 2.2-6.6 foot thick polyhalite bed being targeted by the Ochoa project occurs within the basal anhydrite unit of the Tamarisk Member of the Rustler Formation.

The polyhalite bed is present at a depth of 1,525 feet (465 metres) below the surface. Polyhalite extraction requires the construction and operation of an underground mine, with a planned run-of-mine (ROM) output of two million tons per year. Mined ore with a minimum polyhalite grade of 85 percent will supply a processing plant located on the surface. The mine is expected to extract approximately 80 million tons of ore, sufficient for a mine life of 42-years.

Polyhalite will be extracted by room-and-pillar mining using three large and five small drum-type continuous miners, similar to those used in potash and coal mining. The polyhalite will be mined in a series of production panels. These are up to 8,000 feet long and either 48 inches or 57 inches in height, depending on the seam thickness. Production panels will extract around 70 percent of the available ore as no pillar mining is planned. An underground conveyor system will transport ROM ore from the working face to the production shaft for hoisting to the surface.

Ochoa's surface processing plant (two million t/a nominal capacity) will produce raw granules and pellets (both 3-8 mesh size) under current plans. The plant has a design feed rate of 338 t/h. Production will be split between 1-1.5 million t/a of raw granules and 0.5-1.0 million t/a of pellets. These two products will be conveyed to loadout bins and then transferred 22 miles by road to a rail loadout facility in bottom-dump trucks.

Road access to the mine is provided by 'Country Road 2', off New Mexico State Road 128 (NM128). The planned rail loadout facility will be located west of Jal, alongside the existing north-south running Texas-New Mexico Railroad (TNMR). The TNMR passes through Jal and then connects to the long-distance Union Pacific Railroad at Monahans, Texas. New tracks and switch assemblies will be needed to connect the loadout facility to the TNMR line.

The project's water supply is to come from the Capitan Reef aquifer, via a well field site located around 13 miles north-east of the processing plant. The project will require its own water pumping, pre-treatment and distribution system. Due to its high salinity, part of the water supply will need to be treated by multi-stage reverse osmosis.

Mining and processing activities will require around three megawatts of electricity. Local power utility Xcel Energy will supply this by linking the project to an existing electrical substation located one mile away, to the north of NM128, using a 345-kV or 230-kV service line. Ochoa's pelletiser dryer and building services will also need a supply of natural gas. This will require the building of a new underground pipeline adjacent to the NM128.











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Table 1: **Ochoa project: capital cost estimates**

| | Initial capital ($ million) | Sustaining capital ($ million) |
|---|---|---|
| **Direct capital** | | |
| Mine | 117 | 182 |
| Processing plant | 128 | 146 |
| Storage/loading | $33 | 36 |
| Total direct capital | 278 | 365 |
| **Indirect capital** | | |
| EPCM* | 19 | - |
| Other indirect costs | 29 | - |
| Total indirect capital | 48 | - |
| **Contingency** | **42** | **-** |
| **Total capital** | **368** | **365** |

**Engineering, procurement, construction and management (EPCM)* *Source: Golder Associates, (2016)*

## Product and marketing

Current plans are to market polyhalite as a direct-application fertilizer in the US, Mexico and Brazil. A 2016 market report commissioned from CRU Consulting estimated the following potential polyhalite demand in these three countries:

- US: 5.8 million tonnes
- Brazil: 3.4 million tonnes
- Mexico: 2.8 million tonnes

The combined demand of 12 million tonnes for polyhalite is hypothetical, though, and unlikely to be achieved without a comprehensive marketing and educational campaign.

CRU's market report concluded that polyhalite will have to compete with existing, well-established SOPM (sulphate of potash magnesia) brands such as Mosaic's *K-Mag* for a share of the relatively small K-Mg-S market. This will be a challenge as North American SOPM suppliers have taken decades to build the market for what CRU describes as "a higher analysis version of polyhalite".

Encouragingly, tests carried out on a composite sample of Ochoa polyhalite suggest its nutrient content, nutrient availability and dissolution behaviour are similar to ICL's *Polysulphate*, the only commercial polyhalite product currently on the market. Polyhalite content of granular and standard Ochoa products is 91.8 percent or above. This is higher than ICL's two commercial products and above the reserve grade published by Sirius Minerals for its polyhalite project, PEA test results suggest[1].

## Project economics

The Ochoa project will require initial capital expenditure of $368 million. This includes $278 million of direct capital, earmarked for the mine, processing plant and storage/loading facilities, together with $48 million of indirect capital for EPCM, plus a 15 percent contingency. The project will also need a further £365 million of sustaining capital (Table 1).

Ochoa's initial capex is fairly modest compared to the $1.2 billion stage one financing raised by Sirius Minerals for its much larger scale UK polyhalite mine. In contrast, the switchover to polyhalite production at ICL's Boulby mine, being an existing and already capitalised operation, only required implementation capex of $48 million.

Total Ochoa project operating costs, including mining, processing and product transport to the rail loadout, amount to $44 per short ton. This breaks down as follows:

- Mine: $24/t
- Processing plant $12/t
- Storage / Loading: $5/t
- General & administrative operations: $3/t

In comparison, Sirius Minerals currently estimates operating costs of $32.6 per metric tonne for its *POLY4* polyhalite product, at 10 million t/a mine capacity.

The Ochoa project has a net present value (NPV) of $1.2 billion, and will provide an internal rate of return (IRR, after-tax) of 28 percent, according to the 2016 economic analysis by Golder Associates in the PEA. On this basis, the project is likely to pay for itself within three years. Project revenue forecasts assume that polyhalite prices will vary between $157-224/ton during the life of the mine[1]. The latest investor presentation cites a ROM polyhalite price of $203/ton.

## Project schedule

The Ochoa project will be developed over a six-year timeline, according to last October's PEA. This includes an initial three-year construction period for engineering design, shaft sinking and building the processing plant. After construction, production will ramp-up over a further three year period to eventually reach two million t/a[1]. ICP set out a shorter, accelerated project timeline in its last investor presentation, with initial production commencing in the fourth quarter of 2019 (Table 2).

Table 2: **Ochoa project timeline**

| Milestone | 2016 | 2017 | | | | 2018 | | | | 2019 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
| PEA (complete) | ■ | | | | | | | | | | | | |
| Marketing plan | | ■ | ■ | ■ | ■ | | | | | | | | |
| Feasibility study | ■ | ■ | ■ | | | | | | | | | | |
| Detailed engineering | ■ | ■ | ■ | ■ | ■ | | | | | | | | |
| Mine construction | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | |
| Process plant construction | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | |
| Initial production | | | | | | | | | | | | | ■ |

*Source: IC Potash, July 2017*

In practice, and regardless of the timeline, the Ochoa project will need to take the following critical steps to proceed to the construction phase and subsequently become operational:

- Secure project financing
- Obtain final environmental approvals and construction licensing
- Select a contractor for design, build, operation and maintenance (DBOM)

Also, although the PEA demonstrates Ochoa's potential economic viability, Golder Associates recommended the completion of a prefeasibility study (PFS) as a next step to reduce project risk and "advance the project to a higher level of confidence" – as well as fully scope "various trade-off options". ICP acted on this advice, commissioning additional studies "to ratify the results of the PEA and move the Ochoa project to the PFS level".

Geological reasons also make a PFS necessary. The preliminary mineral resources estimate in the PEA, being partly inferred, is speculative in nature and may not ultimately be realised. Further work is therefore needed, as part of the PFS, to translate the current resource figure into a more economically dependable mineral reserve estimate.

In its most recent financial statement, ICP said the current work plan for the Ochoa project is focussing on:

- The development of a project execution plan
- Refining the cost and schedule estimate
- Developing the market for polyhalite products

## Next steps

Financing remains the make or break factor for any junior mining project – and the Ochoa project is no exception to this. ICP was pursuing the option of financing the project through equity markets and debt, or by entering into partnerships or joint ventures. The strategic investment and new leadership of the project by a private equity firm, Cartesian Capital Group, and the continued participation of a major global fertilizer producer, Yara International, should reassure and encourage others wishing to invest in the project.

The exit of IC Potash from the project, and its $15 million settlement with Cartesian, also ends a simmering legal dispute between the two parties. In May, IC Potash launched a Colorado lawsuit against ICP (USA) – a company now controlled by Cartesian – asking the court to set aside a $800,000 "capital contribution call". Cartesian reacted by filing a counter lawsuit against IC Potash in New York in July, asking for at least $10 million in damages on behalf of its investors. Encouragingly for the project, these disputes now appear to have been settled amicably.

The Ochoa project undoubtedly has good, encouraging fundamentals. Following the favourable resolution of legal disputes, and under fresh leadership, the future of the Ochoa project now depends on the positive outcome of further feasibility work – and will ultimately hinge on successful financing. ■

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THE OCHOA PROJECT PK



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