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FERTILIZER INTERNATIONAL
ISSUE 483
MARCH-APRIL 2018

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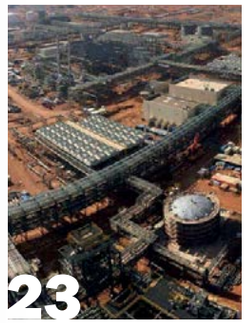

Saudi mega project

Usolskiy gets ready

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A world-changing idea

> ***Financial Times*** **has named precision agriculture as one of '50 Ideas to Change the World'.**

Venture capitalists are hard-headed risk takers, not generally kind-hearted philanthropists driven by a desire to feed the planet. Their acumen generally involves sizing-up emerging, disruptive technologies – ahead of more risk-averse banks and capital markets – and selecting winners. They target innovative start-ups capable of generating high commercial returns at an early stage.

Yet, in recent years, these individuals have sunk their venture capital into agricultural technology (agtech) in ever larger numbers. To the extent that agtech investment ballooned exponentially from $400 million in 2010 to a highpoint of $4.6 billion in 2015.

Precision agriculture ranks as the third most popular type of agtech investment, exceeded only by food e-commerce and the biotech sector. AgFunder, an online marketplace that matches agtech start-ups with potential investors, closely monitors investor interest. It reported that investment in precision ag hit $661 million via 96 deals in 2015, up 140 percent on the previous year.

Investment in precision ag did fall back to $405 million in 2016. But AgFunder was optimistic about a rebound in investor interest in 2017: "We expect growth in agtech driven by investor interest in supporting the future of food and agriculture."

Venture capitalists are not alone. Agtech in general, and precision ag in particular, are being enthusiastically championed by a growing number of converts. *Financial Times* (*ft*), for example, featured precision agriculture in its '50 Ideas to Change the World' series at the end of last year.

Farmers are increasingly arming themselves with a plethora of precision farming equipment, including drones, GPS trackers, robots and large-scale data collection devices. Indeed, these precision ag tools have already become widely-adopted in North America, Europe, Australia and parts of South America.

Digitally determining fertilizer applications is fast becoming the new normal, at least for certain crops in more advanced countries. The story of fledgling agtech company SMART! illustrates how quickly the market is evolving. SMART!'s software can recommend application rates and timings for more than 250 crop types. Having only entered the market in 2014, the company has now sold its fertilizer management platform in more than 62 countries.

The Climate Corporation, a subsidiary of Monsanto, is another fast-expanding agtech company. It is poised to launch its *Climate FieldView* digital agriculture platform in Europe this spring.

Using this platform, "Farmers can manage their inputs to optimise yield in every part of their field with manual variable rate seed and fertility… tools," the company says. The Corporation's technology gives farmers the ability to optimise their fertilizer use via a customised NPK management plan.

"In the past, farmers made field-by-field assessments," comments Mark Young, Climate Corporation's chief technology officer. "Today they are moving towards foot-by-foot data collection and analysis to make better decisions."

The Climate Corporation launched a free digital agriculture platform in India last May. This provide users with regular farming advice, updates on temperature, rainfall and humidity, and the latest crop price information. The Corporation is targeting the 70 percent of smallholder farmers in India with access to smartphones, and has set itself the long-term goal of reaching 150 million of the subcontinent's farmers.

The company also has ambitions to roll-out its agtech platform to Africa and other parts of Asia. Mark Young is convinced of the benefits this will bring. "We will see a new level of sustainable crop productivity across the world, as farmers continue to see the value these tools can bring to their operations," he said.

Agtech, digital farming, smart farming – however it is described – can help poorer, smaller-scale farmers improve their yields and reduce input costs, according to Jeehye Kim, an agricultural economist at the World Bank. She also thinks it will create new market opportunities for selling produce.

"In Vietnam and India, we're piloting internet of things-enabled irrigation devices," Ms Kim told *ft*. "These are affordable and easy to use, can boost yields as well as cut water usage and greenhouse gas emissions."

Fertilizer International will be taking an in-depth look at precision agriculture and its impact on the industry in our May/June issue. The technology's potential is clearly vast. ■

S. Inglethorpe

Simon Inglethorpe, Editor

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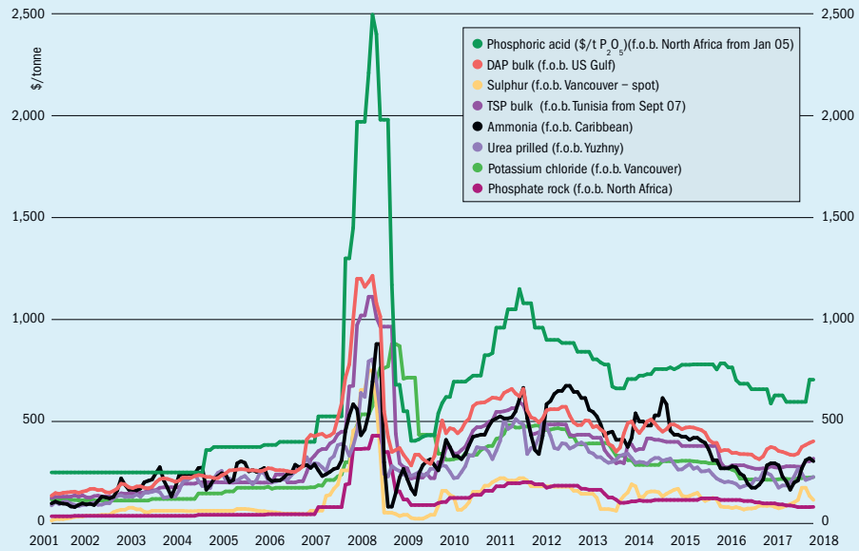
Market outlook

Historical price trends $/tonne



Source: BCInsight

Market insight courtesy of Integer Research

AMMONIA

Prices softened going into 2018. This was after 2017 prices ended the year on an annual high – due to tight supply and planned and unplanned shutdowns. The Tampa ammonia contract price initially increased by $10/t to $355/t cfr in January, only to fall by $15/t to $340 per tonne in February. The ending of a number of temporary plant outages meant this decrease was largely expected, although Mosaic had been seeking a larger price reduction of $25/t. In Trinidad, the Caribbean Nitrogen Company unexpectedly shut down its ammonia plant on 24 January, after the National Gas Company cut off its gas supply due to a breakdown in long-term contract negotiations.

UREA

Northern hemisphere spring demand has started to influence the market. This was kick-started by Europe purchasing around 300,000 tonnes from North Africa, with Egypt delivering 200,000 tonnes and Algeria the other 100,000 tonnes in late January. The emergence of spring demand followed a quiet start to 2018, with Brazil, India and the US largely absent from the market.

Prices kept relatively flat at $220-230/t f.o.b. throughout January only to increase in February. Rises were partly driven by Egyptian producers running out of export availability due to a tight domestic market. Granular urea sales out of Egypt were being concluded at around $270/t f.o.b. in late February. Chinese producers have largely remained out of the export market, with domestic prices remaining $40-50/t above international levels.

PHOSPHATE

The market has been slow entering 2018. Producers have largely focused on fulfilling existing orders while buyers have waited on the sidelines. Most spot activity has occurred in Oceania and Southeast Asia, although around 100,000 tonnes of Middle Eastern DAP is in transit to India. Chinese export availability is limited and expected to remain so until after the New Year celebrations. Finished phosphates prices have continued to edge upwards, despite sluggish demand. Major benchmarks have risen to $395-420/t f.o.b., up from $380-400/t f.o.b. in December, on the back of firm ammonia prices and tighter supply. Sulphur prices are also significantly up on a year ago.

POTASH

Tight availability in Brazil, India and Southeast Asia in the final quarter of last year extended into Europe in early 2018. Many major potash producers were sold out in January, namely APC, BPC and Uralkali, with only Canpotex believed to have some limited availability.

The new K+S Bethune mine in Saskatchewan seems to done little to disrupt the market balance so far, with 2017 production limited to a few hundred thousand tonnes. Furthermore, a beneficiation plant fire at EuroChem's new Usolskiy mine has delayed first production.

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Limited availability has fuelled price increases over the last 12 months. Brazil cfr prices, for example, climbed by $50/t in the year to February to reach $295/t. Similarly, the average Southeast Asia price rose by $27/t over the same period to reach $270/t in February.

SULPHUR

The dramatic upwards shift in prices seen at the end of last year has since unwound. The price of sulphur delivered to China dropped to $135/t by the end of January, having peaked at over $200/t last November. The key Vancouver and Arab Gulf export references for sulphur declined to around $120-130/t f.o.b. by mid-February.

November's price ramp-up always looked shaky. Many sulphur buyers could not live with sharply higher spot prices. Sulphur purchases were postponed because of this, and some downstream operations were also scaled-back. Speculative interest – a strong upwards price driver in China – began to dissipate in December as sulphur prices started to weaken.

Overall, supply and demand in the market are reasonably well-matched and sulphur prices remain relatively robust. February 2018 prices are still nearly double the average $80-90/t f.o.b. level seen in the first half of 2017.

Market price summary $/tonne – Mid-February 2018

Nitrogen	Ammonia	Urea	Ammonium Sulphate	Phosphates	DAP	TSP	Phosphoric Acid
f.o.b. Caribbean	305	n.m.	f.o.b. E. Europe 110-120	f.o.b. US Gulf	398-407	n.m.	n.m.
f.o.b. Yuzhny	290-300	225-230	-	f.o.b. N. Africa	403-427	315-320	600-810
f.o.b. Middle East	330	242-268**	-	cfr India	405-410	-	678*
Potash	KCl Standard	K_2SO_4	**Sulphuric Acid**		**Sulphur**		
f.o.b. Vancouver	212-241	-	cfr US Gulf	60-70	f.o.b. Vancouver	110-120	
f.o.b. Middle East	209-235	-			f.o.b. Arab Gulf	115-125	
f.o.b. Western Europe	-	€420-450			cfr North Africa	126-150	
f.o.b. FSU	194-230				cfr India	140-150+	

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:** The 2018 outlook is bearish – unless further unexpected supply corrections unfold. Further loosening of the merchant ammonia supply-demand balance is likely during the rest of the first quarter and into the second. This is expected to bring softer prices, until demand for US application refill emerges in the third quarter. A failure to resolve the current gas supply contract dispute in Trinidad could provide some upside to the market, if it reduces ammonia plant operating rates or results in plant closures.
- **Urea:** Market uncertainty over the emergence of US and Indian spring demand will influence price ideas in the next few months. US buyers typically import 1.5-2 million tonnes in February and March, in advance of spring applications. However, increased domestic supply is likely to offset this requirement, particularly if capacity expansions at Koch Enid and Dakota Gasification hit their start-up dates. In India, NFL has extended its import deadline to 26 February. This will most likely be met by inventory at Iranian plants. Urea prices are forecast to soften in the second quarter – with or without another Indian tender – as new supply enters the market and global demand eases.
- **Phosphate:** Market activity is expected to pick up in late February as national holidays end in China and Brazil. Recent announcements from India will provide trade and price direction. The first quarter phosphoric acid price settlement translates into a parity price of $425/t for the Indian DAP market. This is about $15/t above the current Indian DAP cfr price, suggesting that Indian DAP demand could be more profitably met by imports. Such a development would support a firmer Indian DAP price benchmark. High production costs are keeping Chinese producer offers high. Domestically-purchased Chinese ammonia averaged $576/t in January. This is more than $200/t above international benchmarks and will penalise Chinese producers who are not ammonia-integrated. The continuing ramp-up of Ma'aden's low-cost Wa'ad al Shamal operation will also maintain pressure on Chinese exporters, particularly for the Indian market.
- **Potash:** Although there is no reason for a downward adjustment in global demand this year, there will be exceptions at country-level. We expect 2018 demand in Brazil to fall back to 9.2-9.5 million tonnes, for example, down from the record 2017 level of 9.7 million tonnes.

Channel inventories are reported to be low, and the market should remain reasonably tight in the second and third quarters. This assumes limited volumes are produced by EuroChem Usolskiy, and that K+S Bethune also takes time to fully ramp-up. It also assumes that overall demand remains strong, and that incumbent producers will exercise discipline in matching supply with demand.

- **Sulphur:** Once again, the long anticipated sulphur supply glut failed to materialise in 2017. The fundamentals do still point to supply exceeding demand over the full course of 2018, although there is still no sign of a substantial supply surplus so far this year.

Around a dozen current hydrocarbon projects in the Middle East, Kazakhstan and China should increase sulphur supply. Steadily increasing demand is unlikely to absorb the incremental volumes expected from this new project activity. Consequently, we still anticipate a market softening in 2018, with the start-up timings of new projects acting as the trigger for softer pricing.

Sulphur from the long-delayed Kashagan project in Kazakhstan has so far failed to materialise on the international market, but its impact is expected to be imminent.

Fertilizer Industry News

BRAZIL

Mosaic completes $2.5 billion Vale purchase

The Mosaic Company confirmed its acquisition of Vale Fertilizantes in January.

The completion of the purchase provides Mosaic with a diverse range of Brazilian fertilizer assets, including five phosphate mines, one potash mine, and four fertilizer production plants. The deal, by adding 4.5 million t/a of phosphates capacity, raises Mosaic's total global production capacity for phosphate fertilizers to 16.8 million t/a. The transfer of Vale's 40 percent interest in Peru's Miski Mayo phosphate mine, as part of the deal, raises Mosaic's interest in the joint venture to 75 percent. Mosaic will also be adding 7,300 Vale employees to its payroll.

Mosaic originally agreed to purchase Vale Fertilizantes for $2.5 billion. This was split between $1.25 billion cash and the transfer of 42.3 million Mosaic shares, giving Vale an 11 percent stake in the company. The terms of the deal were subsequently changed to $1.15 billion in cash plus 34.2 million Mosaic shares (8.9% of the company), after Vale subsequently decided to retain the TIPLAM port terminal in southeast Brazil.

The completion of the deal has also seen Vale's chief financial officer Luciano Siani Pires, elected to Mosaic's board of directors.

In November, Yara agreed to purchase Vale's Cubatao fertilizer complex for $255 million in cash. This in turn allowed Mosaic's purchase of Vale to complete, as Cubatao's sale was one of the deal's closing conditions.

Nutrien purchase Agrichem

Nutrien is buying Agrichem, one of Brazil's largest liquid fertilizer producers. The move strengthens Nutrien's position in a key global growth market for fertilizers.

Agrichem has an annual turnover of more than $55 million and typically generates earnings in excess of $15 million each year. The company produces close to 12 million litres of liquid NPK fertilizers annually and also manufacture biostimulants. It employs 195 staff.

The acquisition will proceed in two stages. Nutrien – the company formed from the recent Agrium-PotashCorp merger – says it will purchase 80 percent of Agrichem in "coming months". It will then look to buy the remaining 20 percent next year, "based on 2018 [earnings] levels", Nutrien said in a statement.

"As a leader in Brazilian specialty nutrient markets, the Agrichem team and extensive product profile will be an excellent fit with our Loveland products business," said Chuck Magro, Nutrien's president and CEO. "Brazil will be a strategic focus for further expansion due to its large and growing agriculture retail and crop input market."

Closure of the deal is subject to the usual regulatory approvals and customary conditions being satisfied.

INDIA

$11bn 2018/19 subsidy allocation

India confirmed a total fertilizer subsidy of INR 701 billion ($11 billion) for 2018/19 as part of the government's 1 February budget.

The 2018/19 allocation is largely unchanged from the INR 700 billion originally allocated for 2017/18. But it could equally be interpreted as an eight percent year-on-year increase, given that the government subsequently revised 2017/18's allocation downwards to INR 650 billion.

Indian finance ministry figures confirm that subsidies will be directed away from nitrogen fertilizers this year in favour of phosphate and potash instead. The 2018/19 subsidy allocation for domestically-produced phosphates and potash fertilizers, for example, will rise (up 28 percent to INR 158 billion), while subsidies allocated for domestic urea will be cut (down 13 percent to INR 350 billion). Subsidy allocations for imported phosphates and potash (up 17 percent to INR 93 billion) and urea (up two percent to INR 100 billion) will all increase.

In a separate development, India's goods and services tax (GST) on phosphoric acid has also been cut from 18 percent to 12 percent, with effect from 25 January. This followed news that OCP had agreed a first quarter 2018 contract price of $678/t cfr with Indian buyers, up $111/t on the last quarter of 2017.

Tata urea plant sale completes

Tata Chemicals has completed the $421 million (INR 26.82 billion) sell-off of its nitrogen fertilizer business to local Yara subsidiary, Yara Fertilisers India Pvt Ltd.

The completion of the sale was confirmed by a Tata regulatory filing on 12 January. "The sale and transfer of urea and customised fertilisers business to Yara has been completed today after the receipt of requisite regulatory approvals, fulfilment of conditions precedent and sanction of the National Company Law Tribunal, Mumbai," it said.

The deal transfers ownership of Tata's Barbala ammonia-urea plant in Uttar Pradesh to Yara, and an accompanying regional distribution network. The site's 700,000 t/a ammonia plant and a 1.2 million t/a urea plant, described as the most efficient in India, date from 1994.

IFFCO phosphate rock offtake

An offshoot of the Indian Farmers Fertilizer Cooperative (IFFCO) has agreed a phosphate rock offtake agreement with a Peruvian greenfield project owned by Canada's Growmax Resources.

The agreement was made between IFFCO subsidiary Kisan International Trading and GrowMax subsidiary Americas Potash Peru S.A. (APPSA). Under the terms of the deal, Kisan has agreed to purchase not less than 50 percent of the phosphate rock produced annually from APPSA's Bayovar concession, up to a total of 500,000 tonnes, if and when this mine enters production.

The agreement is for 15 years initially, commencing from the start of commercial mining by APPSA. The price paid by Kisan will reflect phosphate rock prices at the time of purchase.

The offtake with IFFCO should lower the Bayovar project's market risk and provide a secure source of future revenue, according to the president and CEO of GrowMax Resources, Stephen Keith.

"We are extremely pleased to have signed an offtake agreement with an exceptional and highly-reputed partner

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such as Kisan/IFFCO," Keith said. "This agreement provides GrowMax with the benefit of an ongoing future revenue stream and lower market risk once production of phosphate rock commences, and also provides Kisan with a secure future supply of phosphate rock."

VIETNAM

Vinachem divests fertilizer assets

The Vietnam National Chemical Group (Vinachem) plans to sell-off its fertilizer production business. The company is offloading four diammonium phosphate (DAP) and urea production assets as part of a larger-scale restructuring, privatisation and divestment plan.

State-owned Vinachem is selling all of its shares in 15 subsidiary companies, while retaining equity stakes in a further seven subsidiaries, government news website *chinhphu.vn* has confirmed. The sell-off and restructuring plan has been approved by Vietnam's deputy prime minister, Vuong Dinh Hue.

Vinachem currently produces and trades in basic chemicals, fertilizers and pesticides. Its fertilizer assets include Ha Bac Nitrogenous Fertilizer and Chemicals Co Ltd, DAP-Vinachem Co Ltd, DAP No.2 Vinachem JSC, and Ninh Binh Nitrogenous Fertilizer Co Ltd. It also owns an equity stake in Vietnam Apatite Co Ltd.

The restructuring plan is due to be implemented between now and 2020. The sell-off of Vinachem's fertilizer assets will only go through when these no longer incur losses, according to *Saigon Times*. The sell-off is therefore likely to be conditional on business restructuring and production improvements.

Vinachem will apparently retain stakes of between 50-65 percent in seven subsidiaries, including the joint stock companies Lam Thao Fertilizers and Chemicals, Van Dien Fused Magnesium Phosphate Fertilizer, and Ninh Binh Phosphate Fertilizer. It will also hold capital of less than 50 percent in a further nine joint stock companies, including Binh Dien Fertilizers, Can Tho Fertilizers and Chemicals and Southern Fertilizers.

NIGERIA

KBR wins Indorama contract

KBR has won a contract for the second ammonia train at Indorama's Port Harcourt plant in Nigeria.

Indorama Eleme Fertilizer & Chemicals and Toyo Engineering jointly awarded the contract to KBR on 24 January. KBR will provide technology licensing, basic engineering design, proprietary equipment and the catalyst for the new plant.

"We are privileged to have the opportunity to work with Indorama and Toyo on Indorama's second fertilizer complex in Nigeria", said John Derbyshire, president, KBR technology & consulting. "This contract builds on our long-established relationship with Indorama and Toyo and further highlights our clients' trust in KBR's ammonia technology."

OMAN

Omifco plans third urea train

Oman India Fertiliser Company (Omifco) has announced plans to build a third ammonia-urea train at its Qalhat in Sur plant in the next four to five years.

The proposed 1.3 million tonne capacity urea train would increase the installed urea capacity at Qalhat in Sur to three million t/a, up from around 1.7 million t/a currently.

The site's existing twin trains in Sur have an identical capacity: 2,530 tonnes per day for urea and 1,750 t/d for ammonia. Around 80 percent of the plant's ammonia output is consumed in urea manufacture with the remainder going to export.

The plans for an extra ammonia-urea train, which are still at a very early stage, were revealed by S G Gedigeri, Omifco's managing director, in an interview with the *Times of Oman* in February.

The third train could cost Omifco, a joint venture between the Oman Oil Company (OOC), Indian Farmers Fertilizer Cooperative (IFFCO) and Krishak Bharati Cooperative (KRIBHCO), an estimated $1.2 billion to build.

The funding for the project would largely come from local and international financial institutions, in Gedigeri's view.

"We have repaid all our loans to international lenders well within time. With an excellent track record… and [with] the company having a strong asset base of some $2.5 billion, financial institutions will be willing to fund the project," Gedigeri said. The option of raising finance from export credit agencies, via engineering, procurement and construction (EPC) contractors, was also a possibility in his view.

Approving the budget for feasibility work will be a necessary first step, according to Gedigeri. This will then allow environmental impact and feasibility studies, including a market survey, to be commissioned from external consultants.

The prospect of a gas allocation from Oman's recently-commissioned Khazzan gas project is encouraging Omifco to push ahead with plans to expand its ammonia-urea production. The proposed third train would require a gas supply of around three million cubic metres, Gedigeri suggested. The giant Khazzan project is expected to meet one third of Oman's natural gas demand.

"Our priority is on expanding the capacity by setting up a third train as a brownfield project adjacent to the existing facilities at Sur Industrial Estate," confirmed Gedigeri.

The completion of an expansion project is, however, at least 4-5 years away. Even if fast-tracked, it will take Omifco a minimum of one year to make the final investment decision, admits Gedigeri, and then another three years to complete the EPC work and commissioning.

GERMANY

K+S commissions KCF plant

K+S has commissioned the new kainite crystallisation and flotation (KCF) unit at its Hattorf site in Germany, part of the Werra potash plant.

The €180 million unit – a major environmental investment by the company – was commissioned on schedule in January after 24 months of construction. The KCF will reduce the amount of saline wastewater produced at the Werra plant by one-fifth, a volume of around 1.5 million cubic metres. The unit will also recover about 260,000 tonnes of saleable potassium chloride and magnesium sulphate.

"With our new KCF facility, we are creating a further important condition for the future viability of thousands of jobs in the Hesse-Thuringia potash district," said Burkhard Lohr, K+S chairman. "The fact that we have invested almost half a billion euros in new facilities to reduce wastewater at the Werra site within a few years shows that we treat sustainable production seriously."

Potash production at the Werra plant has faced periodic disruptions in recent times due to limits placed on wastewater discharges into the Werra river. These were imposed by local regulators in Germany due to concerns over the region's water quality.

K+S did, however, finally broker a long-term wastewater agreement with the Gerstungen municipal government at the end of last year. As part of a 30-year deal, the local authority has agreed to drop a suit over saline wastewater injection permits. The two parties have also agreed to amicably settle their dispute over the discharge of saline wastewater into the Werra river.

"It [the agreement] will… secure continuing potash production in the Hesse-Thuringia potash district, on which well over 4,000 jobs depend," K+S said in a statement.

CANADA

Nutrien 'absolutely not' shutting mines

Nutrien's CEO Chuck Magro has said the company is "absolutely not" considering closing down some of its less-profitable potash mines.

Magro issued the denial on 8 February, ending the speculation that followed comments made earlier that month by Raef Sully, Nutrien's executive vice-president of potash.

During Nutrien's fourth quarter financial call, Sully said that the company was looking at all options to reach $500 million in operational savings by the end of 2019. "In the short term, we need the six [Saskatchewan mines] running," said Sully, adding: "We'll look at that halfway through the year and see what the second half does."

However, Magro later insisted that closures are not part of Nutrien's current plans. "You never want to take any option off the table," Magro said. "I don't predict demand, I don't have a silver ball in terms of what's going to happen when it comes to demand globally. But with what we can see today – absolutely not."

Magro expects Nutrien to increase potash production by three percent this year: "Our plans are going to be very similar to last year, in fact we're going to produce more potash this year than we did last year."

Magro insisted that, although mine optimisation was important, there was no rationale for closures. He also said that operational savings would mainly come from the retail part of the business. "Our retail business is a $13 billion business operating in seven countries," said Magro. "We're able to move more of our potash through our own channels and that will create a lot of value and a big part of that $500 million."

TUNISIA

Strikes halts phosphates production

Groupe Chimique Tunisien (GCT) stopped producing diammonium phosphate (DAP) in February due to strike action.

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China News Round-up

Courtesy of Kcomber, owner of CCM and Tranalysis

Chanhen to expand with help of EcoPhos technology

Guizhou Chanhen Chemical Corporation (Chanhen) plans to build a new phosphates complex in Hubei province within the next three years as part of a collaboration with Belgium's EcoPhos.

Chanhen, one of China's main feed phosphates producers, announced the new agreement with EcoPhos in February. This covers the construction of three phosphoric acid lines, plus large-scale downstream production capacity for feed phosphates (400,000 t/a), water-soluble fertilizers (300,000 t/a) and phosphoric acid (100,000 t/a).

The use of innovative EcoPhos process technology will allow the complex to consume medium- and low-grade phosphate rock (2.2 million t/a). It will also generate a high-purity, white gypsum by-product (1.5 million t/a) for the building materials market.

Chanhen and EcoPhos ultimately plan to build at least 10 phosphoric acid lines in Hubei, eventually producing two million t/a animal feed downstream from up to 15 million t/a of phosphate rock. This would make the partners world leaders in feed phosphates production, Chanhen suggested.

China's fertilizer prices to rise in 2018

Fertilizer prices look set to remain on an upward trend in 2018, despite declining demand. Higher prices are being largely driven by three factors: increasing production costs due to higher raw material prices; limits on production resulting from government environmental protection measures; and fewer manufacturers on the market as a consequence of supply-side structural reforms.

Fertilizer demand from China's agricultural industry is expected to slide further, driven down by the zero-growth in fertilizer use policy and falling crop prices. Product prices will, however, receive some support from continuing demand growth in non-agricultural markets.

Higher costs hit phosphates producers

China's phosphates market is expected to remain flat in the near term. Producers are suffering from a combination of sluggish downstream demand and climbing production costs. Phosphate rock supply in China also remains tight at present.

A recent surge in transportation costs has also hit producers. The need to deliver phosphogypsum to cement or building material plants, as required under environmental regulations, has added to the cost burden.

These factors have combined to force high-cost MAP producers to increase their price quotations. Raising prices, on the other hand, is a less viable option for China's DAP producers due to slack demand.

Operating rates for domestic compound fertilizer producers are currently reported to average 40–50 percent, due to environmental inspections and low market demand.

Fertilizer rail freight costs to rise

A fifteen percent maximum rise in rail freight prices was announced at the end of last year by China's National Development and Reform Commission.

Fertilizers were not one of the 12 commodities listed in a notice on rail freight price reform issued by the Commission last December. But rail freight companies have, in general, been asked to adjust their prices in future to reflect market supply and demand.

CCM expects the rail freight announcement from the Commission to accelerate market reforms and give railway transport companies more freedom to match prices to market conditions. Initially, the new price hike will mainly affect fertilizer producers located in remote areas. But it is a signal for the whole industry to act to reduce its exposure to high rail transport costs.

Yinshan Fertilizer resumes SSP production

Yinshan Fertilizer resumed production in December 2017, following a year-long shutdown, after regaining its production license.

The company has the capacity to manufacture 200,000 tonnes of single superphosphate (SSP) annually. But production was suspended in December 2016 after profits were hit by falling SSP prices. Yinshan Fertilizer used the stoppage to repair and overhaul equipment at the plant.

Parent company Yunnan Yuntianhua decided to resume production at Yinshan Fertilizer at the end of last year due to a rebound in domestic prices. Improvements in SSP demand from Yunnan Province and greater international demand from Myanmar also helped make the resumption of production viable.

Yunnan Yuntianhua expects 2017 profits increase

Yunnan Yuntianhua expects to make a net profit in 2017, on the back of business improvements and a general fertilizer market recovery.

Yunnan Yuntianhua cut operating costs and raised output last year. The company also took the opportunity to upgrade its commodity fertilizer business, increase its R&D investment and focus on developing new-types of efficient fertilizers.

These measures have resulted in significant rises in production output, sales volumes and prices for the company's portfolio of phosphate fertilizers, urea and compound fertilizers.

Guizhou Kailin opens DAP production line

Guizhou Kailin held an opening ceremony for a new 100,000 t/a diammonium phosphate (DAP) line at the end of December. This will produce industrial-grade DAP from phosphoric acid using the company's own proprietary technology.

The new line will improve Guizhou Kailin's fertilizer utilisation rate and add value to its resources. The company is also planning to upgrade its product mix by building a new 150,000 t/a water-soluble fertilizer unit and a 300,000 t/a compound fertilizer unit. These will replace an existing 340,000 t/a conventional fertilizer production line. ■

A new round of strikes is reported to have halted the transport of phosphate rock to GCT's DAP plant since the start of February. Consequently, DAP production is said to have completely stopped since 5 February having reached 25,000 tonnes in January.

GCT sold 30,000 tonnes of DAP for February shipment. This is expected to draw down stocks, leaving little or no availability for March, unless the current crisis is resolved.

So far this year, Tunisian phosphate rock production by Gafsa Phosphate Company (CPG) has been below 160,000 tonnes, *Tunis Afrique Presse* reported in early February, compared to the 500,000 tonnes mined over the same period last year.

It is rumoured that phosphoric acid production at the Tunisian Indian Fertilizers (TIFERT) joint venture will also halt by the end of February due to the lack of phosphate rock feedstock. The crisis is so serious that Tunisia's downstream phosphate companies are believed to have discussed the possibility of importing phosphate rock with the government.

The current industrial dispute is just the latest example of the frequent strikes that have hit Tunisia's phosphates industry since the 'Arab Spring' uprising in 2011.

UNITED KINGDOM

Sirius agree shaft-sinking contract

Sirius Minerals has agreed a design and build contract with DMC Mining Services, a leading shaft sinking and mining contractor.

The contract covers the construction of four shafts for the company's polyhalite project in North Yorkshire.

Faster shaft sinking by DMC could bring forward the first production of polyhalite from the project by up to six months, Sirius said in a statement.

"DMC has proven, world leading experience using Herrenknecht SBR technology on deep shafts and represents a strong partner, commercially aligned to our success," said Chris Fraser, managing director and CEO of Sirius Minerals. "We are confident that they can deliver the North Yorkshire polyhalite project shafts significantly earlier than all previous expectations and we look forward to working with the team."

Potash mining to end at Boulby

Potash production at Boulby mine will cease by the end of June, ICL UK has confirmed. The end of production is earlier than expected due to operational and market conditions, the company said.

The company's decision is not surprising, given that ICL UK made significant losses last year. Muriate of potash (MOP) reserves at Boulby have also been declining for several years.

ICL will now bring forward the planned phase-out of MOP mining at Boulby, first announced November 2015, in favour of polyhalite production. A total of around 230 job losses are expected at the mine by the time MOP production finally ends.

ICL will continue to ramp-up production of its *Polysulphate* polyhalite product at Boulby. This is believed to have reached around 450,000 tonnes in 2017. The company has set itself a one million tonne production target for polyhalite by 2019-20.

Boulby's phase-out is expected to remove around 400,000 t/a of potash from global supply. UK potash imports rose sharply last year to meet the growing domestic production shortfall. Around 333,627 tonnes were imported in January-October 2017, for example, compared to 121,847 tonnes over same period in 2016. ■

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People

Frauke Riva is the new head of corporate communications at K+S Group. She joins the company from her previous role as head of communications at thyssenkrupp Industrial Solutions. Frauke will report directly to K+S chairman Burkhard Lohr. **Oliver Morgenthal**, the highly-experienced former head of corporate communications, will now lead n public affairs for K+S, a reflection of the increasing importance of this function for the company.

The Sulphur Institute (TSI) appointed **Sarah Amirie** as its director of operations in January. Ms Amirie will oversee member relations, third party vendor services and office management. Prior to joining TSI, Ms Amirie worked in various roles in several federal government departments, including as an executive assistant, treasury analyst and software development technician. She is a graduate of Marymount University and holds a certificate in computer software engineering from George Washington University. Robert McBride, TSI president and CEO, warmly welcomed Sarah to the Institute: "We look forward to having Sarah's experience which will enhance TSI programs and operations."

Incitec Pivot Limited (IPL) restructured its executive team in January following the departure of **Simon Atkinson**, the former president of Dyno Nobel Asia Pacific (DNAP) and Incitec Pivot Fertilisers (IPF). In future, management responsibilities for the two businesses will be split between two individuals. **Greg Hayne** has become DNAP's new president, while **James Crough** is acting as the interim president of IPF. Mr Hayne has extensive explosives industry experience. He has held a variety of operational and leadership roles in explosives, both in Asia-Pacific and the US, since joining Dyno Nobel in 2000. Mr Crough has also gained extensive fertilizer business experience since joining the company in 2005.

IPL has also created two new executive team roles as part of its high-level restructuring. **Robert Rounsley** has been appointed chief technology development officer. He will lead IPL's global technology group, for both the explosives and fertilizers businesses. Mr Rounsley is an internationally recognised explosives expert who has been with IPL for 20 years. **Seth Hobby** has also been appointed executive commercial officer, the other new role. He will lead corporate-level negotiations, provide corporate oversight for key business contracts and improve IPL's commercial capability. Mr Hobby has been with IPL for ten years and played a key commercial role during the development of the Louisiana ammonia plant.

Rich Mack has stepped down as executive vice president and chief financial officer (CFO) at The Mosaic Company. He will leave the company in May this year. **Anthony Brausen** will serve as senior vice President, Finance, and interim CFO until the position is filled permanently. He will also act as the company's designated principal accounting officer. Previously, Brausen led Mosaic's accounting, financial analysis and reporting, treasury, tax, information technology and business unit finance teams.

Mosaic CEO, Joc O'Rourke praised Mack's performance during his 24 years at the company. This spans the Cargill years, prior to Mosaic's formation, through to the recent Vale Fertilizantes acquisition. "Rich advanced many strategic initiatives for Mosaic and conducted himself and led the CFO organization with the highest ethical standards and integrity," O'Rourke said.

We regretfully announce that the highly-regarded and influential phosphates industry consultant **Paul Smith** passed away in January. Paul's long and distinguished career included a 15-year long stint at Prayon in the 1980s and 1990s, firstly as sales manager and latterly as director of licensing. His time at Prayon coincided with a massive expansion in the phosphates industry. Paul was instrumental in the successful sale of Prayon's acid technology to Brazil, Indonesia, South Korea and Morocco during his time at the company. Later as a consultant, Paul travelled the globe, working extensively on major phosphoric acid projects in India, Venezuela, Florida, South Africa, Canada and, importantly, Brazil – a country he eventually made his home. His sudden and untimely death means Paul will be sadly missed by family, friends and colleagues alike.

Calendar 2018

MARCH

12-14
Phosphates 2018,
MARRAKECH, Morocco
Contact: CRU Events
Chancery House, 53-64 Chancery Lane, London WC2A 1QS, UK.
Tel: +44 (0) 20 7903 2444
Fax: +44 (0) 20 7903 2172
Email: conferences@crugroup.com

APRIL

9-12
IFA Global Technical Symposium,
MADRID, Spain
Contact: IFA Conference Service,
Tel: +33 1 53 93 05 00
Email: ifa@fertilizer.org

MAY

8-9
IFS Technical Conference,
PRAGUE, Czech Republic
Contact: International Fertiliser Society
PO Box 12220, colchester, CO1 9PR, UK
email: secretary@fertiliser-society.org
Tel: +44 (0)1206 851 819
Fax: +44 (0)1206 851 819

JUNE

8-9
42nd AIChE Annual Clearwater Conference 2017, CLEARWATER, Florida
Contact: Perry Alonso,
AIChE Central Florida Section
Email: vice-chair@aiche-cf.org

18-20
86th IFA Annual Conference,
BERLIN, Germany
Contact: IFA Conference Service
Tel: +33 1 53 93 05 00
Email: ifa@fertilizer.org

SEPTEMBER

24-26
CRU Africa Fertilizer Agribusiness 2018,
CAPE TOWN, South Africa
Contact: CRU Events
Tel: +44 (0)20 7903 2444
Email: conferences@crugroup.com

OCTOBER

1-3
TFI World Conference,
SAN FRANCISCO, California
Contact: Valerie Sutton
Fax: (202)-962-0577
Email: vsutton@tfi.org

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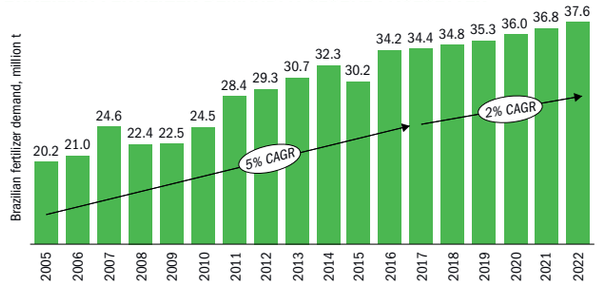
PICTURE THIS...

Brazil's pacesetting market

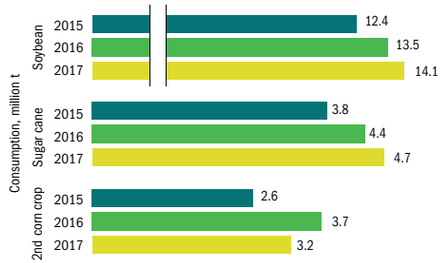
Brazil's fertilizer demand growth – a blistering five percent per annum since 2005 – has been the global pace setter, despite a 2015 dip in consumption. Although growth is likely to moderate to two percent p.a. out to 2022, the country's demand for fertilizers is still set to grow by more than three million tonnes over the next five year to reach 37.6 million tonnes. The country's growing requirement for fertilizers has been fuelled by rising year-on-year demand from soybean and sugarcane. Demand from Brazil's second corn crop, in contrast, has been volatile and a market swing factor in recent years. Servicing Brazil's fertilizer demand is requiring ever larger import volumes. Urea imports reached 5.4 million tonnes last year, fulfilling around 90 percent of the country's total 5.9 million tonne requirement. Potash deliveries to Brazil are forecast to exceed a record 9.5 million tonnes in 2017, led by growing supply from Russia and Israel. Demand for phosphate fertilizers is also on the up: Brazil imported a record 3.6 million tonnes of higher-grade MAP (11-52) plus 2.6 million tonnes of lower-grade MAP in 2017. The latter category includes NPS products such as Mosaic's *MicroEssentials* (12-40-0-10S) and Moroccan product (12-46-0-7S). Imports of *MicroEssentials* tripled between 2015 and 2017. Indeed, overall demand for premium products – NPK, NPS and speciality nitrogen fertilizers – has been spectacular, growing from just three percent of the market in 2014 to around 10 percent last year. The premium product market is expected to continue to expand, and could account for one-fifth of Brazil's fertilizer market by 2022. Imports of speciality potash products (Mosaic's *K-Mag*, *Korn-Kali* from K+S and ICL's *Polysulphate*) are relative small-scale – 130,000 tonnes in 2017 – but increasing rapidly. Deliveries of *Polysulphate* – ICL's new polyhalite product – from the UK to Brazil have notably escalated since they began in 2015.

Sources: GTIS/Argus/CRU/Mosaic

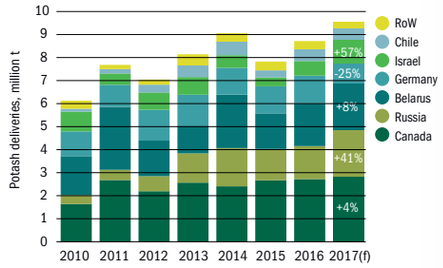
BRAZILIAN FERTILIZER DEMAND: A GLOBAL PACESETTER



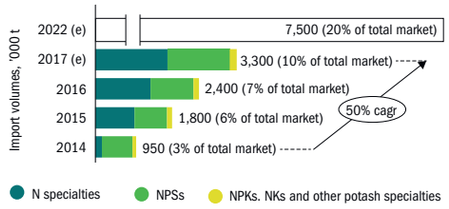
SOYBEAN, SUGAR CANE AND CORN DRIVE DEMAND



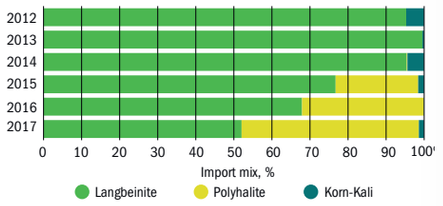
RECORD 2017 POTASH DELIVERIES



GROWING DEMAND FOR PREMIUM PRODUCTS



CHANGING SPECIALITY POTASH IMPORT MIX



Fertilizer demand update

The International Fertilizer Association (IFA) has updated its crop-by-crop estimate of agricultural fertilizer use for the first time since 2013. Applications to soybean and oil palm have both increased sharply.

Demand is everything. It is the engine and mainspring of any market, whatever the product. Demand is what drives sales, supply and trade. Critically for any business, it also determines sales revenues.

It is equally clear that demand – and how it varies and what causes it to vary – underpins the future prospects of the whole fertilizer industry, and companies up and down the value chain. Also, when it comes to measuring and forecasting fertilizer demand, fully understanding the influence of crop growing – nationally, regionally and globally – is essential.

It is also a problematic task. Collating detailed information on the fertilizer consumption of individual crops is by no means easy. "This information is rarely available, challenging to collect, and time-consuming to process," comments the International Fertilizer Association (IFA). Large knowledge gaps also exist.

To help matters, IFA carries out its own crop-by-crop survey of fertilizer use in the main consuming countries every three to four years. These periodic updates are eagerly awaited, being the most in-depth and comprehensive assessment of global crop demand available in the industry.

IFA published it latest global assessment of fertilizer use by crops last September[1]. This is based on two date ranges, 2014 and 2014/15. This is because countries such as China, Brazil, Indonesia publish calendar year (2014) statistics, while others, including India, the US and EU, publish these on a 'fertilizer year' (2014/15) basis. (Note: date ranges have been simplified to 2014/15 for the purposes of this article.)

IFA's latest survey updates the previous 2013 assessment, which was based on fertilizer use in 2010 and 2010/11. This time around, IFA asked the International Plant Nutrition Institute (IPNI) to validate the survey using its considerable agronomic expertise. Survey coverage has also been improved. An extra country, New Zealand, has been added, as well as an extra crop category for 'grassland'.

IFA's latest assessment

IFA's latest assessment covers 28 countries, collectively accounting for 94 percent of world fertilizer consumption, with the EU included as a single bloc. Crops have been divided into the following 14 groups:

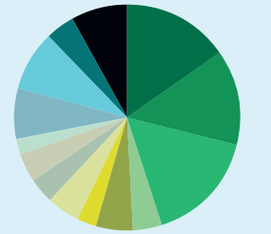
- **Wheat**
- **Rice**
- **Maize**, for grain and silage
- **Other cereals:** barley, sorghum, oats, rye, triticale, millet
- **Soybean**
- **Oil palm**
- **Other oilseeds:** rapeseed/canola, mustard, sunflower, groundnut, coconut
- **Fibre crops:** cotton, flax, hemp, jute
- **Sugar crops:** sugar cane and sugar beet
- **Roots & tubers:** potato, cassava, sweet potato, yam
- **Fruits**
- **Vegetables**
- **Grassland**
- **Residual**

Grassland includes temporary and permanent grassland, as well as pasture for hay, silage and grazing. The residual category is a catch-all that includes pulses, tree nuts, rubber, cocoa, coffee, tea and tobacco. It also encompasses miscellaneous agricultural uses such as forestry, fish ponds, ornamental, turf, golf courses, homes and gardens.

The nutrient consumption figures in the assessment are for the period 2014-2014/15, as published by IFA in September 2017. Although its latest assessment is highly detailed and comprehensive, IFA provides the following health warning:

"Data …are estimates based on the best information available to IFA and IPNI. They provide an order of magnitude but are not hard data and, as such, should be used and interpreted with the necessary caution."

Fig. 1: **Global fertilizer use by crop**



Wheat	15.3%
Rice	13.7%
Maize	16.2%
Other cereals	4.0%
Soybean	5.4%
Oil palm	2.7%
Other oilseeds	4.6%
Fibre crops	3.7%
Sugar crops	4.1%
Roots/tubers	2.3%
Fruits	7.2%
Vegetables	8.6%
Grassland	4.3%
Residual	7.8%

Source: IFA

Fertilizer use by crop

World nutrient consumption reached 181.9 million tonnes in 2014/15. This is divided between 102.5 million tonnes of nitrogen (N), 45.9 tonnes of phosphate (P_2O_5) and 33.5 million tonnes of potash (K_2O) fertilizers.

A breakdown of global fertilizer consumption by crop is provided in Figure 1. It is clear that large-scale cultivation of commodity crops remains a key driver of demand. The 89.6 million tonnes of nutrients applied to cereals accounted for

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Fig. 2: **Fertilizer consumption by crop: top five world markets**

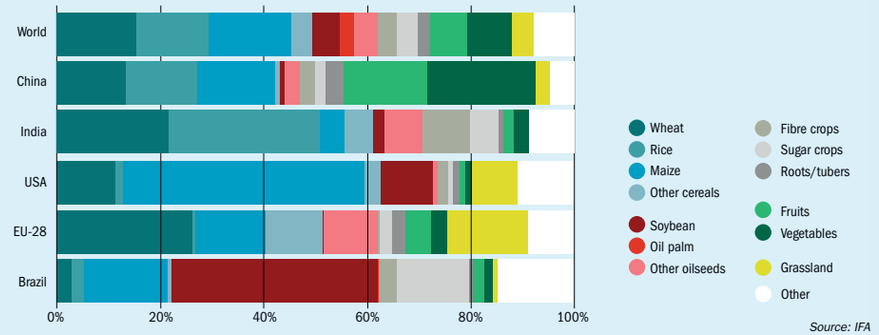
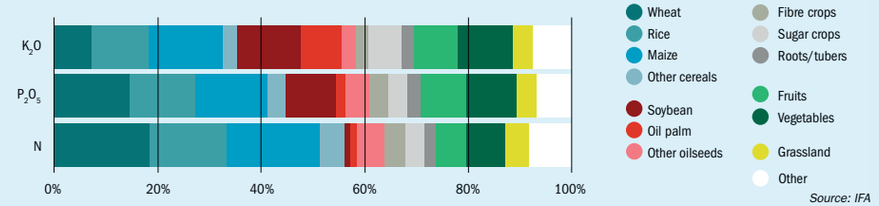


Fig. 3: **Variations in crop consumption of N, P and K**



slightly less than half (49%) of world fertilizer use. The top-three fertilizer-consuming cereals were maize (16%) – the single greatest contributor to world fertilizer consumption – followed by wheat (15%) and rice (14%).

Although overshadowed by cereals, applications to fruits (7%) and vegetables (9%) collectively represent a highly significant 16 percent share of the world fertilizer market.

Oilseeds are next in the demand ranking. Global applications to oil crops were estimated at 23.2 million tonnes in 2014/15, some thirteen percent of world fertilizer consumption. The global consumption shares of soybean (5%) and oil palm (3%) stand out in particular.

Three crop types, fibre, sugar crops and grassland, each accounted for around four percent of world fertilizer applications, while roots and tubers accounted for just over two percent. Grassland's share is likely to be an underestimate, however, due to information gaps for some countries.

National-level consumption by crops

Unsurprisingly, individual crop contributions to fertilizer consumption at national level vary widely. This is largely due to differences between countries in the crop mix, cropping systems and levels of agricultural intensification.

The main crop contributors in the five leading fertilizer-consuming markets (Figure 2) are markedly different:

- China: fruits and vegetables (37%)
- India: rice (29%)
- US: maize (47%)
- EU: wheat (26%) and grassland (16%)
- Brazil: soybean (40%) and sugarcane (14%)

There are also extreme examples of a single crop dominating total fertilizer consumption in some countries – a reflection of geography, soils, climate and land use preferences:

- Bangladesh: rice (69%)
- Malaysia: oil palm plantations (83%)
- New Zealand: grassland (89%)

Crop-to-crop consumption differences

The very different nutrient requirements of individual crops naturally results in substantial variations in their N, P and K consumption (Figure 3). For example:

- Cereals have disproportionately high N consumption
- Oil palm and sugarcane, and other high biomass crops, are large K consumers
- Soybean only boosts P and K consumption, as it biologically fixes N
- Fruits & vegetables also contribute greatly to P and K consumption

Nitrogen consumption by crop

Cereal crops lead on nitrogen consumption globally. An estimated 57 million tonnes were applied to cereals in 2014/15, representing 56 percent of world agricultural nitrogen consumption. Wheat and maize are the main nitrogen-consuming crops, each accounting for eighteen percent of global use, followed by rice with a fifteen percent share. Other cereals account for five percent of the world nitrogen total.

Fruits (6%) and vegetables (7%) account for just under 14 percent of global nitrogen fertilizer consumption. Cotton, sugar crops, and roots & tubers collectively comprise almost 10 percent of global nitrogen fertilizer use. Oil crops contribute a modest eight percent to world consumption of nitrogen fertilizers – mainly because of soybean's ability to fix nitrogen from the atmosphere. Rapeseed, instead, is the main nitrogen-consuming oilseed crop type. Under five percent of world nitrogen fertilizers are applied to grassland.

Phosphate consumption by crop

Cereals received 20.5 million tonnes of P_2O_5 in 2014/15, coming in below nitrogen but still equivalent to 45 percent of world phosphate fertilizer applications. Cereal phosphate consumption is led by wheat (15%) followed by maize (14%) and rice (13%). Fruits (9%) and vegetables (10%) are important phosphate-consuming crops. Combined, they make up 19 percent of global phosphates consumption, a larger market share than for nitrogen. Oilseed crops account for a healthy 16 percent of total global phosphate consumption (7.4 million tonnes P_2O_5). Of this share, soybean contribute almost 10 percentage points. Fibre crops, sugar crops, and roots & tubers represent almost 10 percent of global phosphate fertilizer use, remarkably similar to their nitrogen share. Grassland receives just four percent of total phosphate fertilizers globally.

Potash consumption by crop

Cereals account for a much lower share of world potash consumption, compared to their contribution to nitrogen and phosphate consumption globally. Consequently, high potassium-consuming crops – particularly oil palm and sugar crops – have a stronger influence on global potash fertilizer consumption.

Cereals received 11.8 million tonnes of K_2O in 2014/15, some 35 percent of world potash consumption, with wheat making a much lower contribution (7%) than either maize (14%) or rice (11.%). Oilseeds account for a 23 percent share (7.7 million tonnes K_2O) of total potash consumption – a much higher share than for N and P – with most of this applied to soybean (12%) and oil palm (8%). With a combined 19 percent share of the world total, fruits (9%) and vegetables (11%) are both large consumers of potash fertilizers. Global potash fertilizer use on sugar crops (6%) is also high, relative to fibre crops (2%) and roots & tubers (3%). Applications to grassland make up just four percent of total potash consumption.

Changes in fertilizer use, 2010/11 to 2014/15

Compared to the previous assessment, fertilizer use has grown by 9.7 million tonnes nutrients (6%), from 172.2 million tonnes in 2010/11 to 181.9 million tonnes in 2014/15. Growth has not been uniform across all crop types. Fertilizer applications to the following crops, in particular, all moved sharply upwards:

- Soybean: +3.1 million tonnes
- Fruits: +3.1 million tonnes
- Maize: +1.6 million tonnes
- Oil palm: +1.5 million tonnes

These increases typically reflect rises to the area planted for these crops. Over the same period, fertilizer use also declined in some crop categories, although not to the same extent:

- Roots & tubers: -1.1 million tonnes
- 'Other cereals': -0.5 million tonnes
- 'Other oilseeds': -0.4 million tonnes
- Vegetables: -0.4 million tonnes

Additionally, fertilizer use on maize, wheat and rice has been influenced by continuous gains in nitrogen use efficiency, according to IFA. (It should also be noted that changes to the fertilizer consumption of fruits and vegetables, between the last and current assessments, are partly an artefact of a reallocation between these two categories.) Differences between the two assessments may also reflect changes to:

- The crop mix
- Weightings of different countries
- Fertilizer management practices
- Data quality

Over time, IFA hopes to improve its crop-based assessment of fertilizer use by progressively improving country and crop coverage. Extending coverage in Latin America and Africa – and a better understanding of fertilizer applications to coffee, tea and cocoa – will all be priorities for the next update, according to IFA. ■

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CROP DEMAND

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Low-carbon ammonia and urea production

A vast solar array at Ouarzazarte in Morocco.

PHOTO: MASEN

Could the European nitrogen industry become carbon-neutral by 2050? That is the searching question posed in a landmark study from Cefic, the European Chemical Industry Council. We examine the current and future viability of low-carbon ammonia and urea synthesis and the main technology options.

As a basic chemical, ammonia is second only to sulphuric acid in terms of global, industrial-scale production. Europe, for example, currently manufactures around 17 million tonnes of ammonia annually. More than 80 percent of the world's primary ammonia output is consumed downstream in fertilizer production, principally urea manufacture. A further five percent goes towards making nitric acid.

Can the chemical industry go carbon neutral?

The production of basic chemicals still relies on highly energy-intensive processes. Ammonia and urea production, staples of the nitrogen industry, are no exception to this. Ammonia production is responsible for about 430 million tonnes of carbon dioxide emissions globally, about one percent of the world's energy-related emissions, according to the International Energy Agency (IEA).

The chemical sector has already halved its energy intensity and greenhouse gas (GHG) emissions since 1990, according to trade body Cefic, the European Chemical Industry Council. Despite this, Europe's long-term goal of making its chemical sector carbon-neutral, while at the same remaining globally competitive, remains a massive challenge. The EU's climate and energy agenda, and the wish to move to a more circular economy in Europe, are adding extra policy push for a low-carbon transition in the region.

Cefic says it wants to play a leading role in the transition to a low-carbon and circular economy in Europe – by creating innovative climate- and energy-friendly solutions for the industry's processes. To help deliver this, Cefic recently commissioned a landmark study on low-carbon energy and feedstocks for the European chemical industry[1].

Carried out by Dechema, a Frankfurt-based network of chemical engineering experts, and published last July, the Cefic study addressed a simple but major question: can the EU chemical industry go carbon neutral by 2050?

The study explored the potential for low-carbon ammonia production using hydrogen generated by water electrolysis – the so-called 'power to ammonia' route. The possibilities for more 'climate-friendly' production of urea downstream, by combining low-carbon ammonia with carbon dioxide, were also examined.

"Many promising low-carbon technologies are available at a relatively advanced stage of development," commented Marco Mensink, Cefic's director general. "The industry will need to find the way to overcome the investment, raw material and energy challenges for them to be implemented on a large scale in Europe."

Back to the future

One irony is that, in its search for innovative low-carbon processes, the chemical industry has returned to its early 20th century beginnings. The history of producing ammonia from hydrogen, via the electrolysis of water, is almost as old as the ammonia industry itself. Luigi Casale built the first electrolysis-based ammonia plant at Terni in Italy in 1919, using his own high-pressure ammonia synthesis

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process. This was followed by the Norsk Hydro plant at Rjukan in Norway in 1927 (*Nitrogen+Syngas* 350, p18).

Indeed, until the 1960s, most nitrogen fertilizers sold in Europe were manufactured by hydropower-based electrolysis at Rjukan and Vermork in Norway. Later, with the advent of abundant cheap natural gas, and process improvements and cost reductions, steam methane reforming (SMR) subsequently emerged as the standard ammonia production route in Europe and elsewhere. Nevertheless, a few electrolysis-based ammonia plants built in the 1940s and 50s remained operative. These were typically constructed near major hydroelectric dam projects, such as at Aswan in Egypt, and the Sebakwe Dam in Zimbabwe. Other countries, Chile, Iceland, Peru and Canada, also had electrolysis-based ammonia plants at one time or another (*Nitrogen+Syngas* 350, p18).

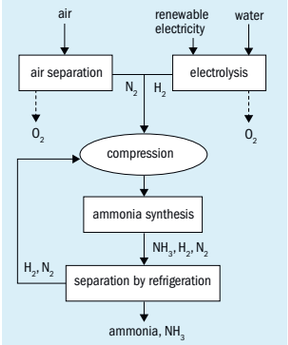
High production costs, however, have always been a major drawback, and have generally made water electrolysis uncompetitive as a commercial route for hydrogen generation, compared to SMR. It takes around 10-12 megawatt hours (MWh) of electricity to produce enough hydrogen to make one tonne of ammonia. At an average 2017 electricity cost of around $70/MWh in the United States, for example, this translates to an ammonia production cost of $840/t – and this is before any other costs are taken into account (*Nitrogen+Syngas* 350, p18).

Even though hydroelectricity tends to be cheaper, the hydroelectric production of ammonia in the US would still cost $550/t. That compares with an ammonia production cost via the conventional SMR route of $75-100/t, at prevailing US gas prices (*Nitrogen+Syngas* 350, p18).

Based on costs alone, it is easy to see why the industrial generation of hydrogen by water electrolysis fell out of favour. Globally, only Egypt's Aswan plant is still operational. The Rjukan ammonia plant in Norway closed in 1991. Iceland's hydroelectric ammonia plant followed suit, closing in 2004. The Sable Chemicals plant in Zimbabwe closed next, finally ceasing production in 2015 when the company switched to buying ammonia from South Africa (*Nitrogen+Syngas* 350, p18).

But the economics of low-carbon ammonia generation could potentially be transformed by the emergence of ever-cheaper large-scale solar and wind electricity generating capacity. The prospect of cost reductions in electrolysis technology could also be set to make renewable hydrogen generation more competitive. Conversely, in regions such as Europe, the costs of SMR production look likely to rise over the longer-term due to increases in carbon pricing.

Fig. 1: **Low carbon synthesis of ammonia by water electrolysis**



Source: Dechema

Low-carbon ammonia production

The hydrogen necessary for the low-carbon synthesis of ammonia is generated by water electrolysis (Figure 1). This synthesis route is known in the industry as 'power to ammonia'. A hydrogen purification step after electrolysis may be necessary, depending on the electrolysis technology. An air separation unit (ASU) is also required to supply pure nitrogen. Additionally, compressors are needed to pressurise hydrogen and nitrogen to 100-250 bar for ammonia synthesis and subsequent refrigeration.

The low-carbon water electrolysis route avoids endothermic primary and secondary reforming, and process steps such as shift conversion. This means that the corresponding energy and process-related emissions of SMR are also avoided. On the downside, unlike SMR, no excess steam is generated. The other main difference is that CO_2 is not obtained as a co-product in the water electrolysis synthesis route.

The technological components of the 'power to ammonia' process are not yet fully commercial, as the Dechema study makes clear, and the heat integration advantages of SMR are also absent. "The individual technologies are, in principle, available and the system integration should be relatively straightforward," comments Dechema, while cautioning: "Nevertheless the combination of electrolysis with ammonia synthesis is not at commercial stage and a certain level of heat integration will be lost in such a setup."

Energy demand

The energy demand for conventional SMR-based ammonia plants in Europe is typically 35 GJ/t NH_3, of which 21 GJ corresponds to the consumption of natural gas feedstock. The specific energy consumption (SEC) of SMR ammonia synthesis is therefore around 14 GJ/t NH_3, if the feedstock contribution is excluded (Table 1).

In contrast, Dechema calculates that the synthesis of ammonia from hydrogen via the 'power to ammonia' route requires a total of 12.5 MWh of electricity per tonne of ammonia. That translates to a total energy demand of 45.1 GJ/t NH_3 for this low-carbon route (Table 1). Total energy demand rises to 49.4 GJ/t NH_3, however, if the absence of excess steam generated by SMR (4.3 GJ/t NH_3) is accounted for in the energy balance.

Water electrolysis is the most energy intensive step in the 'power-to-ammonia' route. Dechema estimates that – to supply the 178 kilos of hydrogen needed to make one tonne of ammonia – the electricity demand for electrolysis is 38.9 GJ/t NH_3 (equivalent to 9.1 MWh/t NH_3 or 4.3 kWh/m^3 H_2). Compressors require an additional 5 GJ/t NH_3 (1.4 MWh) of energy, and the ASU a further 1.19 GJ/t NH3, equivalent to 0.33 MWh/t NH_3, assuming 0.4 MWh/t N_2 (Table 1).

Overall, Dechema concludes that: "The energy demand of the low-carbon ammonia process is… 3.2 times that of the fossil process (feedstock excluded)."

Potential carbon reduction

Total carbon dioxide emissions of SMR ammonia synthesis are 1.83 t CO_2/t NH_3 (Table 1). Natural gas feedstock emissions contribute 1.33 tonnes to this total, while the remaining 0.5 tonnes are accounted for by the consumption of fuel (natural gas, 55.9 kg CO_2 eq/GJ) and electricity during the process.

In contrast, the only emissions generated by the water electrolysis synthesis route are from process energy consumption. Importantly, Dechema assumes that only low-carbon renewable electricity is used, both for hydrogen generation and for

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Table 1: **Ammonia synthesis energy demand and carbon emissions: conventional SMR vs water electrolysis**

Energy demand (GJ/t NH_3)		
Category/process	**Conventional SMR**	**Water electrolysis ('Power to ammonia')**
Feedstock energy	21	-
Fuel demand	10.9	-
Electricity	0.74	38.9
Compressors	5	5
Other utilities	1.7 (auxiliary boiler etc.)	1.19 (air separation unit)
Steam balance	-4.3	-
Total energy demand [Specific energy consumption, SEC]	35.04 [14.04 excl. feedstock]	45.1 [49.4 incl. compensation for missing steam export]
Carbon emissions (t CO_2/t NH_3)		
Feedstock	1.33	-
Process	0.5	0.12
Total	1.83	0.12

Source: Dechema (2017)

the steam needed to power the compressors and the ASU. Dechema emphasises that "all hydrogen-based technologies … only achieve a positive GHG impact if low-carbon electricity is used".

The total carbon footprint for 'power to ammonia' synthesis route is estimated at 0.12 t CO_2 eq/t NH_3 (Table 1). Electrolysis is responsible for 0.1 tonnes of emissions, while additional steam generation contributes the remaining 0.02 tonnes. Consequently, switching from natural gas feedstocks for ammonia synthesis to electrolytic hydrogen generation should avoid 1.71 tonnes of carbon dioxide for every tonne of ammonia produced – a drastic carbon emissions reduction of over 90 percent.

Economics of low-carbon ammonia production

The production costs – relative to conventional SMR – are the key decider when it comes to the commercial viability of 'power to ammonia' as a manufacturing route, both currently and into the future.

Dechema estimates that – at an electricity price of €50/MWh – low-carbon 'power to ammonia' production will typically cost around €626/t NH_3 This cost rises to €800/t NH_3 when capex and opex costs are also factored in.

For a 100 MW plant producing about 73,000 tonnes of ammonia annually, synthesis by electrolysis would have a production cost of €735-800/t NH_3 at an electricity price of €50/MWh – around five times more costly than the current SMR production. The costs of low-carbon production route do, however, fall to €255-380/t NH_3 at an electricity price of €10/MWh, a significant drop but still around twice as costly as conventional SMR (Table 2).

These estimates assume that electricity from renewables will enable continuous operation. This is not realistic currently as solar and wind are intermittent generators which will require still-emerging battery storage technology to generate a constant base load. Dechema also assumes a comparative SMR production cost of €350/t NH_3.

"Manufacturing costs of renewable ammonia… strongly depend on the price of low-carbon electricity," Dechema concludes. "Hydrogen-based ammonia production will be competitive only at extremely low electricity prices. The same is true for urea production – as it builds on ammonia as feedstock."

Table 2: **Low-carbon ammonia synthesis, estimated production costs vs renewable electricity price**

	Renewable electricity price assumption		
Production cost	€50/MWh	€30/MWh	€10/MWh
Water electrolysis 'power to ammonia' synthesis cost* (€/t NH_3)	735-800	450-590	255-380
Cost ratio to conventional SMR synthesis**	4.9-5.3	3-3.9	1.7-2.5

**Assumes continuous operation ** Based on European cost of €350/t NH_3*

Source: Dechema (2017)

Questionable assumptions

It is important to realise that cost estimates for low-carbon production – because the technologies are emerging and not yet fully commercial – are highly sensitive to the assumptions used. The selective use of cost assumptions, which vary widely, can lead to very different conclusions.

For example, a recent concept note from the IEA contends that: "The cost of electricity from solar or wind power plants could be at or below $30/MWh, as suggested by the prices recently announced for new-built wind farms in Morocco and solar plants in Chile and Dubai. At such prices, and with sufficient load factors, the cost of hydrogen would not exceed $2/kg and could compete with SMR [$1-3/kg H_2 cost]."

At face value, this assertion contradicts Dechema's conclusion that low-carbon synthesis, at a similar electricity price of €30/MWh, would be around four times as expensive as SMR (Table 2). Another

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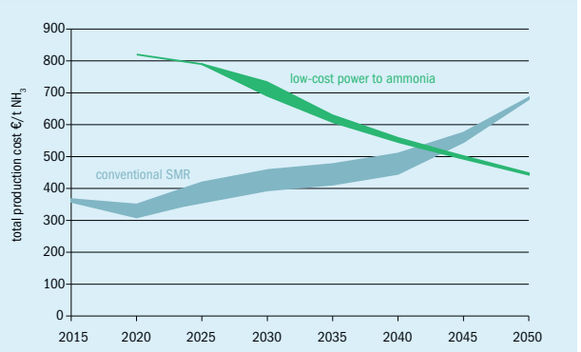
Fig. 2: **Production cost scenarios for conventional steam methane reforming vs low-carbon 'power to ammonia' route, 2015-2050**



Source: Dechema

recent study[3] puts the cost of ammonia production from renewable hydrogen at between $660-1,320/t NH_3 – well above Dechema's estimates – and also came up with a lower cost estimate for SMR of $180-260/t NH_3.

Downstream urea production

Europe produces around six million tonnes of urea annually. Production is typically highly-integrated with conventional SMR ammonia plants. Carbon dioxide generated by ammonia plants during the reforming process, combined with carbon dioxide recovered from reformer and boiler flue gases, is used as feedstock for urea synthesis.

This is obviously not an option for low-carbon ammonia synthesis. For the 'power to ammonia' route based on water electrolysis, the carbon dioxide required for urea synthesis needs to be imported from other sources. Rather than a drawback, this is potentially a positive advantage, as it opens up the option for carbon capture and use (CCU) in urea production, with power plants or industrial processes supplying a source of carbon dioxide.

Urea produced via the low-carbon route would have a total energy demand of around 29 GJ/t urea (8.1 MWh), estimates Dechema. It would also have a negative carbon footprint of -0.35 t CO_2/t urea due to the ability of the process to capture carbon during manufacture. That compares to emissions of 1.7 t CO_2/t for a conventional ammonia-urea production route. Total avoided carbon dioxide emission would therefore correspond to 2.05 t CO_2/t urea.

Dechema estimates a total cost of €450-500/t for renewable urea production. This incorporates the feedstock cost for 'power to ammonia' synthesis (€700-800/t) using a tonne ratio of ammonia feedstock relative to urea product (0.57).

Cost reductions and carbon price

Looking ahead, production costs for renewable ammonia could eventually become more competitive than conventional SMR in around 25 years. Dechema suggests that renewable ammonia costs could fall below a critical cost of around €500/t between 2040 and 2045. This cost threshold marks the point where declining low-carbon technology costs crossover with – and become more affordable than – rising conventional production costs (Figure 2).

To arrive at this conclusion, Dechema makes three key assumptions about the future of low-carbon ammonia production:

- Firstly, electricity prices remain constant at €40/MWh
- Secondly, there will be a decrease in the investment (capex) cost for water electrolysis technology from €1,450/kW to €375/kW between 2015 and 2050
- Thirdly, the price for CO_2-emission certificates in Europe will rise by 10 percent each year – from the current level of €7/t CO_2 to €196/CO_2 by 2050.

Summing up, the viability of producing ammonia using low-carbon renewable electricity largely depends on two things happening: firstly, very dramatic falls of at least three quarters in the capex cost of electrolysers; secondly, huge incremental rises in the carbon price, placing ever higher cost burdens on conventional SMR production. But how realistic are both these assumptions?

SMR will become increasingly uncompetitive in Europe if the costs of CO_2-certificates eventually grow to €196/CO_2, as Dechema suggests, accounting for half of total production costs by 2050. However, a market surplus in the EU's emissions trading scheme (ETS) has left the carbon price flat-lining at under €10/t CO_2 for the last seven years. Analysts are currently predicting that the carbon price under the EU ETS could rise 2-3 times to around €23-38/t by 2030 – but that is just a small fraction of the 2050 rise deemed necessary by Dechema to make the 'power to ammonia' route economic.

Investment costs

What is also clear from Dechema's study is the massive step-change in investment needed for Europe to transition to low-carbon ammonia and urea production over the next 35 years. For ammonia, total investment in retrofitting and new plant capacity could be as high as €76.6 billion. The investment divides between €72.3 billion for low-carbon production and €4.3 billion for conventional production. That is 7-8 times higher than Europe's business-as-usual investment in the ammonia industry, thought to total €9.1 billion out to 2050.

Similarly, for the European industry to make the transition to low-carbon urea production, a total investment of up to €32.9 billion would be required by 2050, some €26.0 billion being earmarked for low-carbon production and €6.9 billion for conventional production. Again, this is 7-8 times higher with Dechema's business-as-usual investment scenario of €4.3 billion.

Power to ammonia

A 2017 report by the Institute for Sustainable Process Technology (ISPT) in the Netherlands also concluded that large capex cost falls for electrolysers and a high carbon price are both necessary to make 'power to ammonia' cost competitive with SMR[4].

The ISPT report presented the findings of a Ministry of Economic Affairs funded project. This examined the economics of ammonia production using renewable electricity and explored the various technology options. It also looked at the potential of ammonia for large-scale electrical storage and generation (*Nitrogen+Syngas* 350, p18).

Project participants included Stedin Infradiensten, Nuon, ECN, Technical University Delft, University Twente, Proton Ventures, OCI Nitrogen, CE Delft and Akzo-Nobel. OCI Nitrogen prepared a business case for a small-scale (20,000 t/a) 'power to ammonia' pilot plant at its Geleen or Europoort sites as part of its contribution to the project (*Nitrogen+Syngas* 350, p18).

"Production of NH_3 using (excess) renewable energy cannot compete with existing fossil based NH_3 production. Drastic changes in production cost of electrolysers to less than 70% of the reference price of €1,000/kW, [together with] the supply of renewable energy and a global increase in CO_2 price are needed to make this a competitive production route," the ISPT concluded.

However, rather than assuming drastic electrolyser capex reductions, as Dechema does, the ISPT's 70 percent cost reduction is a target – one that it is conditional on future research.

Yara's Pilbara project

Yara International recently unveiled plans for a 2.5 MW solar-powered ammonia demonstration project at its Pilbara site in Western Australia. Speaking at a regional development conference last year, Yara said it hopes to move to the engineering and design stage and then begin construction of the 66 t/a demo plant during 2018, after first completing a feasibility study. Yara, which already operates a gas-based ammonia plant at Pilbara, has set an ambitious 2019 target date for the plant's completion and start-up (*Nitrogen+Syngas* 350, p18).

This is just the beginning and, if the demonstration project is a success, Yara will scale-up the project to produce around 10,000 t/a of ammonia using hundreds of megawatts of solar power. The project "could grow to a full replacement of our current natural gas consumption by producing hydrogen with a solar field… or even a step further," comments Yara.

An eventual project expansion to a 4-20 GW solar array generating up to 500,000 t/a of ammonia is also a possibility. Yara's ultimate ambition is the development of multiple plants at this scale. These could produce ammonia for use as a fuel or hydrogen carrier, as well as for fertilizer production.

Casale: the low-carbon challenge

Casale's **Raffaele Ostuni** briefed *Fertilizer International* on the obstacles facing low-carbon ammonia production – and how these might be overcome:

The process of making ammonia from renewable electricity via water electrolysis is technically feasible today – and has in fact been feasible since the early days of ammonia production, prior to the introduction of steam methane reforming. Instead, the main challenges to this low-carbon ammonia production route are currently economic in nature.

One challenge and obstacle is the upper capacity limit of single-train water electrolysers, currently about 500 Nm^3/h of hydrogen for both PEM and alkaline units. This capacity is equivalent to ammonia production of six tonnes per day. That is three orders of magnitude less than existing world-scale industrial facilities, and equivalent to a miniscule 0.001 percent of 2017 global ammonia production.

The diseconomies of scale for small capacity production make ammonia from renewables much more expensive than the current global market price – even with subsidised electricity. Furthermore, a shift to small-scale, distributed ammonia production powered by renewables would require extra supporting infrastructure. Fertilizer production has to match the seasonal pattern of farm demand. To accommodate this, relatively large storage tanks would need to be installed alongside small-scale plants producing fertilizers for local use. This adds to the cost burden and is a further economic disadvantage.

More positively, dedicated solutions can overcome challenges such as the managing the power intermittency and power variation associated with renewable electricity generation. Casale, for example, has developed proprietary methods for controlling an ammonia synthesis loop under these kinds of variable conditions.

A transition period to move from current technology to low-carbon technology is clearly necessary, since production from renewables is not yet ready to meet the high global demand for fertilizers. This transition needs to be smooth and economically-viable. It must also be able to meet both current market needs and forecast increases in ammonia consumption. This could rise by as much as 50 percent to 300 million tonnes per year by 2050, according to IEA.

Such a transition must bring about low-carbon ammonia production both at scale and, critically, at a competitive production cost. We believe that this can be achieved by combining ammonia production from natural gas with carbon capture and storage (CCS). Casale is already developing the novel production processes and technologies needed to deliver this. Advantageously, the new technologies for ammonia production and carbon capture allow for very large single train production capacities of more than 6,000 tonnes/day of ammonia, with full CO_2 capture, at a competitive production cost.

Saipem: a sustainable approach

Saipem is a leading player in the global urea market thanks to its proprietary *Snamprogetti*™ Urea Technology. **Andrea Zambianco** explains more about how the company is constantly developing innovative solutions designed to increase production efficiency and reduce the industry's emissions:

Saipem is highly active in the oil & gas market. The company is a global leader in drilling services, as well as in the engineering, procurement, construction and installation of pipelines and complex onshore and offshore projects. Saipem offers a wide range of products in the renewable energy sector too, such as biomass to fuel and energy, solar, wind, geothermal and ocean energy, and energy storage. It also possesses expertise in CO_2 capture, CO_2 transportation and reinjection, CO_2 utilisation and gasification to hydrogen.

There are energy inefficiencies in the production, transport and use of fertilizers. Also, significant amounts of mineral fertilizers applied by farmers are wasted due to the loss of nutrients to the environment. Both these issues contribute significantly to ongoing global warming. New technologies with a reduced carbon footprint are therefore required. A sustainable approach is fundamental to cope with world energy and fertilizer demand in the future, while reducing the environmental impact. The use of waste streams (including CO_2) as feedstocks to generate both energy and valuable products in the chemical industry may significantly contribute to this goal.

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Low-carbon ammonia generation is technically possible at large scale. However, the operating costs for hydrogen production via electrolysis, one of the most competitive alternatives to reforming or gasification of fossil fuels, are currently too high and need to be reduced significantly. Other necessary factors for success include the reduction of CO_2 capture costs and the availability of inexpensive renewable energy. These could bring about drastic reductions in operating costs, and make the low-carbon ammonia route competitive with conventional steam methane reforming, over the longer-term.

However, the capital expenditure (capex) for the low-carbon route is still too high, in comparison to conventional ammonia and urea plants. Continuous development of renewable technologies to obtain cheaper energy, by minimizing the capex, will be a major driver for the low-carbon production of ammonia and urea.

Saipem is seriously monitoring the viability and practicality of a low-carbon transition. To this end, we are continuously investing in our own technologies. These are aiming to re-use CO_2, both for energy storage (such as CO_2 to methanol for example) and as a valuable chemical product such as urea. Bringing about a low-carbon transition will, however, require the support and intervention of policy makers across the world.

Stamicarbon: a low carbon fertilizer world

Stamicarbon's business development manager, **Harold van der Zande**, shared his views with *Fertilizer International* on the prospects for low-carbon ammonia and urea production:

As a leading urea technology provider Stamicarbon, the innovation and license company of the Italian Maire Tecnimont Group, has significantly aligned its technology development strategy with the longer term goals of the European Commission, towards a lower carbon fertilizer world.

The commission's goal of a completely carbon-free fertilizer industry by 2050 is of course very challenging. Due to the concentrated nature of the carbon emissions in the fertilizers industry, efforts to reduce these emissions can, however, have a significant impact. As a result of the high energy cost environment and the stringent environmental regulations, the European fertilizer industry already has the lowest carbon footprint globally. Still, significant emission decreases are possible and certainly within reach, and our research efforts are focussed on achieving these ambitious goals.

In recent years, Stamicarbon has put a lot of effort into developing different technological solutions to help the Commission achieve long-term goals. As a result, we have at our disposal many technologies capable of significantly reducing the carbon-footprint of the fertilizer industry, such as:

- **Highly energy-efficient urea technologies.** These minimise energy consumption per tonne of urea output, and are already delivering lower carbon footprints at the present day.
- **Controlled-release fertilizer technologies.** These have a much higher nutrient use efficiency and hence a lower carbon footprint. Using this technology for urea also provides a solution to ammonia emissions which are also threatening the atmosphere. These technologies are also currently available.
- **Nitric acid technology.** This operates, unlike urea, without the need for CO_2 in production. It runs at much lower emissions than comparable urea-based technology, and is therefore capable of operating in a low-carbon fertilizer production environment. This technology is also available today and provides a significant carbon footprint reduction.
- **Smaller-scale ammonia and fertilizer production technologies.** These are ideally placed to take advantage of locally-available, low-cost, surplus renewable electricity to produce fertilizers. These integrated technologies are currently under development.

Stamicarbon is putting the strategic goal of low carbon footprint technology development at the centre of its research efforts. The company is ready and able to meet the challenges of a lower carbon footprint fertilizer industry. We will continue our search for innovative new technologies – to drive down further the carbon footprint going forward. ■

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Saudi Arabia's phosphates megaproject

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Phosphates 2018

welcomes you to Marrakech, Morocco

CRU events will convene the 2018 Phosphates Conference at the Mövenpick Hotel Mansour Eddahbi, Marrakech, 12-14 March 2018.

PHOTO: STOCKFORLIVING/SHUTTERSTOCK.COM

Marrakech, Morocco is the setting for Phosphates 2018, the annual international meeting for the global phosphates industry. The conference has bcome a must-attend phosphates sector event and is celebrating its eleventh anniversary this year.

The event regularly attracts more than 400 delegates from over 40 countries. This year's three-day conference offers a typically wide-ranging and topical mix of subjects. Leading international phosphates producers, traders and engineering, technology and equipment providers are all expected to attend.

CRU are particularly excited about bringing the event back to Morocco for the first time since 2012. OCP Group has been the driving force behind the ambitious expansion of the country's phosphates industry. This has made Morocco a hub for investment and innovation in phosphate mining, processing and production in recent years.

Phosphates 2018 features a typically strong commercial programme. This will offer up key insights and in-depth market information on phosphate raw materials, intermediates and finished products. Programme highlights include:

- The global market outlook
- The future of farming and ag-tech trends
- Market opportunities and strategies for success
- A capital markets view of the industry
- The African agribusiness and fertilizer market
- Speciality fertilizer market insights
- Feed, industrial and technical markets insights

The event also offers a separate but equally strong technical programme (see page 30). Popular technical showcases will also focus on mining, processing and production throughout the three-day event.

CRU's head of phosphates, Chris Lawson, sets the scene for Phosphates 2018 with this personal take on the state of the industry:

"Phosphate fertilizer prices have rallied over the past three months, supported by a tight supply and demand balance and higher raw material prices. Margins for phosphate fertilizer producers have bounced, and are expected to remain strong with anticipated declines in raw material values.

"Phosphate rock prices have diverged from phosphate fertilizer values, a trend that has rarely been seen in the past. With the phosphate rock market projected to remain relatively oversupplied over the medium-term, but phosphate fertilizer markets tightening, will this divergence continue?

"China will play a key role to answering this question. Production costs for Chinese producers, the marginal suppliers to the traded market, continue to increase and this has provided recent support to prices and is expected to continue doing so.

"Producers of phosphate fertilizer have looked to diversify product portfolios to combat a low price environment. This conference will focus on the value of this diversification and the nutrient mix end-users are now demanding in fertilizers.

"Capacity expansion is set to slow between 2019-2022. However, beyond this horizon OCP is expected to commission its 'second wave' or Jorf Lasfar hubs, while Ma'aden in Saudi Arabia is exploring the option for a third downstream facility.

"Despite these continued capacity additions in low cost regions, CRU believes there are opportunities for investment within the phosphate industry as sentiment turns more positive."

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Technical programme highlights

A selection of presentations from Phosphates 2018's technical programme.

Phosphogypsum reduction

The wet phosphoric acid process generates five tonnes of phosphogypsum waste for every tonne of P_2O_5 produced. This waste can be very expensive to store and handle. PegasusTSI will show how varying the finished phosphates product mix can reduce the amount of phosphogypsum generated. In some cases, phosphogypsum can even be completely eliminated. Potential reductions in phosphogypsum generation will be discussed for various products, and basic flow sheets will be reviewed. The impact on waste storage costs and phosphogypsum stack life will also be evaluated.

Improving rock fragmentation with air-deck blasting

Rock blasting is an indispensable step when it comes to phosphate rock mining and extraction. The explosive release of energy is used to break-up overburden to allow handling and removal of waste fragments. A technique known as air-decking can improve explosive containment in blasting holes. OCP will present the results of an evaluation of the air-deck method at the company's mines in Morocco. The performance of the method was compared with conventional blasting, both in terms of productivity and the cost of stripping. Results suggest that air-decking can improve blasting outcomes, resulting in positive effects downstream.

The impact of beneficiation on phosphate value chains

The ability to commercially develop phosphate rock reserves globally depends on the economic viability of currently-available beneficiation technology and processes. OCP will look at how beneficiation interacts with the other stages of phosphates production. Different process options, and their capital expenditure costs, will be described. Recommendations on how to optimise the whole of the phosphates value chain will also be provided.

Optimising sedimentary phosphate flotation

Fluor, Mosaic, SOFRECO and Ma'aden have devised a flotation strategy for Saudi Arabia's Alkhabra phosphate ore. A reverse flotation scheme was found to be the best approach for upgrading this sedimentary phosphate rock. The results were used to optimise the flotation process flowsheet at the beneficiation plant of the Ma'aden Umm Wu'al Phosphate Project. High-grade flotation concentrates (up to 34.5% P_2O_5) were easily achieved using the recommended flowsheet. Blending flotation and sized concentrates together helped the project achieve its target concentrate grade of 30% P_2O_5 at a CaO/P_2O_5 ratio of less than 1.6.

MAX3 sulphuric acid technology

MECS has developed *MAX3*. This proprietary sulphuric acid plant technology simplifies the conventional flow scheme by combining a single absorption HRS plant with MECS *SolvR* regenerative SO_2 scrubbing technology. It eliminates equipment, cuts costs and increases efficiency. In a *MAX3* plant, the use of *SolvR* makes it possible to achieve close to zero SO_2 emissions. *SolvR* also improves operating flexibility, capital and operating costs. MECS describes the research and development of *MAX3*, from lab concept to proven technology.

The industrial internet of things

The industrial internet of things (IIoT) can produce significant productivity gains, especially if coupled to investment in new equipment. Flowrox offer IIoT solutions for monitoring almost any asset or system. IIoT monitoring is ideal for hard to reach, dangerous and poorly-lit areas. Processes can be monitored from virtually any smart phone, tablet or PC with an internet connection. A document management system helps maintenance personnel and engineers quickly diagnosis and repair assets. Early detection of asset wear can also lower maintenance and repair costs and reduce or eliminate downtime.

New *BARRACUDA* continuous extraction technology

thyssenkrupp Industrial Solutions is now offering *BARRACUDA*, its latest generation bucket wheel excavator. This combines the cutting technology of surface miners with the block operation of a bucket wheel excavator – allowing continuous operation in both hard and soft materials. The *BARRACUDA* concept and its different configurations will be presented, as well as reference applications from small to large capacities. The *BARRACUDA Compact* can be integrated in any mine without new infrastructure being required. The *BARRACUDA System* option is based on conveyor transport, the most economical way of handling large volumes in mines.

Improving storage and handling properties

Modifiers used by PhosAgro in the granulation process can improve the caking behaviour and increase the granule strength of complex fertilizers (NP, NPS, NPK, NPKS), as well as reduce dust generation. The addition of inexpensive modifiers to the raw material stream during granulation generates denser granules with improved physical/chemical and structural/mechanical properties. Modifiers also have a positive impact during granulation by accelerating crystal formation and allowing larger granules to form. The composition of process modifiers can also increase the agrochemical value of fertilizers.

Reagent formulation in process water recovery

Sludge generation and management is an environmental and economic problem for the phosphates industry. Reagents can be used treat sludge and recover water by increasing the sedimentation rate. OCP and Sidi Mohamed Ben Abdellah University have investigated the use of polymer-based flocculants to recover water from phosphate beneficiation sludges. The influence of eight reagents on sludge treatment and water recovery was tested. Several formulae with the best flocculation behaviour were eventually selected on the basis of the results obtained.

New EcoPhos DCP plant in France

EcoPhos has commissioned Aliphos Dunkerque, a new dicalcium phosphate (DCP) production plant in France. This 220,000 t/a capacity feed phosphates plant is the world's biggest production site for DCP dihydrate. The EcoPhos process at the plant mainly uses phosphate rock, hydrochloric acid and calcium carbonate as raw-materials. The production technology used can also be applied in other phosphate markets, to manufacture fertilizers and technical- and food-grade phosphates. ■

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We take stock of the phosphates market ahead of CRU's Phosphates 2018 conference in Marrakech. The recent emergence of large-scale, low-cost production capacity in Morocco and Saudi Arabia has been one of the main supply-side developments. Last year's phosphates price rally eventually ran out of steam, as widely predicted, although subsequent market tightness and rising raw materials costs did provide some price support in the fourth quarter and into 2018.

Phosphates state of play

The Jorf Lasfar Phosphate Hub, Morocco.

Market conditions for phosphate fertilizers over the last 12 months can be broadly encapsulated in just two words: Price volatility. The marked upswings and downswings in the Tampa DAP (diammonium phosphate) f.o.b. price benchmark illustrate what has been a rollercoaster year for finished phosphates prices.

A most volatile year

The beginning of 2017 did not look promising. The Tampa DAP price languished at around $315/t f.o.b., a new price low not seen in the preceding four years. But an unexpected price rally in 2017's first quarter saw the Tampa price surge by around one-fifth to around $375/t in March. This rebound was linked to the lack of DAP export availability out of China, low channel inventories, jumps in raw materials costs, and ship loading delays at Jorf Lasfar, Morocco.

But the supply tightness did not last and, as predicted, the phosphates price rally ran out of steam as 2017 progressed. The return of China to the export market, OCP's commissioning of JPH-III, and an ammonia price collapse, heralded a mid-year DAP slide (Figure 1). By September time the Tampa price was once again heading back towards the $335/t f.o.b. mark.

Yet that wasn't the end of the story. The Tampa DAP price ended 2017 at around $385/t f.o.b., a $50/t fourth quarter increase and an annual price rise of more than 20 percent. Other DAP benchmarks followed suit. The end-December 2017 North Africa f.o.b. price reached $390-410/t and the India cfr price $405-410/t – annual rises of 20 percent and 27 percent, respectively.

As analysts CRU noted at the end of December, although buyers were reticent to accept higher prices, upward price pressures remained as 2017 drew to a close: "Benchmark DAP prices rose $30-50/t through the fourth quarter. Most suppliers are still pushing for higher prices following the recent upward jolt in raw-material prices."

Margins pressured

Margins for many phosphate producers remain tight, though, with higher product prices not necessarily translating into more profits. Instead, end-of-year finished phosphates prices largely reflected rising production costs and higher raw materials prices, with both ammonia and sulphur prices increasing sharply in 2017's fourth quarter.

Sulphur prices surged, peaking at their highest price level in almost four years, on the back of various supply and demand factors. Vancouver and Arab Gulf sulphur benchmarks rocketed to $181/t f.o.b. in November 2017, having traded in the $80-90/t range during 2017's first half. Chinese sulphur went even higher, with deliveries averaging $209/t at one point. Ammonia prices also moved steeply upwards due to stronger demand and supply interruptions. The Yuzhny Black Sea price increased by nearly 50 percent between August and November 2017 to reach $286/t f.o.b. On the other side of the Atlantic, the Tampa contract price also increased by $118/t over the same period to reach $317/t cfr.

Consequently, higher phosphate prices were driven by production costs and did not yield any fundamental improvement in margins for most producers. Indeed, with product prices close to marginal cost, at times during the last 12 months, phosphate producer profits, in general, remain highly pressured.

This highlights how important both production scale and integration are for producer profitability, according to Integer Research: "Phosagro, EuroChem, Ma'aden and OCP typically achieve the industry's highest gross margin. On the other hand, those producers who are not 100% rock self-reliant, and/or have stable positions on sulphur and ammonia, are increasingly under pressure."

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Fig. 1: **2017, a volatile year for finished phosphate prices**

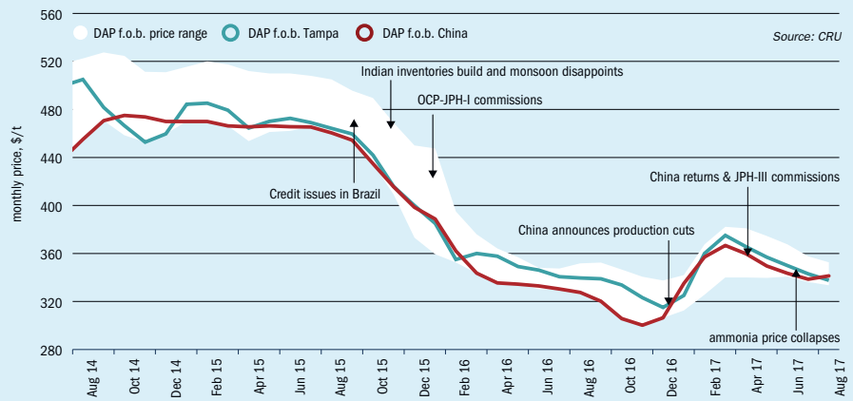
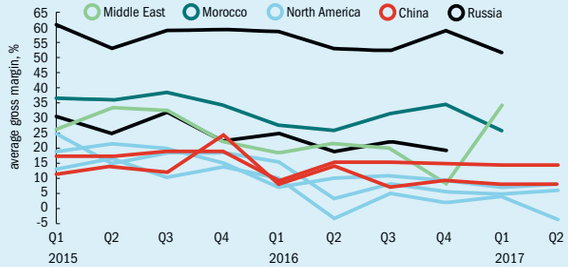
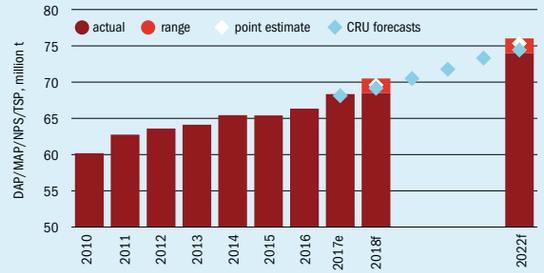


Fig. 2: **Phosphate producer margins: large disparities between regions**



Source: Integer

Fig. 3: **Global phosphate deliveries**



Source: Mosaic/CRU

Producer gross margins vary from region-to-region (Figure 2). Russian, Middle Eastern and Moroccan producers have been able to maintain good margins over the last two years, while some Chinese and North American producers have struggled to maintain margins in double digits.

Demand growth

The pace of global demand growth picked up in 2017, according to The Mosaic Company[1]. It estimates that global deliveries of finished phosphates in 2017 will climb by two million tonnes (three percent) to total 68.3 million tonnes. Mosaic also expects a further 1.3 million tonne increase in demand globally this year (1.8 percent), with world deliveries reaching 69.6 million tonnes (Figure 3). CRU is slightly more bullish, forecasting worldwide deliveries of 69.1 million tonnes in 2017 and 70.1 million tonnes this year.

Encouragingly, global demand estimates for both 2017 and 2018 are above the average annual growth rate (1.6 percent p.a.) seen over the last seven years (Figure 3). This pick-up in demand is being driven by accelerating consumption expected in key countries and regions (Figure 4). A turnaround in Indian demand – described by Mosaic as a shift from "worst-to-first" – and solid gains in markets such as Brazil, Asia (ex China), Africa and the FSU are all expected to contribute. Continuing stable consumption in China also underpins the outlook.

Production and exports

China: the country's DAP exports continue on a downward trajectory, although India, Pakistan, Thailand and Vietnam remain important end-destinations. Exports of 6.4 million tonnes in 2017 were down six percent on 2016, and some 20 percent lower than in 2015. Lower export volumes into India were partly responsible. China's full-year DAP exports to the subcontinent fell 30 percent year-on-year to 2.0 million tonnes in 2017– around half the volume delivered in 2015. China's exports to Vietnam and Bangladesh also fell in 2017, down seven percent to 765,881 tonnes and down 19 percent to 296,400 tonnes, respectively, year-on-year.

China did manage to find other international markets for its DAP output last year. Strong import demand from Pakistan, which reached a record 1.6 million tonnes of DAP in 2017, certainly helped. China's exports to Pakistan jumped 56 percent to 1.1 million tonnes last year. Deliveries to Thailand also grew by a modest three percent to 478,281 tonnes, while exports to Indonesia increased 67% to 358,268 tonnes in 2017.

China's monoammonium phosphate (MAP) exports, in contrast, recovered strongly overall. The country exported 2.7 million tonnes of MAP last year, up 34% on 2016 and a return to 2015 levels. This was spurred by improving MAP exports to Brazil. These rose by 30 percent year-on-year to one million tonnes in 2017. MAP exports to Argentina also increased by more than 50 percent last year to 248,510 tonnes. China also sold 437,059 tonnes of MAP to Australia in 2017, a 27 percent improvement on the previous year. China's MAP exports to India, however, at 128,563 tonnes were down 14 percent in 2017.

Morocco: OCP's margins on DAP exports to India improved during 2017's first half, according to CRU, due to the downward trajectory of Moroccan productions costs[2]. Although OCP continues to export large volumes of phosphoric acid into India, the margins for this declined with the signing of the OCP-India contract at $566/t for the second half of 2017.

Greater MAP market share in Brazil and increasing MAP exports to the US show that OCP is focussing its fertilizer sales on markets outside of India. Developing the African market is also a cornerstone of OCP's strategy. The African NPK market, in particular, has been of growing importance over the last five years. OCP's NPK exports almost doubled year-on-year to more than 800,000 tonnes in 2016, for example, a record that look likely to be matched or exceeded in 2017. The majority of NPK sales have been into the West African market, namely Benin, Togo, Nigeria, Ghana and the Cote d'Ivoire[2].

Morocco's combined phosphate exports totalled 6.0 million tonnes for January-September 2017, a 22 percent year-on-year rise. Over the same period, Morocco's phosphate rock exports (8.1 million tonnes) and phosphoric acid exports (1.5 million tonnes) also moved upwards, by 41 percent and 7 percent, respectively.

The latest Moroccan trade figures confirm the rise in OCP's finished phosphate exports in 2017. January-November DAP exports were up 30 percent to 2.1 million tonnes, the US, Turkey, Spain, France and Nigeria all being key markets. MAP exports also rose by 9.5 percent over the same period to reach 2.1 million tonnes. Brazil, the US and Argentina were

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Fig. 4: **Global deliveries of finished phosphates by region**

the most popular end destinations for Moroccan MAP.

United States: the US exported less and imported more finished phosphates in 2017. January-November MAP exports were down 16 percent year-on-year at 2.0 million tonnes, while January-November DAP exports fell four percent to 1.5 million tonnes. Over the same period, MAP imports were up 32 percent to 1.0 million tonnes and DAP imports rose 46 percent to 803,080 tonnes.

Russia: following the pattern seen in China, Russian MAP exports outperformed DAP exports in 2017. Russia's January-November MAP exports grew significantly, up 13 percent at 2.1 million tonnes, with Brazil being the largest single market. In contrast, January-November DAP exports at 925,261 tonnes, were down 15 percent year-on-year. Lower volumes to India, down more than 50 percent at 110,097 tonnes, were largely to blame.

Import markets: Brazil up, India down

Brazil's phosphate demand continues to recover, two years on from 2015 downturn. Full-year MAP imports ended up at a record 3.6 million tonnes in 2017, up 34 percent year-on-year, with volumes from Morocco up 38 percent at 1.1 million tonnes. Brazil's DAP imports were also up 8.2 percent last year, reaching 416,095 tonnes.

In India, higher DAP prices curtailed imports and drove down stock levels during 2017. Although volatile, the price of India's DAP imports increased markedly during 2017, rising from $320-325/t cfr in January to $405-410/t cfr by the end of December. Lower raw material prices and improving margins in India last year also favoured the domestic production of DAP over imports. During the first half of 2017, Indian DAP producers enjoyed "far superior returns, owing to lower raw materials prices", according to CRU[2]. As a result, imports of phosphate rock and phosphoric acid into India surged, with domestic DAP producers benefiting from government tax credits. CRU still expects India's DAP imports to grow over the medium-term, however, though at a lower rate[2].

The latest trade data, for January-October 2017, show Indian DAP imports down 17 percent at 3.7 million tonnes. Volumes from China declined over this period, in particular, falling by 17 percent to 2.0 million tonnes. Figures from the Fertilizer Association of India for the second and third quarters of 2017 confirm DAP imports were down around one-fifth on 2016. But they also report a modest rise in total sales due to rising domestic output. Total April-September sales of DAP in India were up three percent at 4.4 million tonnes. When preliminary October data is also included, the country's DAP sales rise to 5.6 million tonnes, up 6 percent year-on year. India is expected to enter 2018 with one of the lightest DAP inventories on record. September government stocks were nearly one million tonnes, down significantly on last year's 1.3 million tonne level.

Latest 2017 import data and key trends for other selected phosphates markets are summarised below:

- **Argentina:** full-year MAP imports down 13 percent to 719,783 tonnes; volumes from China up 44 percent at 269,515 tonnes
- **Argentina:** full-year DAP imports down 18 percent to 265,180 tonnes; volumes from China up 57 percent to 82,064 tonnes
- **Japan:** full-year DAP imports up eight percent at 396,765 tonnes; volumes from Saudi Arabia up 58 percent to 47,956 tonnes
- **Indonesia:** January-October DAP imports up 54 percent at 337,824 tonnes; volumes from China up 57 percent
- **New Zealand:** full-year DAP imports up 24 percent to 267,166 tonnes, volumes from China up 24 percent to 242,909 tonnes
- **Ukraine:** January-November MAP imports up 22 percent to 246,476 tonnes; volumes from Russia up 15 percent to 211,519 tonnes
- **Colombia:** January-November DAP imports flat at 155,332 tonnes; volumes from China up 42 percent to 31,063 tonnes

New production capacity

As 2018 progresses, the market will be carefully monitoring two new large-scale phosphate production start-ups: firstly, the Ma'aden Wa'ad al Shamal Phosphate Company (MWSPC) in Saudi Arabia (p40); and, secondly, the coming on-stream of OCP's Jorf Phosphate Hubs III and IV (JPH-III & JPH-IV) in Morocco.

As Mosaic observes[1]: "Most analysts had projected that these facilities would be flooding the market by now, causing prices to plummet. That has not happened so far [due to a combination of factors]. A slower-than-planned start-up of each of these facilities is one of them."

The MWSPC joint venture (JV) entered production in August and is thought to have produced about 450,000 tonnes of DAP in 2017. That is less than half the one million tonne volume initially expected by the market. Mosaic, who own a 25 percent stake in the JV, expect MWSPC's production to ramp up to 1.5-2.0 million tonnes in 2018, before eventually reaching its ultimate capacity of 3.0 million tonnes the year after.

CRU has scaled-back the projected ramp-up of Saudi Arabian phosphates production, although it still forecasting that the country will reach an output of two million tonnes (P_2O_5 basis) by 2020, roughly double 2016 production levels. Although DAP will remain MWSPC's dominant product, it has the flexibility to produce MAP – to target sales at Brazil, for example. MWSPC will have the capacity to enter NPK production this year too. It also began making small NPS shipments late last year[2].

OCP's JPH-III and JPH-IV in Morocco have a phosphates production capacity of one million tonnes each. Both hubs have entered production later than expected. The JPH-III granulation plant started up in spring 2017, but initially consumed phosphoric acid from other plants at OCP's Jorf Lasfar complex. Only when the hub's phosphoric acid plant eventually started-up – in mid-2017 about six months behind schedule – did the extra phosphates output from JPH-III truly begin. There is an expectation that OCP's latest phosphates hub, JPH-IV, originally scheduled to start-up in late 2017, will now enter commissioning late in the second quarter of 2018. As with the previous hub, the JPH-IV granulation plant may enter production several months ahead of its dedicated phosphoric acid plant. This offers OCP flexibility with its product-mix, prior to extra phosphate being placed on the market.

CRU now expects the next hub to be added at Jorf, JPH-V, to be pushed back from 2019 to 2022, the delay capping OCP's phosphoric acid capacity at 8.0 million tonnes P_2O_5 (Figure 5). In the interim, OCP will concentrate on production efficiency gains, line adaptations at Maroc Phosphore and the addition of 'Line F', as well as the commissioning of Laayoune, according to CRU (Figure 5).

Mosaic's decision last October to temporarily but indefinitely idle one of its higher-cost production sites, US Plant City, is also a significant development – as it will eventually remove 1.5 million tonnes of DAP/MAP from the market. It also demonstrates that, mirroring moves by the potash industry, phosphate producers are prepared to address market oversupply by cutting back uncompetitive production at the high end of the cost curve. As well as showing supply discipline this also makes economic sense for producers.

Fortunately, strategic moves such as recent acquisitions in Brazil and the company's ownership stake in MWSPC will allow Mosaic to continue serving its customers in North America, Brazil and India

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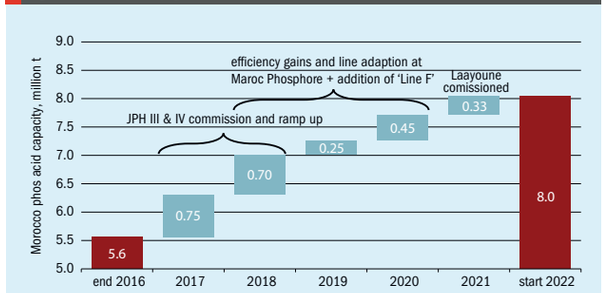
Fig. 5: **OCP capacity growth, 2016-2022**



Source: CRU

– and from more cost-competitive phosphate production sites. The loss of Plant City "will be more than made up by [Mosaic's] 25% of MWSPC output (750,000 tonnes when fully ramped up) and the… capacity obtained from the pending acquisition of Vale Fertilizantes (about 1.8 million tonnes of MAP/TSP at Uberaba)", commented Mosaic.

Steady demand outlook

Looking further ahead, CRU is forecasting annual demand growth of 1.7 percent over the next five years, with global deliveries of finished phosphates climbing to 74.4 million tonnes by 2022. Mosaic is slightly more optimistic. It expects annual phosphates deliveries to increase by 9.0 million tonnes between 2016 and 2022, a per annum growth rate of 2.1 percent. Deliveries to global markets outside of China and India will set the pace, in Mosaic's view, growing at a faster 2.5 percent annual rate, corresponding to a rise in product demand of 6.2 million tonnes out to 2022.

The prospects of lower and less volatile raw materials costs should moderate phosphate prices and fuel steady gains in demand across the globe, in Mosaic's view. It expects Indian demand to get back on a track over the next five years, due in part to government price support for key crops, and a stable or strengthening rupee.

China to restructure – but when?

The main difference between the Mosaic and CRU's medium-term forecasts is that CRU expects Chinese phosphates output to decline.

Both agree that significant restructuring of the Chinese phosphates industry will eventually occur – driven by higher costs, the removal of subsidies, new environmental taxes and tighter regulations. The alignment of the domestic industry's need to boost profits with the government's wish for better air and water quality means there are now common goals in place, making structural change more likely to happen.

But how quickly China's long-heralded restructuring will happen remains an open question. One factor to watch will be rising costs. CRU expects China's DAP production costs to rise more quickly than the global industry average over the next five years – with Chinese producers moving towards the high end of the cost curve because of this. By 2021, CRU expects that the average DAP site costs of China's 'Big Four' producers will be around $300/t, while the costs of China's other producers will approach $340/t. That compares with a forecast global average DAP site cost of around $290/t.

But, as Mosaic notes, total Chinese finished phosphates exports, as of October 2017, were actually up 20 percent year-on-year, being likely to end the year at around 9.5 million tonnes or above. "Larger-than-expected exports in 2017 are a testament to strong demand growth and relatively high export prices," observes Mosaic, while still concluding: "At the end of the day, we expect China will produce slightly less phosphate but from a smaller, more profitable and environmentally compliant industry in the near future."

Summary of market prospects

On the supply side, no world-scale projects are in the pipeline out to 2021, after JPH-IV in Morocco and MWSPC in Saudi Arabia. Ma'aden's future phosphates expansion plans, a third project potentially adding three million tonnes of new DAP/MAP capacity, are beyond the 2021 horizon, although feasibility studies are in progress. The volumes of new product entering the market will also be lower than originally forecast. This is because of the slower than expected ramp-ups of new projects, the likely delay of OCP's JPH-V, and Mosaic's idling of Plant City. Further capacity closures in North America and Southeast Asia are also a possibility.

Global demand looks set to grow at 1.7-2.1 percent per annum over the next five years, and become less reliant on India and China. Other Asian and Latin American markets, particularly Brazil, alongside Africa and the FSU, are shaping up as demand pacesetters.

On prices, CRU foresees a modest recovery beyond 2019. It predicts a rise in the Tampa DAP benchmark from an average of $325/t this year to around $400/t f.o.b. by 2021, although this forecast comes with both upside and downside risks attached. On the upside is the prospect of capacity closures in China, rather than lower operating rates, and greater than expected demand growth, particularly in India, Africa and Russia. The downside risks include an "aggressive approach" by MWSPC in placing new product on the market, and poor producer discipline in China.

The future of China's phosphates industry remains "the greatest unknown" according to CRU. Utilisation of production capacity is low but plant closures have been minimal to date. The ramp-up of new low-cost capacity in Morocco and Saudi Arabia will, however, affect China's export competiveness, especially at a time when Chinese production costs are escalating and its industry is becoming more tightly regulated. ■

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Saudi Arabia's phosphate megaproject


PHOTO: LONGXIN CONSTRUCTION GROUP

Ma'aden Wa'ad Al-Shamal Phosphate Company (MWSPC) finally began producing phosphate fertilizers from its Umm Wu'al project in Saudi Arabia in the third quarter of last year. The $8 billion megaproject, a joint venture between Ma'aden, Mosaic and SABIC, enters operation as one of the lowest cost producers of finished phosphates in the world.

August last year saw Saudi Arabia successfully complete one of the largest and most challenging fertilizer industry construction projects of modern times. Four years on from its inception and after eight billion dollars of capital investment – not to mention the millions of hours worked by thousands of workers drawn from over 50 countries – the Ma'aden Wa'ad Al-Shamal Phosphate Company (MWSPC) finally delivered its first production tonnages of phosphate fertilizers.

Megaproject on a vast scale

MWSPC was set up in 2014 as a joint venture (JV) between the Saudi Arabian Mining Company, Ma'aden (60 per cent), The Mosaic Company (25 per cent) and the Saudi Basic Industries Corporation (SABIC, 15 per cent). The JV allowed these three partners to pool their collective resources and together develop, build and eventually profit from the highly-ambitious Wa'ad Al-Shamal (WAS) project.

Completed in the third quarter of last year, the $7.5 billion (SAR 28 billion) megaproject – also known as the Umm Wu'al phosphate project – has successfully created an extra 16 million tonnes of production capacity in Saudi Arabia, both for phosphates and intermediate products (Table 1). This massive joint endeavour was a highly complex, tightly choreographed and hugely costly gamble – one that is only now starting to pay off.

The project's integrated production capabilities are split between plants located at two sites: the new Wa'ad Al-Shamal industrial city in the northern Sirhan-Turaif region, and Ma'aden's existing Ras Al-Khair industrial city on the east coast, some 80 km north of Jubai.

The project's mine, beneficiation plant, sulphuric acid plant and phosphoric acid plant are located deep in Saudi Arabia's interior at Wa'ad Al-Shamal, while its ammonia plant and downstream diammonium phosphate (DAP) fertilizer plant are sited on the coast at Ras Al-Khair, a convenient gateway for exports. The two industrial complexes are connected by a railway.

MWSPC plans to mine around 16 million tonnes of phosphate rock annually from extensive reserves (246 million tonnes proven and probable) at Al-Khabra in Umm Wu'al, 40 km northeast of Turaif. A mine life of 28 years is expected. The company's operations are fully integrated.

At MWSPC's production plants in Wa'ad Al-Shamal and Ras Al-Khair, mined phosphate rock is beneficiated and, when combined with domestic natural gas and sulphur, ultimately transformed into finished phosphates and compound fertilizers. Other downstream products include purified phosphoric acid (PPA). An original plan to produce feed phosphates – dicalcium phosphate (DCP) and monocalcium phosphate (MCP) – as part of the project was subsequently shelved.

The project's total annual production capability of around 16 million tonnes (Table 1) includes three million tonnes of capacity for finished phosphates and compound fertilizers, effectively doubling Ma'aden's phosphates output.

Saudi Arabia's existing $5.6 billion, three million tonne capacity Ras al-Khair phosphates complex entered production in 2012, and is home to the Ma'aden Phosphate Company (MPC), a Ma'aden and SABIC joint venture dating from 2008. The site is supplied with phosphate concentrate brought 1,500 km by train from the Al-Jalamid mine in the north of the Kingdom. MPC currently exports ammonia to India and East Asia from the Ras Al-Khair complex, as well as shipping DAP and monoammonium phosphate (MAP) to India, Southeast Asia, Latin America, Africa and Oceania.

Table 1: **Ma'aden Wa'ad Al-Shamal Phosphate Company (MWSPC) production capabilities**

Production plant	Capacity (million t/a)	Location	Contractor	Licensor
Beneficiation	5.3*	Wa'ad Al-Shamal	China Huanqui C&E Corp (HQC) / HQC Middle East	-
Sulphuric acid & power plant	4.9	Wa'ad Al-Shamal	SNC-Lavalin International / SNC-Lavalin Arabia, Sinopec Engineering / Sinopec Middle East	MECS
Phosphoric acid	1.5	Wa'ad Al-Shamal	Hanwha E&C / Hanwha Saudi Contracting	Jacobs/Tenova
Ammonia	1.1	Ras Al-Khair	Daelim Industrial Co / Daelim Saudi Arabia	ThyssenKrupp
Diammonium phosphate (DAP) plant	3.0	Ras Al-Khair	Intecsa Industrial	Incro
Total	**15.8**			

**Phosphate rock concentrate*

Sources: Ma'aden/ICIS/GPCA

Finance, marketing and governance

Ma'aden signed a five billion dollar (SAR 18.9 billion) financing deal for the project in July 2014. The 17-year loan agreement was made with 16 commercial banks and the Public Investment Fund, Saudi Arabia's $2 trillion sovereign wealth fund. Repayments are due to begin at the end of this year. The project was also part-funded by Saudi Arabia's finance ministry. It awarded a total of $700 million (SAR 2.6 billion) towards the construction of the Wa'ad Al-Shamal industrial city. Equity loans from project sponsors were expected to make up any remaining project funding shortfall.

Under the terms of the JV, Ma'aden, Mosaic and SABIC will market 60 percent, 25 percent and 15 percent of the project's fertiliser output, respectively, pro rata to their investment stakes in MWSPC. Mosaic has also agreed not to market any fertiliser products within Saudi Arabia. The JV entitles Maa'den to exclusively market production intermediates, including phosphate rock concentrate, sulphuric acid, phosphoric acid and ammonia.

MWSPC is a limited liability company with SAR 8.4 billion of share capital. This is comprised of 843,750,000 shares, nominally valued at SAR 10 each. MWSPC is governed by a seven-member board, four appointed by Ma'aden, two by Mosaic and one by SABIC. Ma'aden also has the right to appoint MWPC's chairman and nominate the president, while the company's VP of operations and internal auditor are Mosaic and SABIC nominees, respectively.

Project management consultancy

Bechtel were awarded an initial project management consultancy (PMC) contract by MWSPC to develop the project during its first phase. This covered front end engineering and design (FEED), the preparation of a scoping study and a master plan. The company is also managing the construction at Wa'ad Al-Shamal of:

- Community buildings
- Retail and office area
- 40 kilometres of roads
- 1,000 residential units

A wide-ranging, major PMC contract was also awarded to **Fluor**. This covered the testing, commissioning and start-up of plants at the Wa'ad Al-Shamal industrial city. Fluor assumed overall responsibility for the management and supervision of contractors, including the development and tendering of engineering, procurement and construction (EPC) contracts.

Managing a construction project of this size and complexity – unprecedented even for Saudi Arabia – was a hugely testing challenge. Fluor put together and managed six international and three local EPC/EPCM contractors with team members in the United Kingdom, the Netherlands, United States, Canada, Spain, China, Korea, Italy, the Philippines, India and Saudi Arabia. Fluor also supervised and managed the project's bankable feasibility study, including the development of basic design packages by a FEED contractor (Jacobs).

Fluor hired more than 80 Saudi nationals to support the project, and from year one set itself the goal of at least 20 percent for local Saudi labour content. Fluor

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Ma'aden's eye on the prize

Speaking recently to the GPCA[1], Ma'aden president and CEO Eng. Khalid bin Saleh Al-Mudaifer outlined the company's ambitious plans to place Saudi Arabia in the front rank as a global fertilizer producer.

"Our phosphate business continues to expand in markets such as India, East Africa and Brazil. With MPC producing since 2012, MWSPC coming online this year, and our recently announced third phosphate project scheduled for 2024, we are building a position that will place the Kingdom among the world's top three fertilizer exporters."

MWSPC came online during 2017's third quarter, and Ma'aden is intent on fully pursuing the commercial opportunities created by the mammoth project, as Ma'aden's president and CEO makes clear.

"Wa'ad Al Shamal will play an important role in meeting global demands for phosphate fertilizers. In August, we delivered our first shipment of DAP and as the project climbs to full capacity of three million tonnes a year, we are confident it will serve many new markets.

"The future of Wa'ad Al Shamal is bright; it will bring new value to our shareholders, reliable and high quality product to our customers, and will contribute to sustainable economic development in its surrounding communities in the Northern Province of the Kingdom."

Khalid bin Saleh Al-Mudaifer also unveiled plans for further large-scale expansion of Ma'aden's phosphates business in the 2020s.

"Our third phosphate project is currently progressing through feasibility studies. We have announced that production will be phased in by 2024, and we will watch the market indicators closely to ensure we time the project to best serve growing global fertilizer demand. The project is likely to have a similar annual capacity to Wa'ad Al Shamal."

He also made it clear that external partnerships have been critical in delivering the step-change in phosphates production achieved in Saudi Arabia.

"I have often said that no company on its own could have built the position that Ma'aden has built. In each of our businesses, our strategy has been to collaborate with the best, so Ma'aden and the Kingdom may benefit from their expertise. We are lucky to be partnered with both Mosaic and SABIC in our phosphate business.

"These two partners have brought a depth of experience, technical knowledge and project management skills that have enhanced tremendously our projects and greatly benefited our own Ma'aden teams. Our strategy will continue to include strategic partnering across all of our businesses."

With sector rivals OCP also investing billions in new production capacity, the finished phosphates market is exposed to the risk of increasing oversupply, at least in the short- to medium-term – something Khalid bin Saleh Al-Mudaifer acknowledges.

"The phosphate industry is currently witnessing short-term overcapacity as new capacities are concentrated over the next 3-4 years, and all are export-oriented. We believe there will be a market balancing around 2021 – and this is why we are contemplating our third project in the 2024 timeframe."

Although new supply is likely to have a short-impact on pricing, growing demand will eventually reassert itself, in his view.

"We expect the downward pressure on near-term prices to continue as additional supplies are delivered from both Wa'ad Al-Shamal and Morocco. However, we believe that strong fundamentals in our industry will help the demand to absorb this capacity growth in the mid-term.

"Key markets in South Asia and Latin America, and new markets like Africa will lead to an annual growth rate of around 1.5 percent from 2017 until 2021. For example, we see that the potential for fertilizer demand on existing arable land in East Africa could double."

Ma'aden's CEO signs off on a positive note, stressing that the company's role in regional and international fertilizer markets has been overwhelmingly positive.

"In only a few short years, Ma'aden phosphate fertilizers have helped many farmers around the world to increase their yields by building the best in class, customer-oriented value chain – from our mines in the north of the Kingdom, to ships loaded at Ras al Khair." ■

executed the project from Al Khobar, Saudi Arabia, with support from its global offices in Ireland, the US, UK, Canada, the Netherlands, China, Spain, South Korea, the Philippines and India.

Remarkably, Fluor has overseen more than 46 million work hours on the project without a single lost-time incident, as of August 2017. This is considerable achievement given that workforce at its peak reached 28,000 and spanned more than 50 nationalities.

The project's main production plants, and their EPC and licensing arrangements, are set out below.

Beneficiation Plant

China Huanqiu Contracting & Engineering Corp (HQC) were awarded the $557 million (SAR 2,089 million) turnkey EPC contract to build the beneficiation plant at Wa'ad Al-Shamal, and an associated crusher and overland conveyor. The 5.3 million t/a capacity plant produces a phosphate rock concentrate suitable for wet-process phosphoric acid manufacture. Phosphate rock is firstly ground, washed and de-slimed. Froth flotation is then used to remove deleterious gangue constituents, such as calcium and magnesium carbonates.

Sulphuric acid plant

The $764 million (SAR 2.9 billion) turnkey EPC contract for building the project's sulphuric acid plant and associated power unit at Wa'ad Al-Shamal went to **SNC-Lavalin** and **Sinopec**. The 4.9 million tonne capacity, three-line plant manufactures sulphuric acid using the **MECS** process under license. As well as manufacturing sulphuric acid from molten sulphur for downstream phosphoric acid production, the plant also generates power for the Wa'ad Al-Shamal industrial city using high-pressure, super-heated steam.

Phosphoric acid plant

Phosphoric acid is manufactured at Wa'ad Al-Shamal at a 1.5 million tonne capacity plant, consuming phosphate rock concentrate and sulphuric acid produced on-site. The $935 million (SAR 3.5 billion) turnkey EPC contract for this three-line plant was secured by **Hanwha Engineering & Construction**. Two companies, **Tenova** and **Jacobs**, are licensors for the project's phosphoric acid process, covering various aspects of plant development, design, engineering and project execution.

Jacobs also had other major engineering responsibilities at Wa'ad Al-Shamal industrial city. MWSPC awarded the company the engineering, procurement and construction management (EPC/EPCM) project for the site, a task it successfully completed last September.

"The teams did an excellent job in the safe and timely delivery of the utilities and infrastructure at MWSPC's new facility. While it was the last project to be awarded, it was also the first of all the EPC/EPCM packages to be completed, and maintained an excellent safety record of 21.3 million safe man-hours without any lost time," said Gary Mandel, Jacobs' president for petroleum & chemicals.

More than 400 Jacobs employees globally – in Australia, India, the Netherlands, Saudi Arabia, the UK and the US – helped deliver the EPCM project. All of the project engineering work was performed in Jacobs' High Value Execution Centre in India.

Prior to the award of the EPCM contract, Jacobs also completed a bankable feasibility study (BFS) and front end engineering design (FEED) for the whole Wa'ad Al-Shamal complex.

Ammonia and fertilizer plants

The project's 1.1 million tonne capacity ammonia plant at Ras Al-Khair is supplied by natural gas procured from Saudi Aramco via a dedicated gas pipeline. **Daelim** were awarded the $825 million (SAR 3,093 million) EPC contract for the plant. **ThyssenKrupp** supplied the process design package and is also the ammonia plant's licensor.

The $600 million (SAR 2.3 billion) contract for building the Ras Al-Khair phosphates fertilizer plant went to **Intecsa Industrial**. The three million tonne capacity plant began producing diammonium phosphate (DAP) last August, combining ammonia generated on-site with phosphoric acid transported by rail from Wa'ad Al-Shamal.

The plant uses phosphates process technology licensed by **Incro**, a subsidiary of Intecsa. The plant has the flexibility to produce monammonium phosphate (MAP) should this be necessary. Another EPC contract, covering the equipment and services needed to complete construction at Ras Al-Khair, went to **Dragados Gulf Construction**.

Production commences

MWSPC began producing ammonia, merchant-grade phosphoric acid and fertilizer last year. Although only one production train was up and running when the first tonnes of finished DAP left the granulation plant last August, all four trains were expected to come online by the end of 2017. When this happens, "The joint venture is expected to produce approximately three million tonnes per year of DAP, MAP and NPK fertilizers. Once complete, it will be one of the lowest cost phosphate producers in the world," commented Mosaic.

"Mosaic's 25 percent ownership in MWSPC, along with Ma'aden's 60 percent and SABIC's 15 percent, complements our existing operations by providing a new source of phosphate rock and improving access to growing agricultural markets, most notably India," Mosaic added. ■

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The new Aliphos Dunkirk feed phosphates plant.

PHOTO: ALIPHOS

Aliphos regains its crown

2018 is set to be a landmark year for Aliphos. The firm, part of the innovative phosphate technology and engineering group EcoPhos, is poised, once again, to become Europe's largest feed phosphates producer.

Aliphos is on course to regain its position as Europe's largest feed phosphates producer, thanks to extra capacity from the company's new €75 million plant in Dunkirk, France.

The 220,000 tonne capacity *Dical®+* (dicalcium phosphate dihydrate) Dunkirk plant has entered commissioning and is expected to ramp-up to full production by mid-2018. The new plant will initially serve the local French and wider European feed phosphates market, with the potential to eventually export outside of the continent through the port of Dunkirk.

Construction of the Dunkirk plant began in spring 2016 and was completed in the third-quarter of last year. Around 200 workers and technicians helped build the plant. The new operation will create 45 direct jobs and 45 indirect jobs locally and generate an estimated turnover of €100 million annually.

Aliphos' feed phosphates production capacity will rise to 620,000 t/a, once its new French plant enters production. The company already operates two other European feed phosphate plants in the Netherlands and Bulgaria. The expansion in capacity this year should allow Aliphos to take back the prime position it once held in the European feed phosphates market, prior to the closure of the Belgian Hams production site by previous owners Tessenderlo in 2013.

Sustainability: a core value

Aliphos operates as a sustainable business, having both economic and environmental goals. It want to offer customers top quality and high-performance feed phosphate products, while at the same time reducing the release of phosphates into the environment. This sustainable approach extends to all aspects of the company's business, as its chief operating officer, John Gustin explains:

"There are two parts to EcoPhos, the ecology and the economy. This is something we believe in. Our process is sustainable. We use industrial by-products such as hydrochloric acid and low-grade phosphate rock that nobody else is using.

"We are also bringing greater value to customers by offering a more digestible product. We want to take care of the environment with a good economic product from a sustainable process. That is a key message for us, for our customers and the environment."

Dunkirk ready for ramp-up

Gustin updated *Fertilizer International* on the current status of the state-of-the-art and highly innovative Dunkirk plant.

"The plant was mechanically-completed last year. We are still in the start-up phase at the end of commissioning ready for ramp-up. We expect to be at full capacity April-May time. We have started to deliver to customers. Production for this year is probably going to be 150,000 tonnes."

For feed phosphates production, EcoPhos technology is the best in the world, according to Gustin, both for raw material flexibility and product quality. The Dunkirk plant should be able to continue to operate, for example, at times when other plants stop production due to poor phosphoric acid availability.

The Dunkirk plant's operational flexibility should give Aliphos the edge over other non-integrated feed phosphates plants, explains Gustin:

"Raw material flexibility is very important as it means we can guarantee the production and supply of feed phosphates to our customers. Other non-integrated plants need to buy special feed-grade, de-fluorinated phosphoric acid. They are forced to work with just a few dominant players who influence the market and decide the price – knowing that phosphoric acid represents 75 percent of the cost of their finished goods.

"Whereas EcoPhos technology allows us to buy less costly merchant-grade phosphoric acid from many players. The Dunkirk plant is able to processes this and produce a high-quality, cadmium-free feed phosphate end-product – the technology is therefore the best in Europe."

Flexible sourcing

The Dunkirk plant can manufacture feed phosphates using externally-sourced hydrochloric acid to treat low or medium-grade phosphate rock imported from North Africa or the Middle East. Alternatively, it can also produce feed phosphates more directly from merchant-grade phosphoric acid. Gustin outlines the benefits this brings:

"The technology allows us to run the plant (a) on only hydrochloric acid or (b) only on phosphoric acid. But the goal is to actually use a mixture of both. We want to be able to source and buy our raw materials depending on price and availability. We don't plan to use 100 percent phosphoric acid because it's costly. We don't want to go to 100 percent hydrochloric acid either, as you're back in the situation of relying on only three or four market players."

There is also, says Gustin, the fall-back option of self-generating hydrochloric acid at the Dunkirk plant at a later stage:

"If the price or availability of hydrochloric acid is a problem we can deploy 'module four' of EcoPhos technology. This would allow us to transform recycled calcium chloride into hydrochloric acid, simply by adding sulphuric acid. We'd also obtain an extremely pure [99.9% grade] white gypsum powder – for which there is a market.

"The extra module would take us 12 months to install. Just a go-ahead decision is needed as it is already designed. That's a way of putting pressure on hydrochloric acid suppliers. They know, if they limit availability or increase their prices, that installing 'module four' becomes the cheaper option for us."

This is helpful when it comes to negotiating with suppliers.

"The way we buy from suppliers, we commit to a minimum volume at an agreed price," says Gustin. "The ability to balance our production needs with raw material cost and availability provides an upside."

When fully operationally, the Dunkirk plant will be a highly competitive addition to the European feed phosphates market, in Gustin's view, with lower production costs than a standard non-integrated plant.

"In the long run, Dunkirk's production costs will be closer to those of integrated plants than non-integrated plants. It is cheaper [operationally] than the traditional process used at the Aliphos plant in Rotterdam. We are not there yet – and running at a higher cost right now – but only because we've just started production.

John Gustin, Aliphos COO.

"We want to take back the market-leading position we had in 2013. The rest of Dunkirk's output will be exported, if Europe doesn't buy everything," Gustin explains.

Getting what you pay for

The *Dical®+* produced at Dunkirk has distinct performance, environmental and handling advantages. This means it will sell at a premium, says Gustin, while also offering customers much better value for money. The average biodigestibility of standard dicalcium phosphate (DCP) is around 55 percent. The remaining 45 percent is rejected and ends up in animal manure. In contrast, the 82 percent biodigestibility of *Dical®+* means much more of the phosphate present ends up in the animal instead of manure.

"Yes, there is a premium over standard anhydrous DCP," confirms Gustin. "What makes a big difference is that *Dical®+* is a dihydrate, with two water molecules within the DCP crystal, making it much more biodigestible. The animal is absorbing more phosphate. What you pay for goes to the animal, not to polluting the environment."

He adds: "*Dical®+* is microcrystalline, extremely free-flowing, very pure, and nearly cadmium-free, with less than three parts per million for all heavy metals. Whereas standard DCP is powdery, more difficult to handle and makes a lot of dust."

Value for money as well as quality is the other key selling point for *Dical®+* . In comparison to standard feed phosphates, a smaller amount of *Dical®+* will go further.

"Because of its superior chemical and physical properties, the customer can decide to keep the same percentage of *Dical®+* in the recipe, and the animal will grow more quickly, or they can decrease this to leave more space for other animal feed additives," says Gustin.

He continues: "We know the European market very well. In Europe, we will target DCP customers and some MCP [monocalcium phosphate] customers in poultry. *Dical®+* works very well for ruminants but the poultry market is where we have the most advantage. The product needs to be very digestible as its time within the animal is shorter."

Recapturing market share

The European feed phosphates market suffers from oversupply currently. The strategy for Aliphos therefore, says Gustin, is to recapture market share by competing on performance and quality.

"There is large oversupply in Europe, that's clear. But Aliphos wants to regain the market share it had previously, and meet a growing market demand for high quality products. Europe is well advanced in animal nutrition and the range of additives in feed formulations is growing. This makes high biodigestibility very important as it leaves more space for extra additives by reducing the amount of phosphate in the feed recipe."

While the position of integrated MCP producers in Europe looks assured, Gustin believes Aliphos can displace DCP producers and some smaller MCP players.

"The European feed phosphates market is not growing, for sure. But we are confident that a high-quality, free-flowing and cadmium-free product such as *Dical®+* can increase its market share," Gustin concludes. ■

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Phosphates project listing 2017

Fertilizer International in collaboration with Integer Research presents a round-up of new phosphate rock, phosphoric acid and finished phosphates projects.

Finished phosphates, phosphoric acid and integrated phosphate rock projects

Plant/project	Company	Location	Product	capacity ('000 t)	Status	Start-up date
ALGERIA						
Bled Al-Hedba	Asmidal/Manal Group/Indorama	Oued El Kebrit, Hadjar Soud	Phosphate rock	5,000	PL	2020
Bled Al-Hedba	Asmidal/Manal Group/Indorama	Oued El Kebrit, Hadjar Soud	Phos acid (P_2O_5)	1,600	PL	2020
Bled Al-Hedba	Asmidal/Manal Group/Indorama	Oued El Kebrit, Hadjar Soud	DAP/MAP (3 x 1.3 Mt)	3,900	PL	2020
BRAZIL						
Serra do Salitre	Yara/Galvani	Minas Gerais	Phosphate rock	1,200	UC	2018
Serra do Salitre	Yara/Galvani	Minas Gerais	Phos acid (P_2O_5)	200	UC	2019
Serra do Salitre	Yara/Galvani	Minas Gerais	SSP	650	UC	2019
Serra do Salitre	Yara/Galvani	Minas Gerais	DAP/MAP	350	UC	2019
Santa Quiteria	Yara/Galvani	Itatiaia	Phosphate rock	800	PL	2020
Santa Quiteria	Yara/Galvani	Itatiaia	Phos acid (P_2O_5)	240	PL	2022
Santa Quiteria	Yara/Galvani	Itatiaia	MAP/NPK	290	PL	2022
Catalão (Ouvidor)	Copebras/CMOC (ex Anglo)	Goiás	Phosphate rock	1,200	PL	post-2020
Catalão (Ouvidor)	Copebras/CMOC (ex Anglo)	Goiás	Phos acid (P_2O_5)	400	PL	post-2020
Catalão (Ouvidor)	Copebras/CMOC (ex Anglo)	Goiás	MAP	520	PL	post-2020
Catalão (Ouvidor)	Copebras/CMOC (ex Anglo)	Goiás	TSP	240	PL	post-2020
Arrais	Itafos	Tocantins	SSP	500	C	2017
Salitre Patrocinio	Mosaic (ex Vale)	Minas Gerais	Phosphate rock	1,100	PL	2019
Salitre Patrocinio	Mosaic (ex Vale)	Minas Gerais	Phos acid (P_2O_5)	560	PL	post-2020
Salitre Patrocinio	Mosaic (ex Vale)	Minas Gerais	MAP	780	PL	post-2020
Salitre Patrocinio	Mosaic (ex Vale)	Minas Gerais	TSP	330	PL	post-2020
CHINA						
Chifeng	Inner Mongolia Dadi Yuntianhua	Inner Mongolia	Phosphate rock	1,000	UC	n.a.
Chifeng	Inner Mongolia Dadi Yuntianhua	Inner Mongolia	Phos acid (P_2O_5)	300	UC	n.a.
Chifeng	Inner Mongolia Dadi Yuntianhua	Inner Mongolia	DAP/MAP	600	UC	n.a.
Weng'an	Guizhou Batian	Guizhou	Phos acid (P_2O_5)	300	UC	2018
Weng'an	Guizhou Batian	Guizhou	PPA	100	UC	2018
Weng'an	Guizhou Batian	Guizhou	NPK	3,000	UC	2018
Guizhou Jinlin	Wengfu (Guizhou Jinlin Chemical)	Guizhou	Phosphate rock	5,000	UC	2020
Guizhou Jinlin	Wengfu (Guizhou Jinlin Chemical)	Guizhou	Phos acid (P_2O_5)	900	UC	2020
Guizhou Jinlin	Wengfu (Guizhou Jinlin Chemical)	Guizhou	DAP/MAP	1,000	UC	2020
EGYPT						
Ain Sokhna	NCIC	Suez Ain Sokhna	Phos acid (P_2O_5)	400	UC	2018
Ain Sokhna	NCIC	Suez Ain Sokhna	MAP/TSP	400	UC	2018/19
El Wadi El Gadid	Misr Phosphate/Abu Qir	Abu Tartur	Phosphate rock	3,000	PL	2022
El Wadi El Gadid	Misr Phosphate/Abu Qir	Abu Tartur	Phos acid (P_2O_5)	600	PL	2022
El Wadi El Gadid	Misr Phosphate/Abu Qir	Abu Tartur	DAP/MAP	650	PL	2022
El Wadi El Gadid	Misr Phosphate/Abu Qir	Abu Tartur	TSP	650	PL	2022
INDIA						
Orissa expansion	Paradeep Phosphates	Orissa	DAP	440	PL	2020
Orissa expansion	Paradeep Phosphates	Orissa	SSP	560	PL	2020
Sikka expansion	GSFC	Sikka	Phos acid (P_2O_5)	165	UC	n.a.
Sikka expansion	GSFC	Sikka	DAP/NPK Train 4	500	UC	n.a.
KAZAKHSTAN						
Zhanatas	EuroChem	Zhanatas	Phosphate rock	1,500	PL	2019/20
Zhanatas	EuroChem	Zhanatas	NPK	330	PL	2020/21
Zhanatas	EuroChem	Zhanatas	DCP	650	PL	2020/21
Taraz	Kazphosphate	Taraz	PPA (P_2O_5)	110	UC	2017/18
Taraz	Kazphosphate	Taraz	MAP	210	UC	2017/18

Plant/project	Company	Location	Product	capacity ('000 t)	Status	Start-up date
MOROCCO						
JFC III	OCP/Jorf Fertilizers Company	Jorf Lasfar	Phos acid (P_2O_5)	450	C	2017
JFC III	OCP/Jorf Fertilizers Company	Jorf Lasfar	DAP	1,000	C	2017
JFC IV	OCP/Jorf Fertilizers Company	Jorf Lasfar	Phos acid (P_2O_5)	450	UC	2018
JFC IV	OCP/Jorf Fertilizers Company	Jorf Lasfar	DAP	1,000	UC	2018
SAUDI ARABIA						
Wa'ad Al Shamal/ Umm Wu'al	MWSPC	Wa'ad Al Shamal	Phos acid (P_2O_5), 3 lines	1,500	C	2017
Wa'ad Al Shamal/ Umm Wu'al	MWSPC	Ras al Khair	DAP/MAP, 3 lines	3,000	C	2017
TUNISIA						
M'dilla	GCT	M'dilla	TSP	500	UC	2018
UGANDA						
Sukulu	Guangzhou DonSong Energy Group	Tororo	Phosphate rock	1,500	UC	2018
Sukulu	Guangzhou DonSong Energy Group	Tororo	Phos acid (P_2O_5)	400	UC	2018
Sukulu	Guangzhou DonSong Energy Group	Tororo	DAP/MAP	150	UC	2018
Sukulu	Guangzhou DonSong Energy Group	Tororo	NPK	150	UC	2018

Notes: Extra to its Jorf Lasfar expansions, OCP Group has announced a new integrated fertilizer complex at Phosboucrra by 2020/21, including a 450,000 tonne capacity phosphoric acid unit and one million tonnes of granulation capacity. At Maroc Phosphore, OCP plans to expand existing phosphoric acid units and add a new 500,000 tonne unit. The International Fertilizer Association (IFA) also lists a 900,000 tonne phosphates fertilizer unit, a 200,000 tonne capacity TSP/SSP unit and a 120,000 tonne capacity soluble MAP unit at Maroc Phosphore in its 2017-2018 capacity developments.

KEY

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

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Phosphate rock projects

Plant/project	Company	Location	capacity ('000 t)	Status	Start-up date
ANGOLA					
Cabinda	Minbos Resources Ltd	Cacata, Porto de Caio	800	FS	2018/19
ALGERIA					
Djebel Onk expansion	Somiphos	Djebel Onk	2,000	PL	2021/22
BRAZIL					
Goias expansion	Copebras/CMOC	Goias	200	UC	n.a.
CANADA					
Lac-a-Paul	Arianne Phosphate	Quebec	3,000	FS	2020
Sept-Iles	Mine Arnaud	Quebec	1,500	FS	2020
CHINA					
Qingping expansion	Haohua Qingping	Sichuan	1,000	UC	2019
Leibo	Hubei New Yangfeng	Sichuan	900	UC	2018
Baokang Zhuyuangou	Hubei New Yangfeng	Hubei	1,200	UC	2018
Yuan'an Changda	Hubei New Yangfeng	Hubei	4,000	UC	2020
Changyi	Hubei New Yangfeng	Hubei	280	UC	2018
CONGO					
Hinda	Cominco Resources	Hinda	4,100	FS	2019
GUINEA-BISSAU					
Farim	GB Minerals	Bissau	1,300	FS	2019
JORDAN					
Eshidiya expansion	JPMC	Eshidiya	1,300	UC	2018/19
PERU					
Bayovar 12	Focus Ventures	Sechura	1,000	PL	2022
Sechura expansion	Miski Mayo	Sechura	1,900	PL	2020
SENEGAL					
Avenira mine expansion	Avenira	Gadde Bissik	2,000	PL	n.a.
SOUTH AFRICA					
Elandsfontein	Kropz	Elandsfontein	1,500	C	2017

KEY

C Project completed
FS Feasibility study complete
PL Planned
n.a. Not available
UC Under construction

Notes: Integer has more than fifty junior mining projects on its current database. Only those with a published feasibility study are listed. The International Fertilizer Association (IFA) reports that Tunisia could expand its phosphate rock capacity by 12 million tonnes over the next decade, with new mines at Sra Ouertane, Nefta Tozeur and Oum El Khcham. OCP Group is currently expanding phosphate rock capacity at its main Khouribga mining centre in Morocco. The company also plans to open new mines at Meskala in the country's Essaouira region. Consequently, IFA expects Morocco's phosphate rock capacity to rise to 45 million tonnes in 2021, and to 55 million tonnes by 2022-2025, up from a 2016 baseline of 39 million tonnes.

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Usolskiy enters production

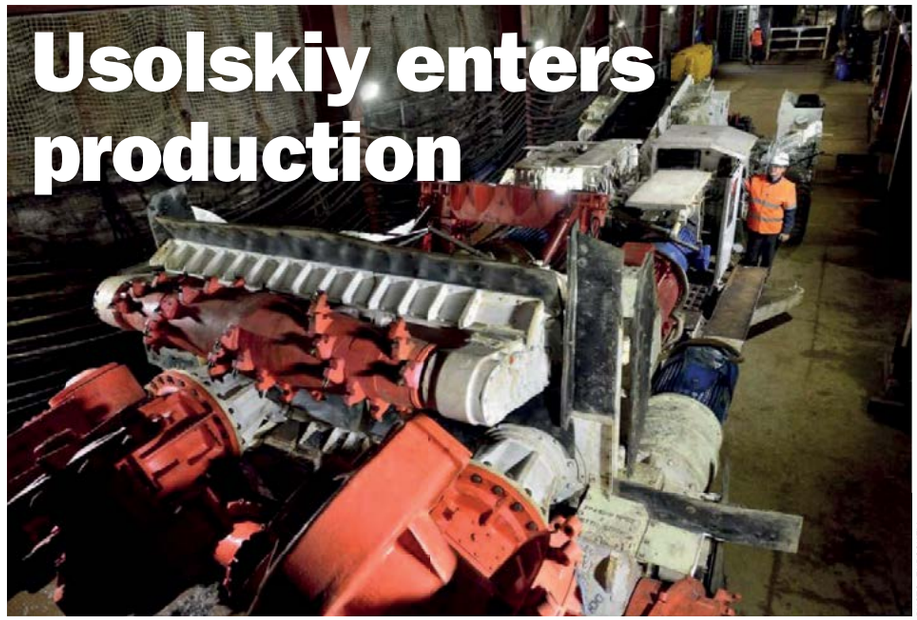

PHOTO: EUROCHEM

The first phase of EuroChem Group's $3 billion Usolskiy potash project in Russia's Perm region is on the verge of production. We provide an update on Usolskiy's progress, and report on the latest developments at its sister VolgaKaliy project in the Volgograd region.

With just a handful of major suppliers, the global potash market is routinely described – fairly or unfairly – as an oligopoly. But a new entrant may be about to change such preconceptions.

EuroChem Group is very close to delivering on its ambition to break into the potash market as a world-scale producer – and looks set to becoming self-sufficient in potash, as well as a major global exporter in the process. In a landmark moment, the first phase of the company's $3 billion Usolskiy mine and beneficiation complex in Russia's Perm region is set to enter production in late February or early March this year.

Usolskiy will be the first of the Group's two potash production sites to launch. EuroChem's even larger sister project, VolgaKaliy in the Volgograd region, is not far behind. The first marketable product is expected from the initial phase of the $3.8 billion VolgaKaliy mine in mid-2018.

The low-cost market entrant

Building a potash mine requires substantial and sustained capital expenditure over a minimum of five to seven years. In EuroChem's case, with great efforts they have gone from bare prairies and woodlands to working mines in approximately 10 years, a difficult process which few other producers have the resources or tenacity to see through. EuroChem, the Swiss-headquartered but largely Russian-based fertilizer producer, is investing around $7 billion in the development of its two multimillion tonne potash projects.

With more than 10 billion tonnes of ore reserves at its disposal, EuroChem initially plans to develop 4.6 million t/a of new 'greenfield' potash capacity in Russia by 2021. Its ultimate aim is to bring a total of 8.3 million t/a of potash capacity on-stream by 2024 through a second development phase.

EuroChem has made the completion of the two potash mines a strategic pillar of its business and a central part of its future growth ambitions. The fertilizer producer will also maximise the benefit from having its own in-house, integrated supply of potash by channelling this into the manufacture of value-added/premium NK, NPK and SOP (sulphate of potash) fertilizers, and other potassium-based products.

Usolskiy, Verkhnekamskoe deposit

The sinking of the 473-metre deep cage shaft and skip shafts at Usolskiy were completed back in October 2013 and August 2014, respectively. A great amount of work on grouting, guides, and surface facilities with hoists and headframes, was then done. This allowed the mining crews to finally begin operating in the deposit's two potash layers in October last year. Currently, eight continuous mining machines are working underground excavating permanent drifts, together with shuttle cars, transfer bins, conveyors and loading pockets.

Usolskiy site overview.

Usolskiy beneficiation plant, December.

Ore and finished product storage buildings, Usolskiy.

PHOTOS: EUROCHEM

Above ground, construction work on the three main sections of the beneficiation complex – grinding and flotation, drying and compaction, and thickening – is continuing but nearing completion. The mine's water supply, heating and ventilation systems have all been completed and are awaiting certification. Boilers and other heating systems underwent commissioning in November in preparation for the upcoming winter.

Usolskiy was due to become operational at the end of 2017, slightly ahead of schedule, with the start-up of the first of its four production trains. But the start of commissioning of the mill's first floatation train was delayed by around two months, following a fire at the beneficiation complex in December. However, fire damage repairs were quickly completed by mid-January. This allowed the beneficiation system to be successfully filled with ore and brine in early February.

EuroChem now expects Usolskiy to begin initial production in the coming weeks. This should allow routine production and the sustained ramp-up of operations to follow from early May onwards. Usolskiy is currently aiming at a 2018 potash production target of around 450,000 tonnes.

Usolskiy is being commissioned in stages with second production train due to come on-line during the first half of this year. The project will reach its full operational capacity of 2.3 million t/a in 2021, under EuroChem's first phase development plans. The third and fourth production trains will be brought on-line to ensure "continuous and smooth ramp-up", according to EuroChem.

EuroChem remains confident that Usolskiy is proceeding according to plan – and does not expect any major deviations from the project's timetable and its projected production ramp-up over the next eighteen months. However, in a statement last November, the company cautioned: "As a new potash greenfield entrant, [we] nevertheless remain acutely aware of potential commissioning challenges which tend to naturally occur with such large-scale projects, as seen at

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PHOTO: EUROCHEM

VolgaKaliy site overview.

other recently launched sites, including brownfield expansions."

With an expected useful mine life of more than 35 years, the majority of the potassium chloride (muriate of potash, MOP) product from Usolskiy will be rail-freighted over a distance of 1,600 km to the Baltic port of Ust-Luga for export.

EuroChem is giving itself the option of further long-term expansion at Usolskiy. An additional 1.4 million t/a of capacity will subsequently be phased-in by 2024 under current plans.

The potash layer at Usolskiy is 500 metres-deep, less than half the depth of the Gremyachinskoe deposit at VolgaKaliy, although the Usolskiy potash is lower grade (30.8% KCl). In 2014, EuroChem gained an additional exploration and production licence for the Belopashinsky plot of the Verkhnekamskoe deposit, a 65 km² area immediately adjacent to the 123 km² Palashersky plot where the Usolskiy mine is sited. This increased accessible reserves at Verkhnekamskoe to about 2.3 billion tonnes, sufficient for a mine life of 60 years or more, based on MOP production of 3.7 million t/a, according to EuroChem.

VolgaKaliy, Gremyachinskoe deposit

An underground mine to extract potash from the Gremyachinskoe deposit in Russia's Volgograd region is currently under construction as part of the VolgaKaliy project. Production from VolgaKaliy is expected to begin in mid-2018 and ramp up to 2.3 million t/a of capacity by 2021 as part of the project's first phase. A subsequent second phase of development will increase capacity to 4.6 million t/a by 2024. With proven and probable reserves of 492 million tonnes, the mine is predicted to have a useful life of over 40 years. The majority of the MOP produced at VolgaKaliy will be for export, and transported 500 kilometres by rail to EuroChem's Tuapse bulk cargo terminal on the Black Sea for onward shipment.

Mine development continues

Underground mine development continued at VolaKaliy during the fourth quarter of last year. The deposit's potash layer was finally entered in October, ahead of schedule, with drilling work confirming a potash seam thickness of around six metres.

EuroChem Volgakaliy is sinking three, seven-metre diameter shafts – when completed the complex will have a cage shaft and two skip shafts – all sunk to a depth of more than a thousand metres. The two skip shafts will each have two 55 tonne skips which will be able to convey potash to the surface at a hoisting velocity of sixteen metres per second. The skip shafts each have a total annual hoisting capacity of 7-10 million tonnes. The mine's cage shaft has the capacity to hoist and lower 80 people or 25 tonnes of material.

Development of VolgaKaliy's skip shafts is proceeding according to plan. Both shafts are now connected, having reached their base level 1,099-1,147 metres below ground. The two skip shafts will work in combination as a cage and skip during the first phase of the mine's development.

Operational freeze plants are maintaining an ice wall around the site's two skip shafts and cage shaft to a depth of around 820 metres. The cage shaft, required for the VolgaKaliy mine's second development phase, is now expected to be ready in July 2021. The freeze wall in this shaft has recently been extended down to 838 metres by drilling and activating six additional freeze holes. The cage shaft was intentionally but temporarily flooded while these additional holes were being drilled. This was to prevent inflow of water eroding the protective freeze wall.

By the end of 2017, crews at VolgaKaliy had excavated over 37,700 m³ of rock as part of the mine development process. More than 24,000 tonnes of potash ore had been excavated and placed in surface storage, as of early February 2018.

VolgaKaliy is expected to produce its first marketable potash by mid-2018. The current state of construction and commissioning will allow the beneficiation mill to be filled with water to begin initial circulation and tightness testing as early as mid-April. The plant will convert this to brine during commissioning in mid-May. The final commissioning step will take place in mid-June when the plant accepts feed ore to the mill to begin initial production testing. EuroChem expects VolgaKaliy to produce 130,000-140,000 tonnes of potash in 2018.

Favourably positioned?

EuroChem expects to occupy a "cost leadership position" in the market. Production costs – estimated at $100/t for Usolskiy and around $75/t for VolgaKaliy (delivered duty paid, DDP) – place the company at the lower end of the global cost curve. This should make both of EuroChem's potash assets cost-competitive with recent greenfield projects such as K+S Bethune, Canada, and the capacity additions planned by rivals Belaruskali, Uralkali and Nutrien out to 2021. VolkaKaliy's lower production costs reflect its close proximity to Black Sea ports and lower freightage.

Both Usolskiy and VolgaKaliy are conveniently located for internal company supply, the Russian domestic market and international export sales, according to the company. EuroChem has extensive transport assets in place to distribute potash both domestically and overseas. These include 43 locomotives, around 6,000 railcars and transhipment facilities in Russia, Estonia and Belgium.

Internal supply needs

EuroChem, expects its potash production capacity to climb from almost 600,000 tonnes this year to 2.1 million tonnes by the end of 2019. Its base case assumes that the ramp-up to full potash production capacity will take three years, for both the first (2018-2021) and second (2021-2024) development phases. Under this scenario, EuroChem's annual potash production capacity will reach 4.6 million tonnes by 2021 and then rise to 8.3 million tonnes by 2024.

Not all of the company's potash output will supply the export market. A substantial share will be consumed internally by EuroChem, especially during the early years of production. In 2016, for example, the company needed to externally-source around 700,000 tonnes of potash (MOP/SOP), split between its Antwerp (290,000 tonnes) and Nevinnomysskiy Azot sites (160,000 tonnes), as well as a third-party trading requirement (250,000 tonnes). Over the long-term, EuroChem expects to channel more than one million tonnes of its potash output towards the downstream production of compound fertilizers. ■

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