Nitrogen + Syngas 2023

CRU's Nitrogen + Syngas conference convened at the Hyatt Regency Barcelona Tower in Barcelona, from March 5th-8th.

Above: La Sagrada Família, Barcelona at night.

The Nitrogen+Syngas conference met for its 36th year in Barcelona this March, following a successful return to face to face meetings last year in Berlin. This time, in spite of the situation in Russia, there were 600 attendees, and the meeting very much felt back to 'normal'. Sadly it also marked the swan song of CRU's event director Amanda Whicher, who has successfully organised the meeting for nine years, who is moving on to other duties within the company, and who opened the conference proper on Monday afternoon, following the morning's technical showcases.

Nitrogen markets

The first paper was of course the nitrogen market overview, presented by CRU's Alex Derricott. Ammonia had a very volatile 2022, he said, with prices spiking above $1,000/t. Several factors contributed to this; high gas prices in Europe, peaking at over $93/MMBtu, led to 70% of European ammonia capacity and 78% of urea capacity being idled. Trinidad also had power cuts at the start of the year and gas supply disruptions, and the closure of the ammonia export pipeline to Odessa meant that Russian ammonia exports dropped from 4 million t/a in 2021 to just 800,000 t/a in 2022. More recently, European markets have been assisted by lower gas prices, and only 35% of ammonia capacity, 25% of nitrate capacity and 46% of urea capacity remains idled. There are also forecasts that the Yuzhnyy pipeline may be back onstream in the second half of 2023. Meanwhile, new merchant projects in the US and Middle East will compensate for loss of Russian tons. Alex's forecast was for gas prices to continue to fall, European production to restart, and probably lower than anticipated industrial demand leading to falling prices out to the end of 2023, although now that the EU gas market is increasingly reliant on LNG, it may have a higher floor price.

Looking to the longer term, nitrogen demand is forecast to rise to 204 million t/a by 2027, still dominated by urea, and with some lower carbon ammonia capacity beginning to commission.

On the urea side, prices peaked in Q4 2021. The following year saw a lot of new capacity and more producers globally, and hence less exposure to EU gas prices and lack of Russian supply. Black Sea prices continue to trade at a discount to the market, while Egyptian prices are at a premium as they replace Russian AN shipments. Urea demand has been flat in 2021-22 with increased demand in Europe and India balanced by lower demand in Latin America, Southeast Asia and the US. In China, inland prices have tended to be below port prices, but the gap has closed as demand increases in the interior. The government has restricted exports leading to high stock levels. India continues to see new projects coming on-stream, with production rising to 29 million t/a this year. Overall, urea prices are on a slow decline to the end of 2023 at around $300/t. Longer term, falling gas prices may have an impact, but likely lower than that on ammonia. Capacity growth outpaces demand as far as 2027, but demand will recover from 2024 onwards as affordability increases.

On decarbonisation, there is an increased push from governments and regulation, and growing new markets in power and marine fuels. European carbon prices have increased to $65-70/t CO_2e, and could rise to $128/t by 2027. In that year, the new Carbon Border Adjustment Mechanism (CBAM) will come into force, which will expose any importer of nitrogen products into the EU to EU carbon prices. This puts Chinese coal-based capacity at the highest production cost, particularly if China introduces, as it aims to, a similar carbon pricing mechanism. Green ammonia was competitive with grey ammonia in Europe when gas prices were high, but less so as they have fallen back. But the CBAM means that users will have to pay for the carbon cost wherever the ammonia is sourced from, which should make EU green ammonia cost competitive.

Gas markets

Laura Page of Kpler discussed gas pricing. There was 64 bcm less Russian gas flowing into Europe in 2022 compared to 2021, she said. To balance this shortfall, Europe had imported 30 bcm of LNG from the US and 20 bcm of LNG from other sources, as well as more Norwegian pipeline gas, and had built up gas supplies ahead of winter. But there was also 60 bcm of demand destruction in Europe and Asia which helped LNG markets pivot to supplying Europe. As a result the EU will end the winter with gas storage up 18 bcm, and approximately 50% full. Even so, it needs to restock to 90% by November if it is to get through the next winter, and Russian gas supplies could fall by another 38 bcm this year. China is also expected to return to the LNG market and draw cargoes away from Europe even though the global LNG supply will increase by 19 million t/a in 2023, 45% of that in the US. Asian demand is forecast to be up 5 million t/a this year as the Chinese economy rebounds (Chinese LNG demand fell 15 million t/a last year), balanced by lower LNG demand from Japan and Korea as nuclear power generation increases. Europe may manage to attract 14 million t/a of that extra 19 million t/a (equivalent to 19 bcm). There are new import terminals in Finland and Germany and fewer bottlenecks in internal pipeline networks. But this will only offset half of the gas lost from Russia this year, and this is likely to mean more demand rationing (down another 15%?) to meet the 90% storage target. There is scope for lower consumption from power, but the picture on industrial demand is mixed. Even so, global gas prices are expected to be lower and less volatile than they were last year, with the European TTF averaging $19/MMBtu as compared to $40/MMBtu in 2022. US Henry Hub prices are put at $3.10/MMBtu on average for 2023, down from $6.50/MMBtu in 2022. Longer term, more Russian gas will flow to China, but this is a long term prospect as most of the pipelines currently run to Europe.

Green markets

AFRY is a leading advisor to hydrogen project developers, and Solomos Georgiou and Raimon Marin of that company were on hand to discuss how to optimise green hydrogen production. The main challenge of course is to convert intermittent renewable energy supplies into a steady hydrogen production flow. This can be achieved by hybridising the feed (combining wind and solar), using hydrogen storage (though this can be expensive and there may be space or safety restrictions on-site), using batteries (expensive and with a potential efficiency loss), making demand more flexible, and via a connection to the electricity grid, though at the cost of increased complexity and possibly carbon intensity. Optimisation at the concept stage can identify the best economically competitive systems, and this is often very site specific. Solomos and Raimon showcase AFRY's modelling of these factors with reference to some case studies.

This was followed by Alex Amin of CRU on green ammonia supply. Announced low carbon ammonia capacity now totals more than 160 million t/a, with a roughly 4:1 ratio of blue to green. But there is a funding disconnect, Alex said, and an open question as to how much of this would ever produce ammonia. The average carbon cost of producing ammonia from natural gas is about 2.5 tCO_2e/t ammonia. Blue production aims to reduce this to around 0.8 tCO_2e/t. Most CO_2 will be destined for enhanced oil recovery. This is a mature technology and a medium term solution for many players. Blue ammonia projects are concentrated in North America, Russia and parts of Asia. Green ammonia depends on the availability of renewables and is more spread geographically. In the US, the Inflation Reduction Act offers subsidies of $50/t for carbon capture and storage or $35/t for carbon capture and use respectively, and $3/kg of green hydrogen produced. In the EU, the RED II programme mandates that 50% of the hydrogen used in industry must be renewable by 2030. The EU is looking at 10 million t/a of green hydrogen being produced domestically by that time, and another 10 million t/a imported. Looking to the longer term, the demand potential is greatest for shipping fuels, with up to 120 million t/a of low carbon ammonia demand by 2050. Ammonia as a hydrogen carrier and ammonia co-firing for power might require another 35 million t/a by that time, with some substitution for existing ammonia production also occurring. But in the short term, Alex calculated that there is 6 million t/a of low carbon ammonia capacity at the final investment decision stage, and another 9 million t/a at the front end engineering design stage, and he forecast that there would be 3 million t/a of low carbon ammonia being produced by 2026. As the traded ammonia market is only 18 million t/a, merchant green ammonia could have a significant impact on markets.

Keshni Shri of OCI gave a producer's perspective on low carbon ammonia. OCI has a 1.1 million t/a blue ammonia project in Texas due to come onstream in 2025, and is expecting to make a final investment decision on a 90,000 t/a green ammonia facility in Egypt this year. It also uses waste gasification at BioMCN in the Netherlands. Keshni saw that low carbon ammonia could represent 50% of merchant ammonia by 2030, with power generation an attractive use for the near term market, and shipping fuel as a longer term focus form 2030-35, once engine development and shipowners safety concerns have been addressed. She felt that low carbon methanol would be a better prospect for the 2020s. Existing producers are best positioned to take advantage of these markets because they have an existing sales and distribution infrastructure.

Finally, Andy Franks of Lloyds Register looked at ammonia as a shipping fuel. The IMO has mandated that the shipping industry must reduce its carbon emissions by 50% by 2050, and there are moves afoot – a decision may be taken later this year – to make that 100%. It would require three times the current world market for ammonia to replace fuel for the entire shipping fleet, and double the world's current renewable energy production. But shippers have an aversion, he said, to ammonia's toxicity, and some operators have said they will not use ammonia because of the risk. There is also the question of risks to local residents where ammonia is bunkered at ports. Lloyds Maritime Decarbonisation Hub has an ongoing project to evaluate the risks. Ammonia also has a low energy density, which reduces cargo capacity and ship economics.

Ammonia as an energy carrier

If ammonia is to be used as a hydrogen carrier, then a way of breaking it back down to nitrogen and hydrogen at the other end is required. Elena Stylianou of KBR described KBR's new H2ACT process, which is a chemical cracking of ammonia in a furnace similar to a steam reformer, using a nickel or ruthenium catalyst at high temperature and low (20-40 bar) pressure. The flowsheet uses some hydrogen generated by the process to burn to generate the temperatures required, but nevertheless manages a yield of 76% and an efficiency of 85%, which KBR hopes to improve in future. They are confident that they can deliver reactors from 5 t/d up to 1,200 t/d, as every stage of the process uses existing, proven technology. It is designed for flexible offtake rates and has a turndown capability to <50% which can be moved at 25% per hour. A demonstration unit is due to be up and running in 2025.

Lower carbon syngas

The technical papers perhaps unsurprisingly focused on lower carbon ways of generating syngas, beginning with a presentation by Topsoe on their new eREACT electrically heated reformer. The process is described in the article on pages 37-39 this issue. The contribution by thyssenkrupp Industrial Solutions detailed the practicalities of injection of green hydrogen from an electrolyser stream into an existing ammonia plant, something that a number of producers are considering, which of course can be used as part of a revamp to increase capacity and improve efficiency.

Several papers covered the topic of blue hydrogen, ammonia, and other syngas production, using carbon capture and storage or utilisation. To sequester the CO_2, you must of course first separate it, and BASF presented their *OASE*® white amine scrubbing technology for deep CO_2 removal from syngas. Linde likewise presented their *HISORP* adsorptive CO_2 removal process. A paper from thyssenkrupp looked at ways of optimising CO_2 removal, by treating flue gas from the primary reformer or (for an autothermal reformer plant) from the fired heater, to bring carbon recovery up from 70% to 98%. KBR showcased their own blue ammonia process is based on its *PurifierPlus*™ technology which incorporates KBR's *Purifier*™ and KBR Reforming Exchanger technologies while capturing more than 95% of the units overall CO_2 output.

KT Kinetics Technology detailed a case study of blue hydrogen production for refinery or chemical use, and noted that the imposition of carbon taxes in regions like Europe shifted the balance between capital and operating expenditure when designing a conventional steam reforming based hydrogen plant. Clariant also looked at increasing efficiency in blue syngas production with a concept they called recuperative reforming. A detailed look at this can be found on page 40 of this issue.

For a real world look at blue production, Saipem and Horisont Energi presented the latter's Barents Blue ammonia project in northern Norway, capturing 99% of the CO_2 produced and feeding it back to the offshore natural gas supplier for pumping underground. The remote coastal site has necessitated a high degree of modularisation in the construction.

Urea technology

A number of papers covered urea technology. Toyo has been working on its ACES-21 urea process and developed a lower pressure version, which operates at 136 bar instead of 152 bar, with new steels allowing a reduction in passivation air and lower pressure meaning lower power requirements and more efficient operation. Toyo also covered its post-EPC assistance for improved reliability of urea plants.

Stamicarbon gave two papers on urea, one on using their proprietary Safurex steel, this time as a thin foil for pressure, level and flow measurement devices. The other looked at the very end of the urea plant, and turning the salty by-product from acidic scrubbers either as lean UAN or UAS into valuable products., either by upgrade the acidic scrubber to convert the lean UAN solution into UAN-32 via "*mini-UAN*™ plant" technology, or via recycling lean UAS solution into the urea product to provide traces of sulphur as a micronutrient. Also at the project finishing step, Casale has tied up with Green Granulation and is now able to offer fluidised bed urea granulation as part of its portfolio. A first project has recently been signed.

Real world operating experience was provided by our regular correspondent Mark Brouwer of UreaKnowHow, in this case how to deal with a blocked leak detection system. Iffco Kalol detailed how they had improved the performance of their high pressure synthesis and waste water treatment sections of their urea plant, Engro Fertilizers related optimising a vintage urea plant to enhance capacity and efficiency, Abu Qir fertilizers presented lessons learned from replacing a high pressure stripper and scrubber, and Petrokimia Gresik described problems with carbamate solution carryover during a urea plant startup.

Nitric acid

For the nitric acid strand, Carmen Perez of Stamicarbon presented her company's nitric acid process. Although Stamicarbon licensed many plants in the 1960s-80s, it has not been in the nitric acid business since 1989, returning to the field only in 2017. The company has now licensed its first new nitric acid plant since the 1980s, using monopressure technology and Stamicarbon's own proprietary tertiary NOx abatement system.

NOx abatement always remains a hot topic in nitric acid production, and Umicore, Heraeus and thyssenkrupp Uhde all showcased their own NOx removal systems. Johnson Matthey looked at start-up, often the most difficult phase of nitric acid operations emissions-wise, and how improved start-up can improve gauze performance and ammonia oxidation. Mitsubishi detailed experiences with the commissioning of the Navoiyazot nitric acid plant in Uzbekistan. Measuring emissions from nitric acid plants is a continually moving target, as described by David Inward of Sick AG – an article on this is on page 48 of this issue.

David Kelley of PGM Technologies explained how platinum and other precious metal catalysts are lost from the gauze during plant operation, and methods of recovering it at the end of a campaign, both destructive and non-destructive. Finally, Johan Olsson of KBR talked on nitric acid and ammonium nitrate plant safety, and avoiding pre-ignition in a nitric acid converter cone, or deposition of ammonium nitrate in the neutraliser. ■