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Review of global ammonia supply

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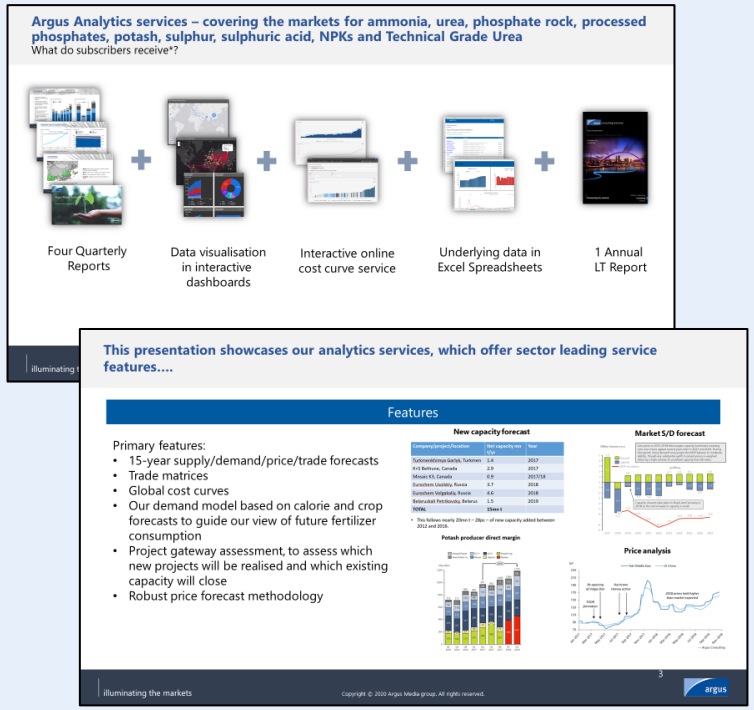
Agenda

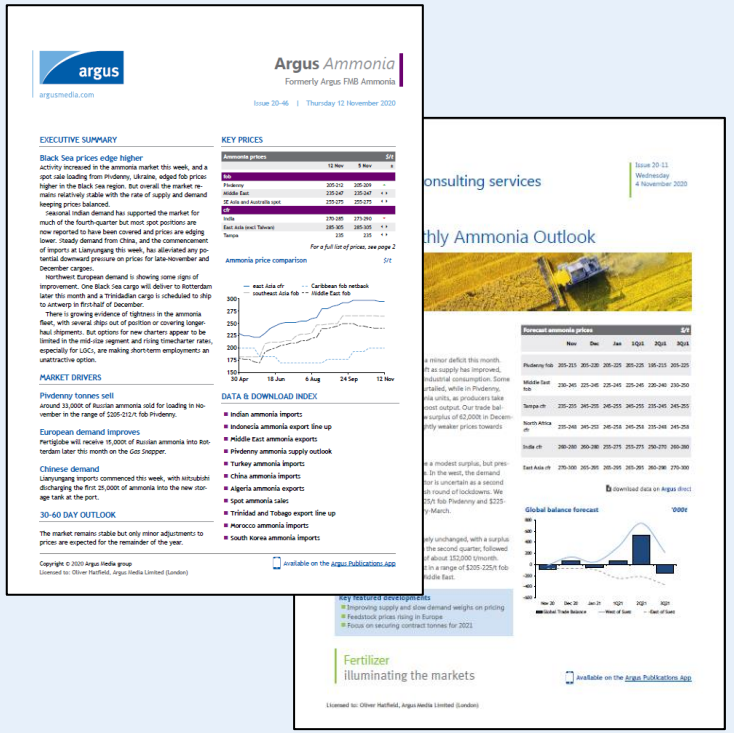
- Overview of global ammonia capacity – gross, merchant, geography, orientation
- Consideration of the availability and flexibility of supply
- Conclusions

Argus is the leader in ammonia price assessments and analytics +

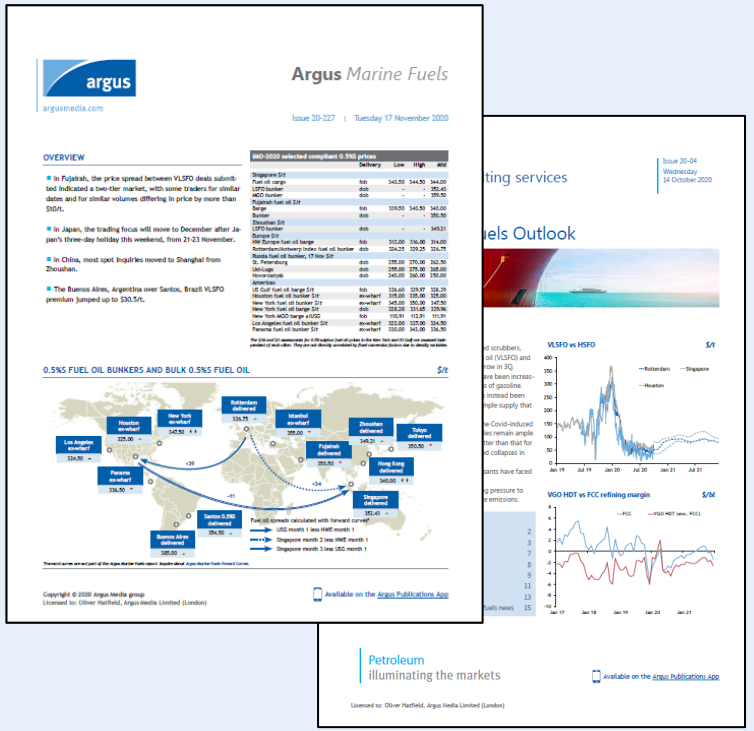
Ammonia analytics service



Price assessments and 12m outlook



+ Comprehensive fuel sector market coverage: e.g. marine fuels

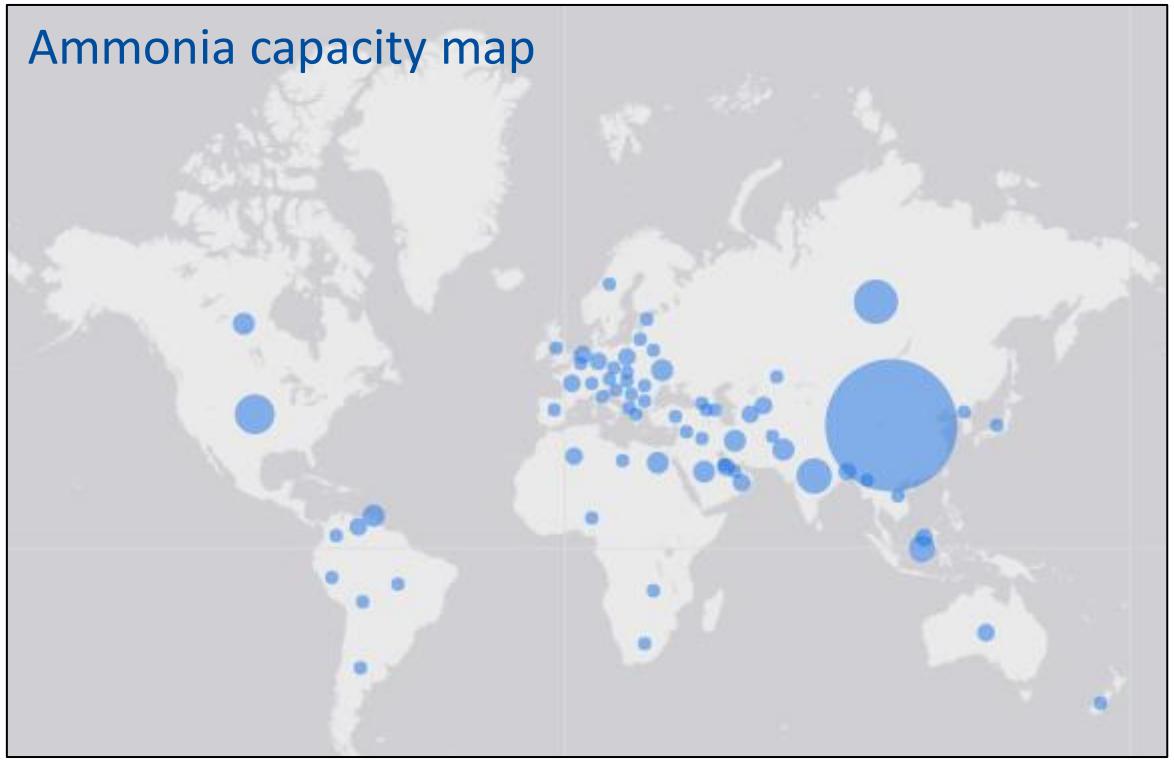


Ammonia capacity is global, with a broad distribution

Capacity and production by region (million t)

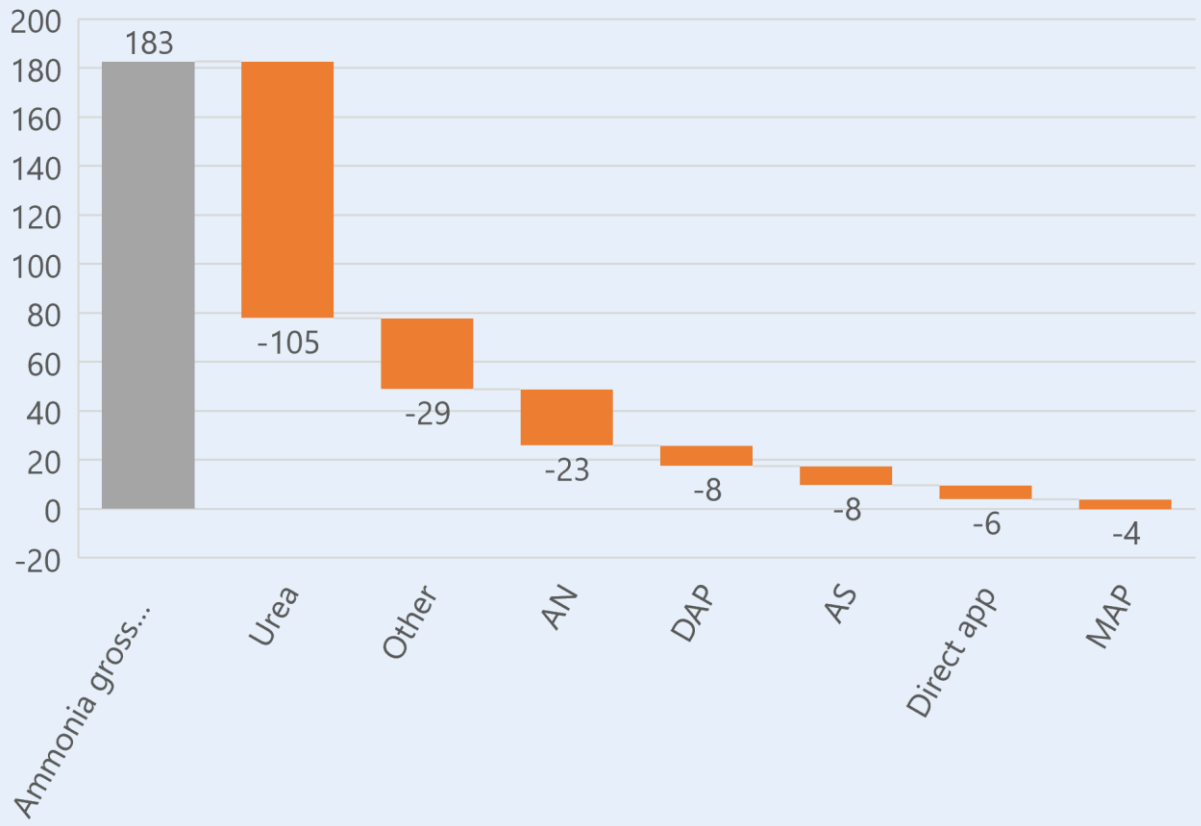
Region	Capacity	Gross Production
World	224.6	182.6
Africa	10.2	9.7
Australasia	2.3	1.9
Central & Eastern Europe	15.2	8.9
Latin America & Caribbean	9.8	6.7
Middle East	20.5	16.8
North America	24.4	22.2
Northeast Asia	76.1	55.1
Russia & Central Asia	23.4	22.9
South Asia	18.7	19.3
Southeast Asia	12.5	10.5
Western Europe	11.3	8.5

Ammonia capacity map



Most ammonia is consumed captively on-site, but there is a significant merchant market

Ammonia consumption by end-use 2020 (million t)

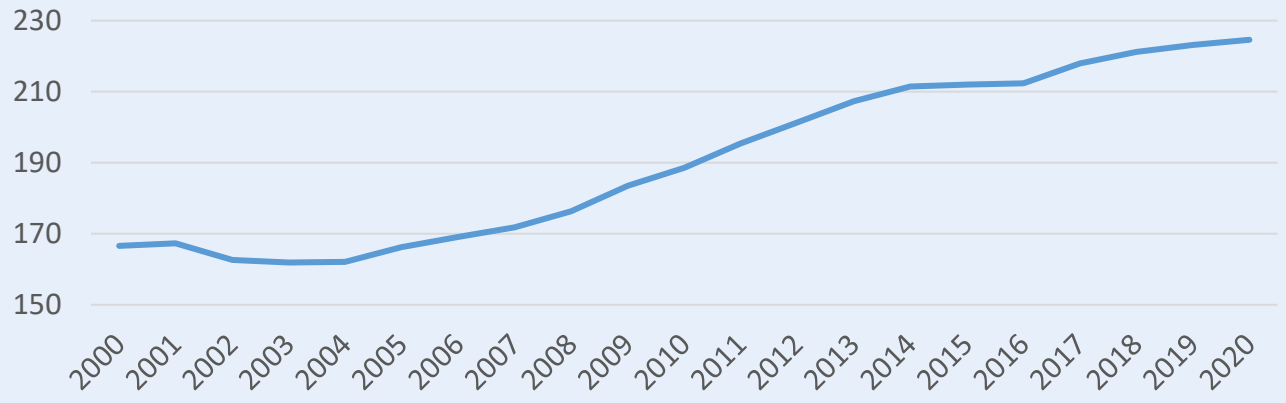


Exports

Imports

Ammonia capacity has grown steadily over decades; trade growth has stalled

Ammonia capacity (million tpy)

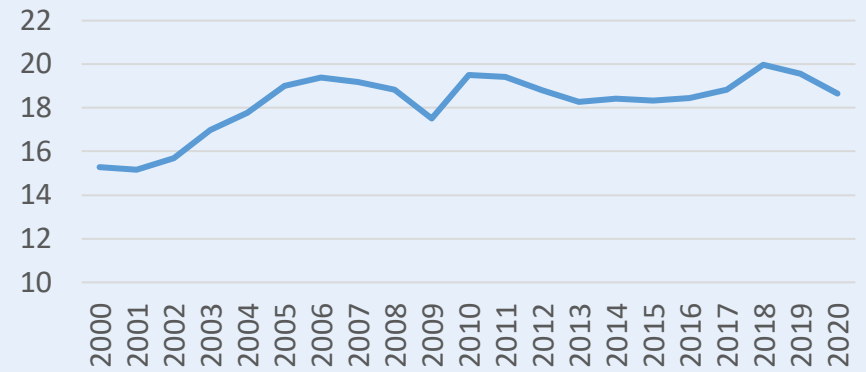


Annual growth in capacity, 2000-2020:

- Net 58 million tpy of net capacity change
- 105 million tpy of capacity added:
  - ~ 100 significant revamps/debottlenecks, +19 million tpy of new capacity
  - ~ 190 new lines/projects; +85 million tpy of capacity
- 47 million tpy of capacity closed

Changes are cyclical!

International ammonia trade (million t)

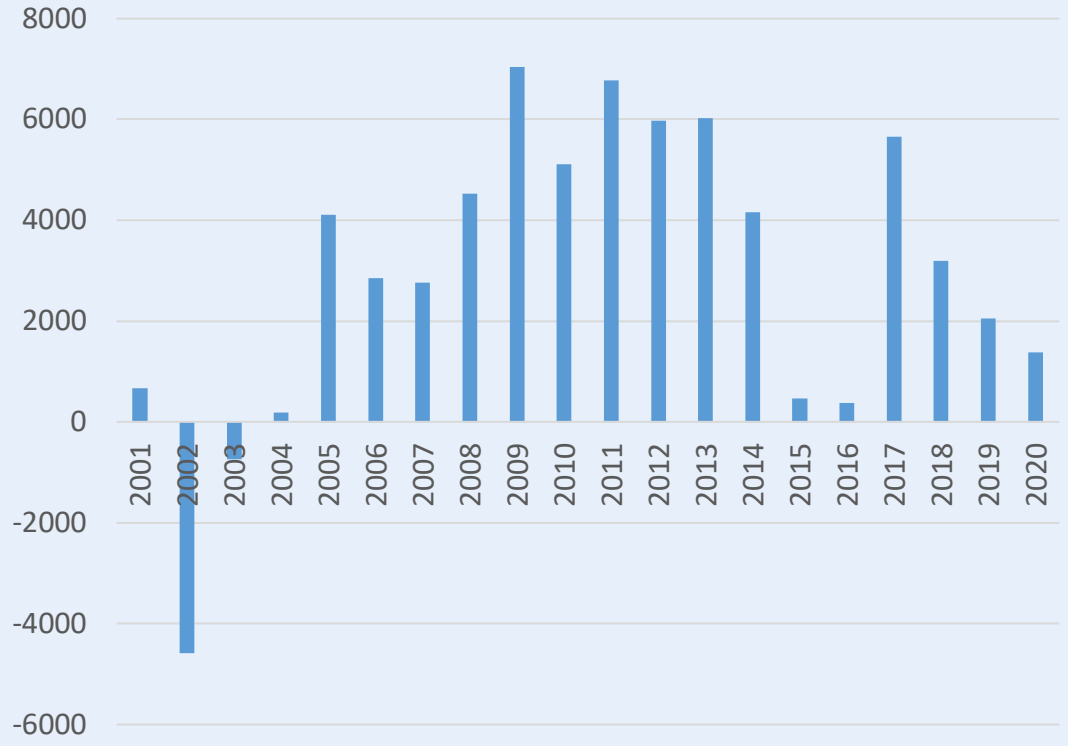


International ammonia trade grew in the 2000s, but recently stalled:

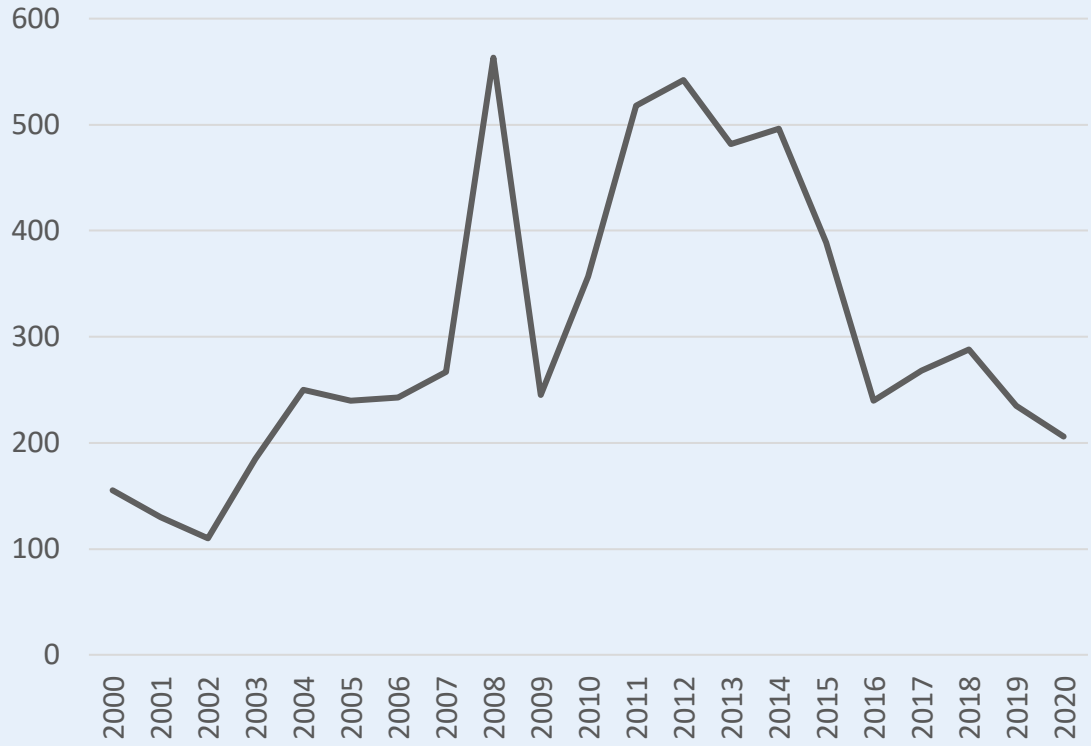
- Growth in 2000s associated with expansion of downstream sectors like processed phosphates and industrial end-uses; plus uneconomic ammonia plant closures
- Flat trade more recently: growth in integrated processed phosphates operations and construction of integrating ammonia plants

Capacity growth spurts related to price fly-ups and changes in production costs/competitiveness

Annual change in ammonia capacity (thousand tpy)



Annual ave. ammonia price, fob Black Sea (US$/t)

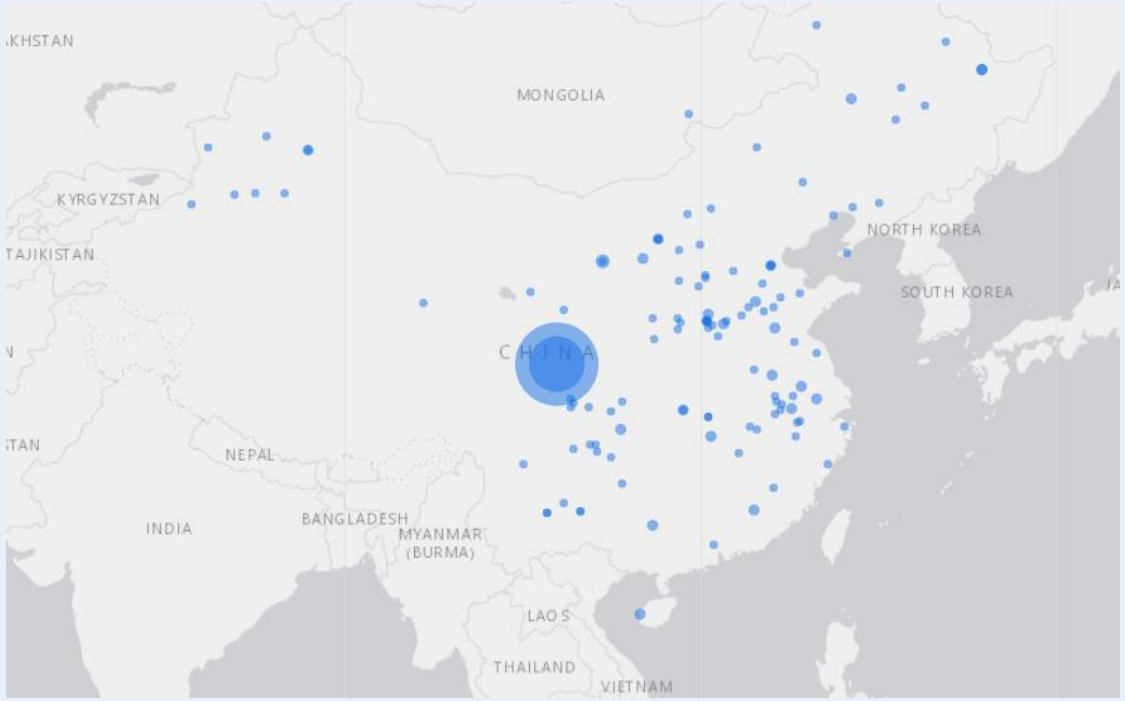


Nominally, there is significant spare capacity; price signals could bring it to market but there are constraints

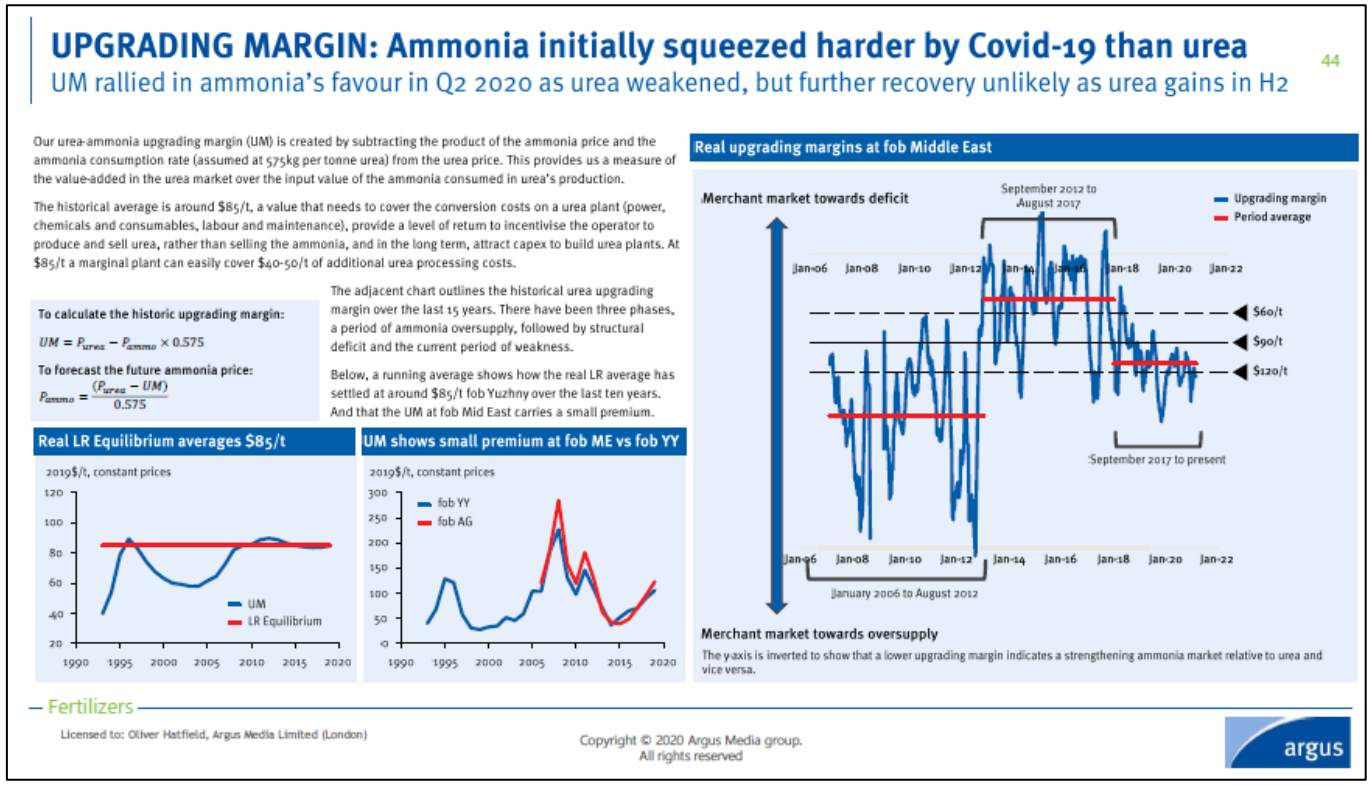
Global ammonia capacity 'spare' capacity 2020 (million tpy)

Region	Capacity utilization	'Spare' capacity
Total	81%	42.0
Northeast Asia	72%	21.0
Central & Eastern Europe	59%	6.2
Middle East	82%	3.7
Latin America & Caribbean	68%	3.1
Western Europe	75%	2.9
North America	91%	2.2
Southeast Asia	84%	2.0
Russia & Central Asia	98%	0.5
Australasia	81%	0.4
Africa	96%	0.4
South Asia	103%	-0.5

Map of Chinese ammonia capacity



There is always flex between ammonia and downstream products like urea



UPGRADING MARGIN: Ammonia initially squeezed harder by Covid-19 than urea

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UM rallied in ammonia's favour in Q2 2020 as urea weakened, but further recovery unlikely as urea gains in H2

Our urea-ammonia upgrading margin (UM) is created by subtracting the product of the ammonia price and the ammonia consumption rate (assumed at 575kg per tonne urea) from the urea price. This provides us a measure of the value-added in the urea market over the input value of the ammonia consumed in urea's production.

The historical average is around $85/t, a value that needs to cover the conversion costs on a urea plant (power, chemicals and consumables, labour and maintenance), provide a level of return to incentivise the operator to produce and sell urea, rather than selling the ammonia, and in the long term, attract capex to build urea plants. At $85/t a marginal plant can easily cover $40-50/t of additional urea processing costs.

The adjacent chart outlines the historical urea upgrading margin over the last 15 years. There have been three phases, a period of ammonia oversupply, followed by structural deficit and the current period of weakness.

Below, a running average shows how the real LR average has settled at around $85/t fob Yuzhny over the last ten years. And that the UM at fob Mid East carries a small premium.

To calculate the historic upgrading margin:

$$UM = P_{urea} - P_{ammo} \times 0.575$$

To forecast the future ammonia price:

$$P_{ammo} = \frac{(P_{urea} - UM)}{0.575}$$

Real LR Equilibrium averages $85/t

UM shows small premium at fob ME vs fob YY

Real upgrading margins at fob Middle East

The y-axis is inverted to show that a lower upgrading margin indicates a strengthening ammonia market relative to urea and vice versa.

Fertilizers

- Merchant ammonia availability is also responsive to 'upgrade margin' (UM).
- It's a calculation which indicates which nitrogen product is most attractive to sell.
  - Deduct the ammonia price at its consumption rate from the urea price.
- A high UM incentivizes/attracts ammonia to downstream products and vice versa.
- Recent ammonia prices have been relatively weak and incentivizing volumes to move downstream.
- But the reverse position is equally possible.

Fundamentally, ammonia is a typical commodity; supply availability is rarely a constraint…

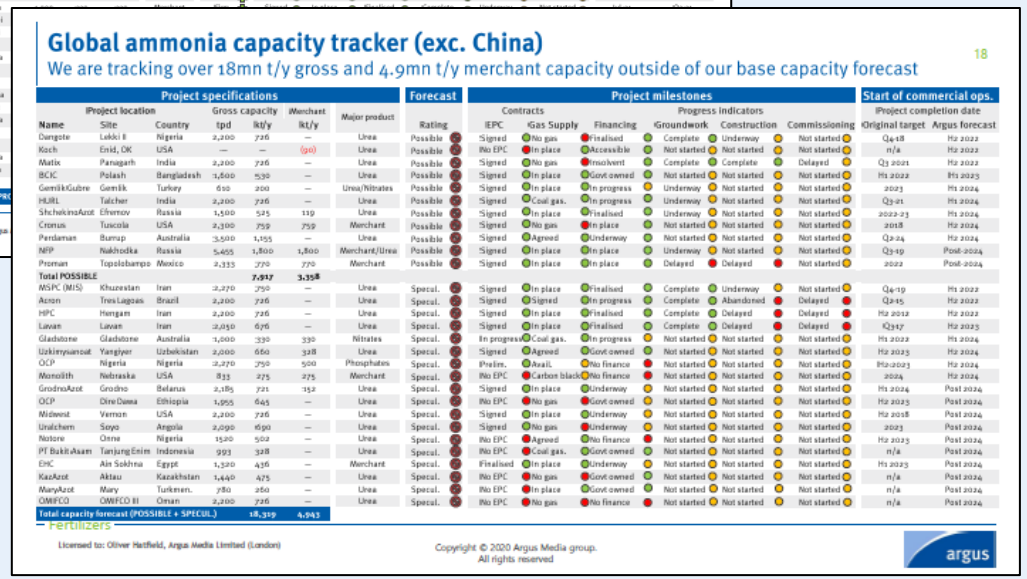
We are never short of ammonia projects! Over supply is more common than under-supply.

Grey

Global ammonia capacity forecast (exc. China)

We are currently forecasting 10.7mn t/y gross & 0.8mn t/y merchant ammonia capacity at the construction stage

17

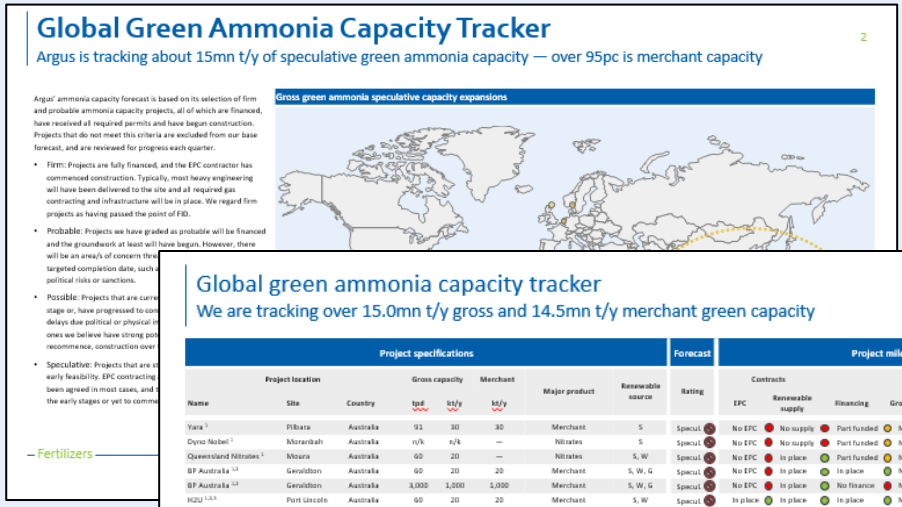


Global ammonia capacity tracker (exc. China)

We are tracking over 18mn t/y gross and 4.9mn t/y merchant capacity outside of our base capacity forecast

18

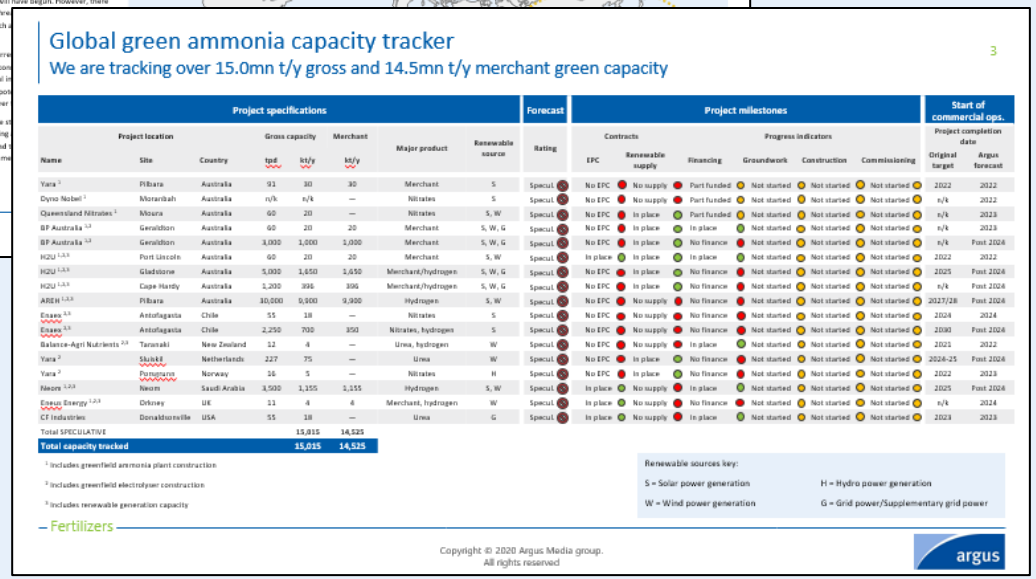
Green



Global Green Ammonia Capacity Tracker

Argus is tracking about 15mn t/y of speculative green ammonia capacity — over 95pc is merchant capacity

2



Global green ammonia capacity tracker

We are tracking over 15.0mn t/y gross and 14.5mn t/y merchant green capacity

3

Ammonia supply will continue to grow with demand including energy demand

NEOM PROJECT REVIEW: Green ammonia production costs will be high

Air Products will have to charge a high premium over brown ammonia to breakeven on their investment in NEOM

A joint-venture between Air Products, ACWA Power and NEOM (equal shares) is planning the construction of a 3,600 tpd green ammonia plant. The $5bn investment, based in the north west of Saudi Arabia, will use renewable electricity from over 4GW of solar and wind farms to produce hydrogen and nitrogen for ammonia production.

At a basic level, green ammonia is simply the removal of the SMR process and its methane feedstock from ammonia production, and its replacement with an electrolyser and an integrated renewable power supply. NEOM will use 100% renewable energy to power the electrolyser, the ASU (air separator) and the ammonia synthesis process at the new project. This mans that there will be no carbon emissions produced by the ammonia plant. NEOM will use Air Products' own in-house technology for the ASU andthyssenkrupp technology for the electrolyser. Ammonia synthesis will be supplied by Haldor Topsoe.

Access to Resources: Few locations globally provide suitable conditions for a mix of renewable sources that would meet a largeelectolyser's baseload power requirements, 24 hours a day. Saudi Arabia is one of the better locations for the construction of a renewables-based electrolyser given its abundance of solar flux. NEOM's coastal location also means reliable wind generation is viable. Both electricity and hydrogen storage will be used to maintain constant ammonia production through periods of low solar or wind power output.

Access to Markets: Air Products will be the exclusive ammonia off-taker. Outside of the project scope assessed here, Air Products will invest $2bn in a carbonfree hydrogen distribution network using the green ammonia produced. Ammonia will act as the hydrogen carrier. Each tonne of ammonia will 'carry' 176kg of hydrogen which is dissociated back into hydrogen at the destination.

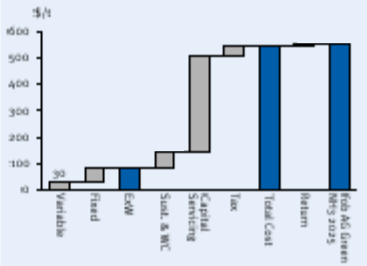
Access to Capital: The plant will form part of NEOM – a new industrial hub focussed on sustainability that came from the Saudi Vision 2030 initiative. NEOM is a closed joint-stock company fully owned by Saudi's Public Investment Fund, which have invested $500bn into the NEOM masterplan. State financing will provide extremely favourable loan rates for this project, helping to keep debt costs to a minimum.

The $5bn of capex quoted for this project initially looks like a lot of capital for an investment in an ammonia plant. However, most of this will be used to build the wind and solar generators. We also need to take into account the speculative nature of a worldscalegreen ammonia plant. The largest installed electrolysers in the market today are in the 5-10MW range. The capacity needed to supply hydrogen to a 1.2mn t/y ammonia plant is around 2GW. The step up in capacity is considerable. For 4GW of renewable generation, 2GW of electrolysis, as well as the ammonia plant equipment and lithium ion storage to fit within a $5bn envelope, investment costs for each technology will need to come down significantly from todays levels (2019$ terms).

Project details and assumptions

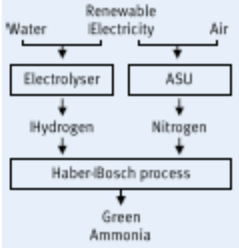
Site location	Saudi Arabia	
Start of production	2025	
Target market	Green H_2	
Capacity	1,260	kt/yr
Capex	$ 5.0	bn
Cost of equity	13	pc
Corp. WACC	10	pc
Project WACC	16.6	pc
Project gearing	60	pc

Economic cost*



* Return based on forecasted green NH_3 price on start up for NEOM to breakeven

Green ammonia production



Fertilizers

Grey

- Price will continue to incentivize construction of new capacity, and raise production from spare capacity.
  - Projects are feasible when there is availability of the right priced capital and raw material resources, and market access.

Green

- Price will also incentivize supply.
- For now it's a higher price, but the fundamentals are the same.
  - And technology is similar and widely available.

Conclusions

- There is a substantial stock of existing ammonia supply, widely available geographically.
- Ammonia supply is rarely a market constraint. There are periods when demand grows more quickly, resulting in higher prices, but this normally brings significant supply response:
  - Short term (within months): higher output/utilization, use of spare capacity; N product switching.
  - Within quarters/years: expansionary revamps (including green retrofit?).
  - ~3 years: greenfield and brownfield new plants/lines (longer for green projects?).

- So, there are no obvious fundamental supply constraints to market growth for ammonia for energy use.

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