Knowledge grows

Fertilizer Industry Handbook 2025

April 2025

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What is fertilizer?

Fertilizers are plant nutrients, required for crops to grow

Crops need energy (light), CO_2, water and minerals to grow

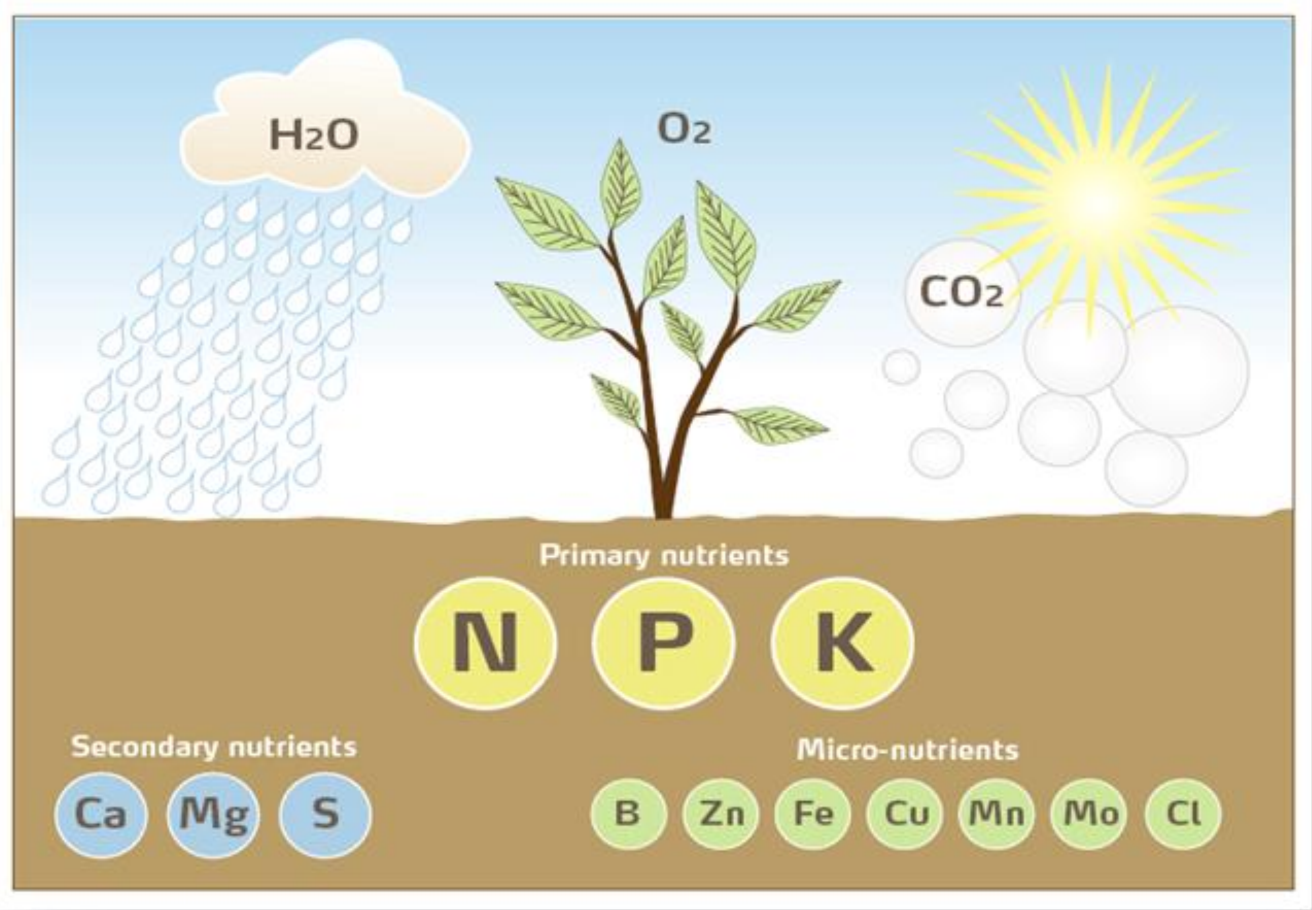
The carbon in crops originates from CO_2 absorbed through the leaves

Crops absorb water and plant nutrients from the soil

Plant nutrients are building blocks of crop material. Without nutrients, the crops can not grow

Mineral fertilizers provide plant nutrients for crops

Three main nutrients: Nitrogen, Phosphorus and Potassium are primary nutrients



Mineral fertilizers are produced from natural elements, into a form which makes them easily available for plants

Nitrogen (N)	Nitrogen originates from the air (78% of the earth's atmosphere is nitrogen). The most common process in nitrogen fertilizer manufacturing is to create ammonia from a mixture of nitrogen from the air and hydrogen from natural gas
Phosphate (P)	Phosphate is sourced from insoluble calcium phosphate rocks. Rock phosphate is made available for the plant usually through a chemical process to create plant-friendly fertilizers
Potash (K)	Potassium is sourced from old sea and lake beds formed millions of years ago. Since potassium sources are often located far below the soil surface (1-2km depth), plant roots are unable to reach them naturally

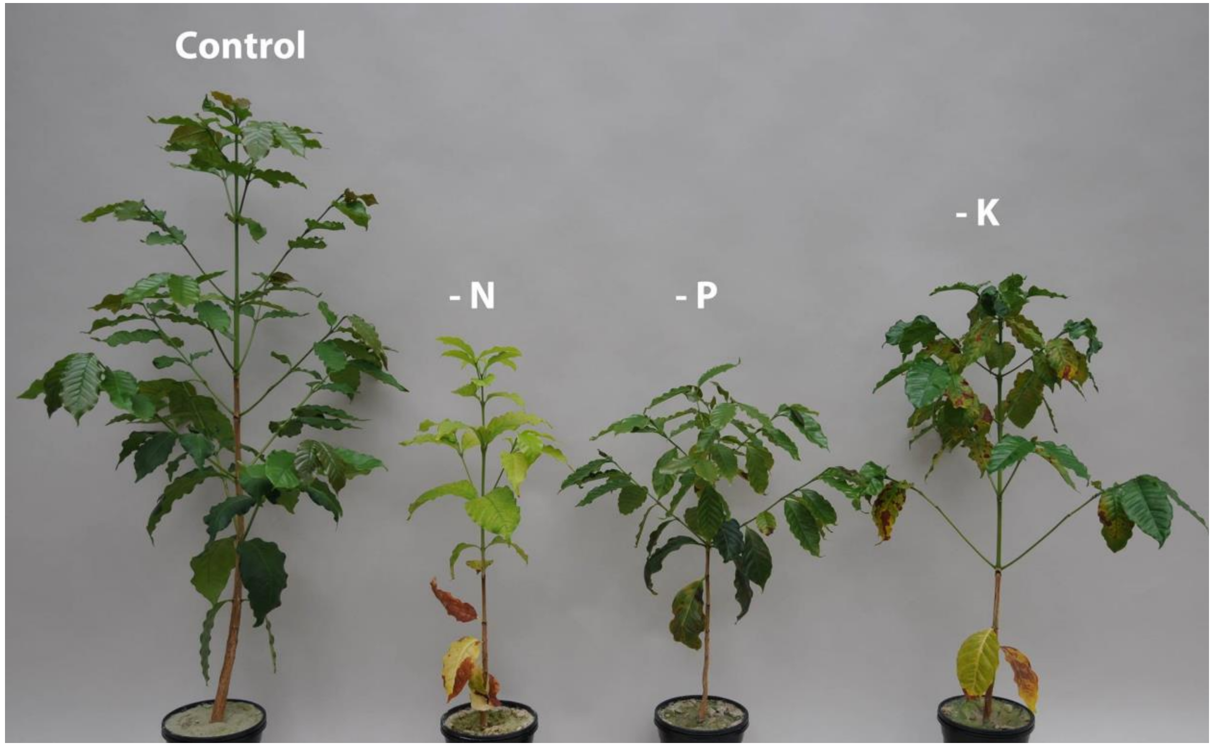
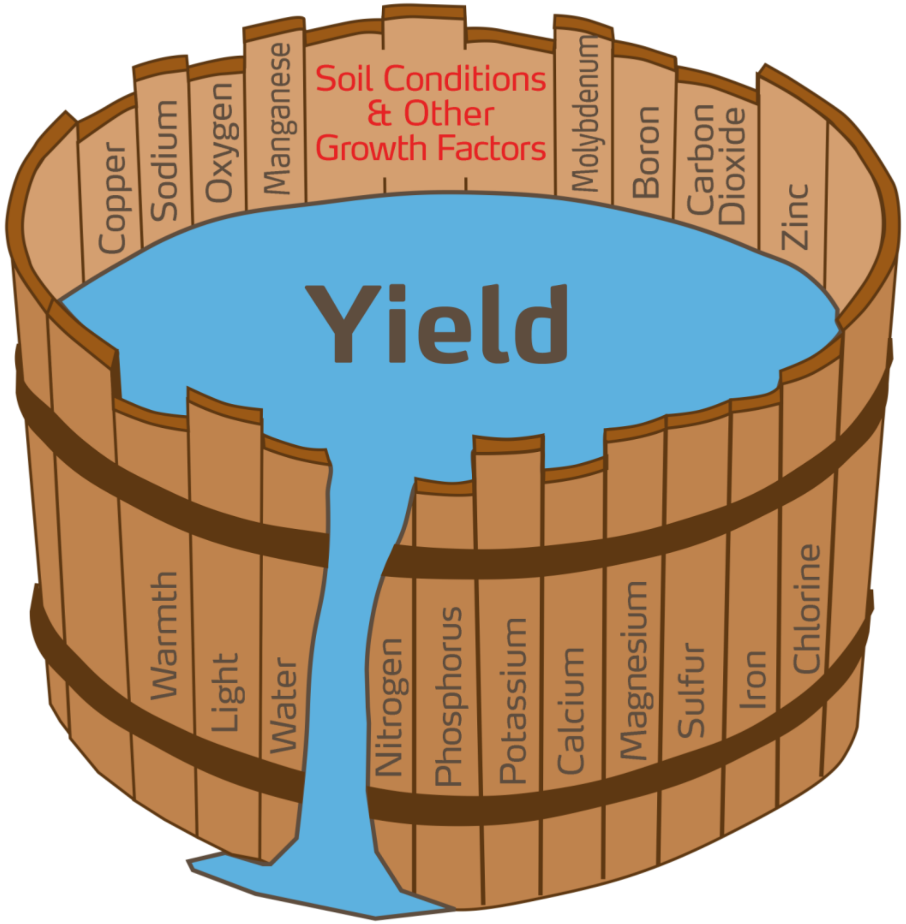


Illustration: lack of either N, P or K typically leads to plant deficiencies including reduced crop growth, reduced crop quality and/or lower resistance to drought and diseases

Principle of crop nutrition: crop growth is limited by the most deficient nutrient

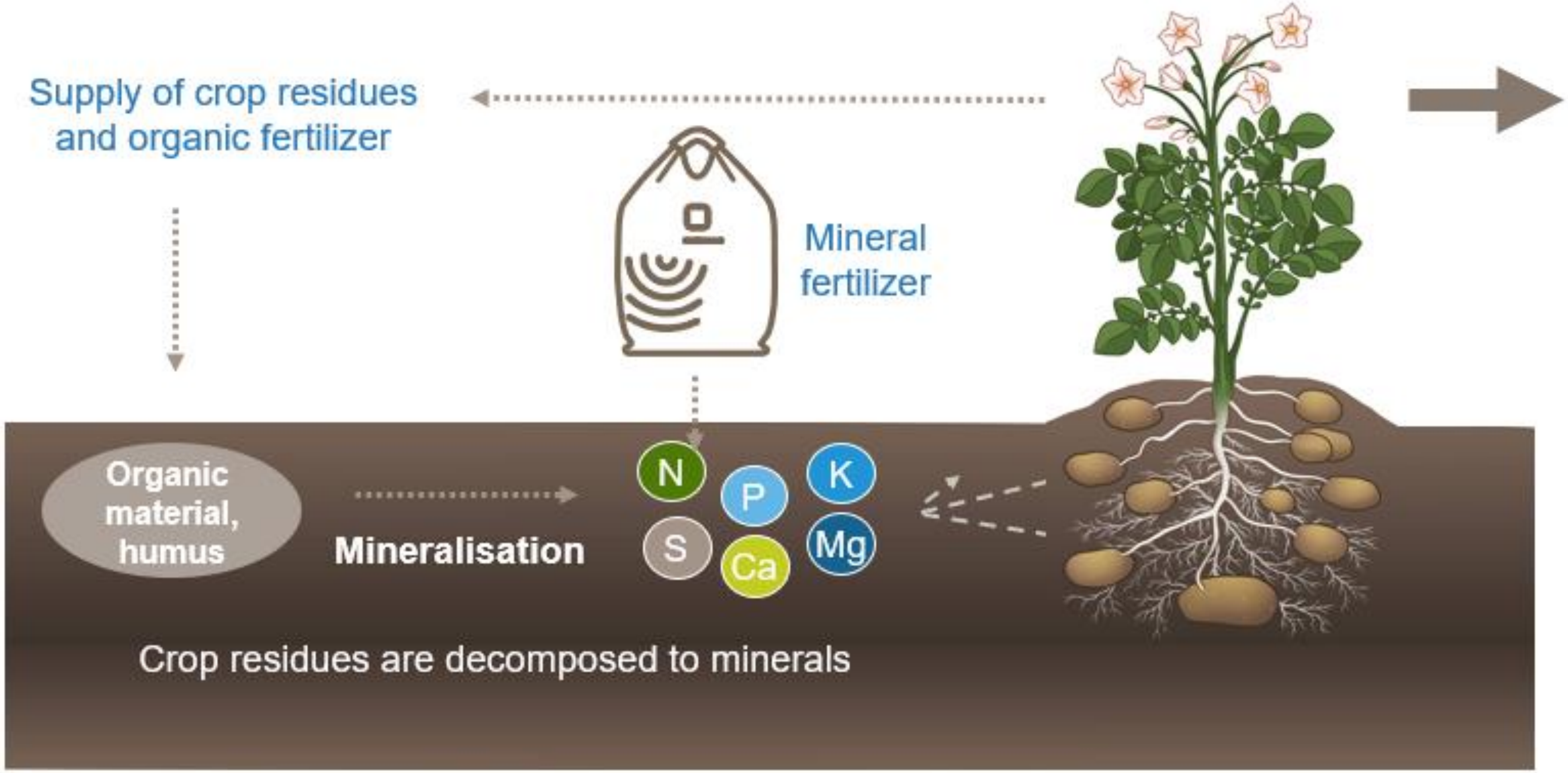
- Law of the Minimum (Liebig, 1843): “Crop yields are proportional to the amount of the most limiting nutrient.”
- Plant nutrients have specific and essential functions in crop metabolisms
- They cannot replace each other, and lack of any one nutrient limits crop growth
- It is therefore essential to focus on balanced nutrition of all plant nutrients



JUSTUS VON LIEBIG 1803 - 1873

Why mineral fertilizer?

Mineral fertilizers replace nutrients removed from the soil with the harvest



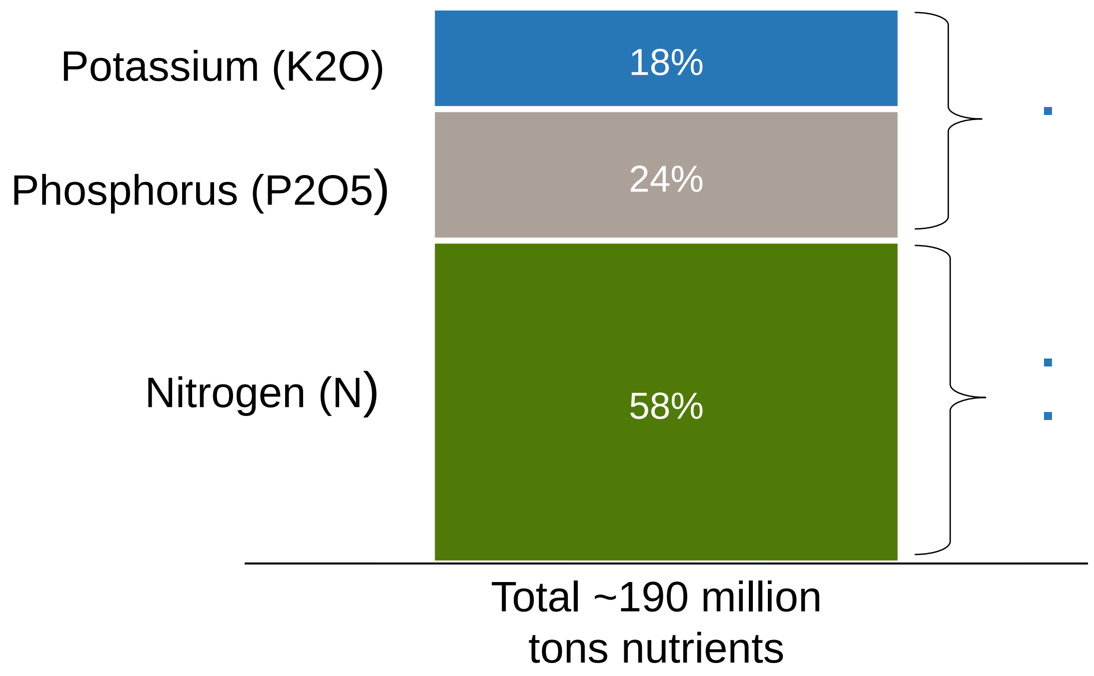
- Export of nutrients with the harvest
- Growing demand for food & feed

Mineral and organic fertilizers supply the same inorganic molecules to crops, but have different characteristics

Characteristics	Mineral fertilizer	Organic fertilizer
Nutrient source	Nitrogen from the air, Phosphate and Potassium from deposits / mines	Crop residues and animal manures, other organic material
Nutrient concentration	High nutrient concentration Low logistical cost	Low nutrient concentration High logistical cost due to large volumes to transport and store
Nutrient availability	Immediately available for the crop	Variable, organic material needs to be decomposed to release nutrients
Quality	Traceable and consistent	Often inconsistent Dependent on source

- Plant productivity achieved by supplying only organic matter is on average low compared with mineral nutrients supplied in the form of fertilizers.
- However, mineral and organic fertilizers are not mutually exclusive. When using the right source, at the right rate and time and in the right place, both can improve farmers’ livelihoods, support soil health on the farm and protect the environment.

Nitrogen – the most important nutrient



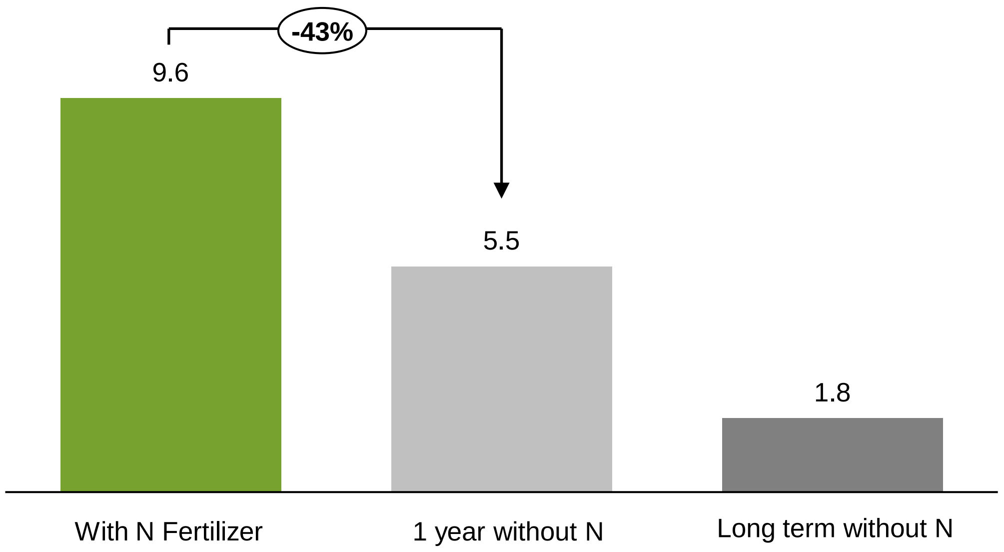
Nutrient characteristics

Primary benefit	Application	Industry structure
▪ Improve crop quality	▪ Application can be varied	▪ Fewer suppliers, production discipline
▪ Increase crop size ▪ Most important and commonly lacking nutrient	▪ Annual application critical	▪ Fragmented industry ▪ More dynamic prices, but stable volume

Regular nitrogen application is required in order to maintain yields

Annual N-application is critical for yield

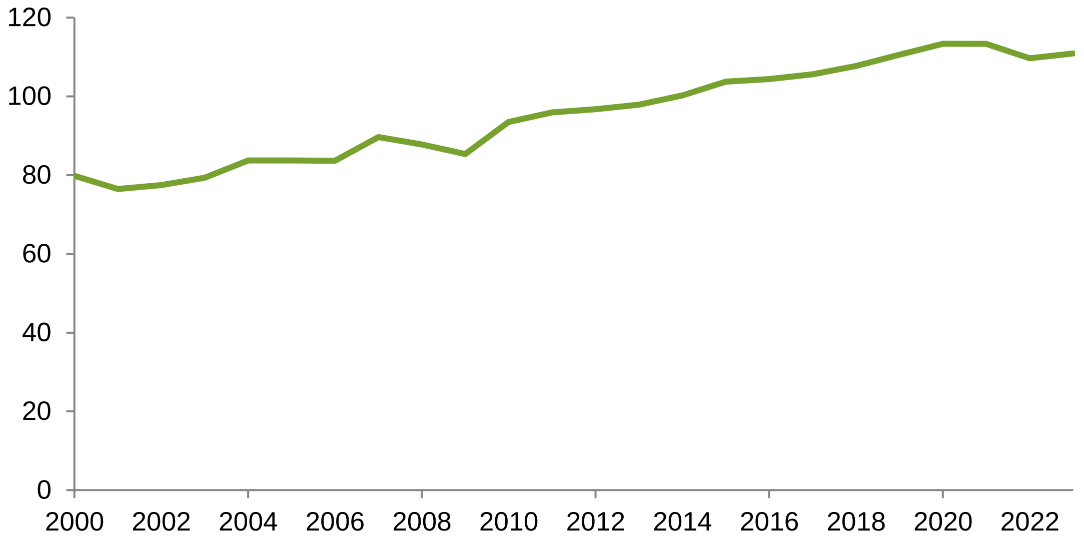
Grain yield from Nitrogen fertilizer
Ton per hectare



Source: Broadbalk long term trial Rothamsted UK

Stable global nitrogen consumption pattern

Million tonnes of nitrogen (ex China)



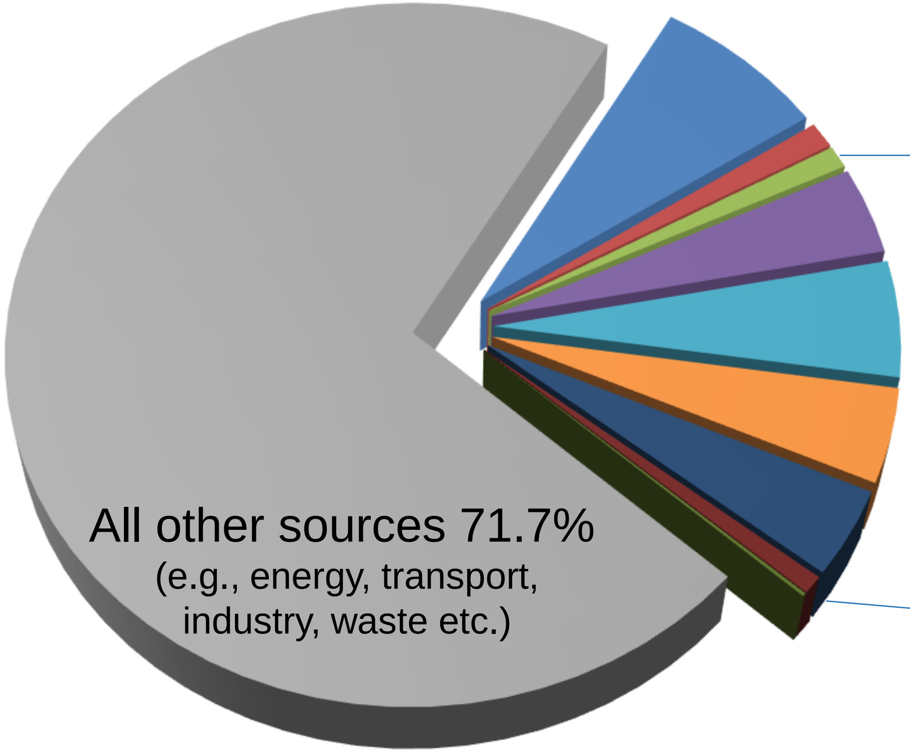
Source: IFA, August 2024

Fertilizer CO_2 footprint

The agri-food system is responsible for <30% of global greenhouse gas emissions

Fertilizer production and use represent <2% of emissions

Emission sources



7.4% Livestock and manure

1.2% Rice

1% Mineral fertilizers (use)

4% Others (e.g., residues, org. soils, energy use)

Farm gate 13.6%

5.3% Agricultural land use change

Agricultural land 19%

4.3% Food consumption and waste

4% Food processing and retail

0.8% Fertilizers production

0.2% Pesticides production

Agri-food system 28.3%

Total emissions in 2022: 57.4 Gt CO2e*

Source: FAOSTAT. *When including removals from forestland, the net balance is 54.8 Gt CO2e. All figures are rounded to one decimal place.

Fertilizer reduces the carbon footprint of farming

Fertilizer - an efficient solar energy catalyst

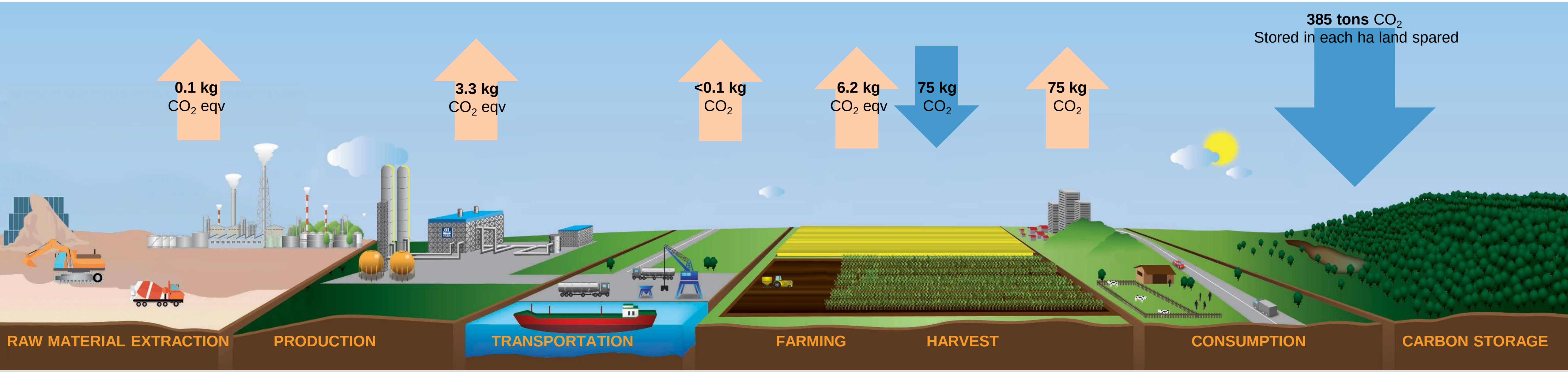
- Production is a marginal part of the carbon footprint; efficient application is more important
- Huge positive effects of fertilizer use, since higher yields enable lower land area use

Production

- Yara's production is more energy-efficient than the competitor's average

Application

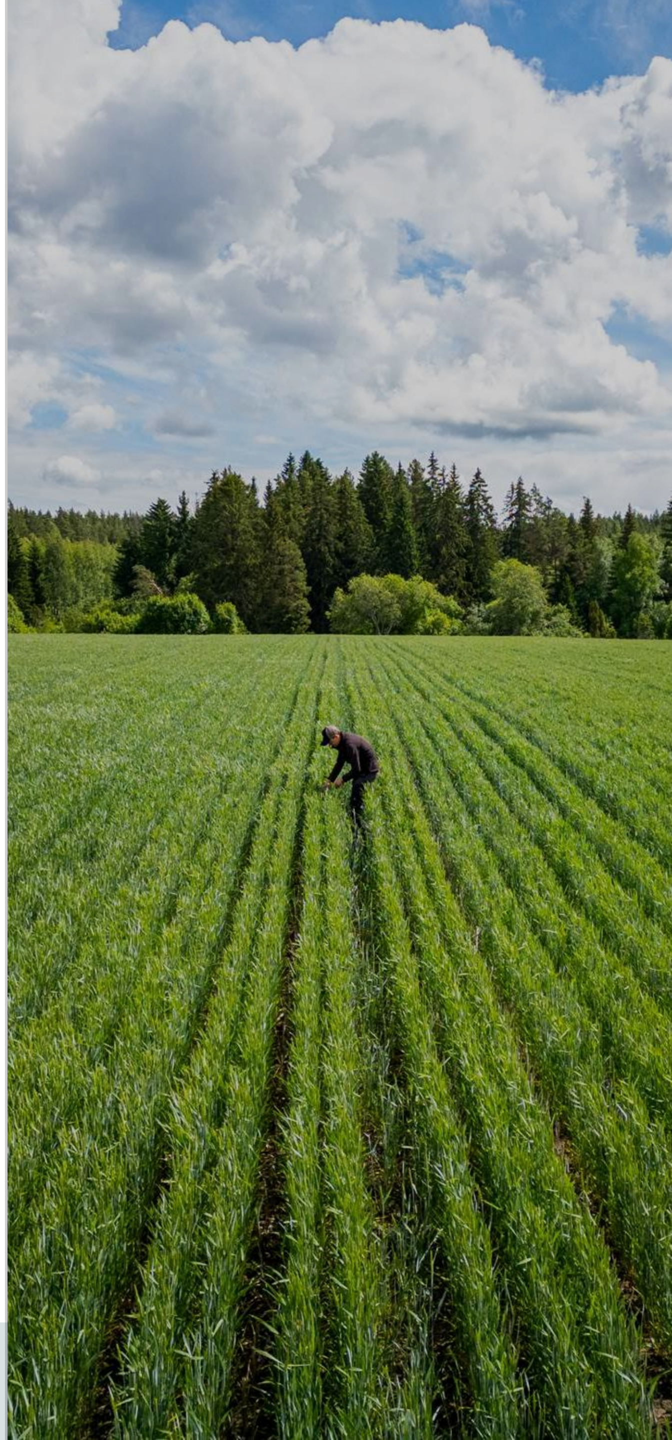
- Higher efficiency with nitrates
- Precision farming tools



Numbers show emissions as CO2eqv per kg Nitrogen in fertilizer product for Calcium Ammonium Nitrate 27%

More than half of total GHG emissions from fertilizer take place in the field

- **More than half of total emissions in the fertilizer industry comes from fertilizer use** – Scope 3 category 11 emissions from
  - Direct N_2O emissions (nitrification and denitrification)
  - Indirect N_2O emissions (ammonia volatilization and nitrate leaching followed by nitrification/denitrification)
  - CO_2 emissions from urea hydrolysis
- In-field N2O emissions occur when nitrogen, either as mineral fertilizer or organic matter, is applied to the soil and transformed by different soil microbes in the natural nitrogen cycle. The activity of the microbes depends on several environmental variables, making the N_2O emissions hard to predict and manage.
- Key mitigation levers are:
  - Inhibitors
  - Climate-smart fertilizer management
  - **Nitrogen use efficiency**
  - Carbon sequestration
- Per April 2025 there does not exist a specific target-setting framework for the fertilizer industry to align with the 1.5 degree goal of the Paris agreement
- **An ideal target setting for scope 3, category 11, is a crop intensity-based target setting**. This approach can better support collaboration across the food value chain, and it can be developed so that it does not jeopardize food security.
- For more information, please check out Yara's latest Integrated report:



YARA

Increasing N_2O emissions from the agriculture sector

- Atmospheric abundance of nitrous oxide (N_2O) has increased by more than 20 per cent since the pre-industrial era due to human activities
- Increase in nitrous oxide abundance is primarily being driven by globally increasing emissions from agriculture
- Nitrous oxide's current contribution to warming is about 0.1° Celsius (C), and is growing. Because it has a long atmospheric lifetime (around 120 years), its warming effect accumulates and will last long time
- Nitrous oxide is currently the most significant ozone-depleting substance emitted and poses a serious threat to stratospheric zone
- Emissions from adipic acid and nitric acid production can almost be eliminated by adopting relatively lost cost abatement measures
- Through installation of Yara's own catalyst technology Yara had by the time of the Paris agreement negotiations eliminated nearly half of its scope 1 GHG emissions.

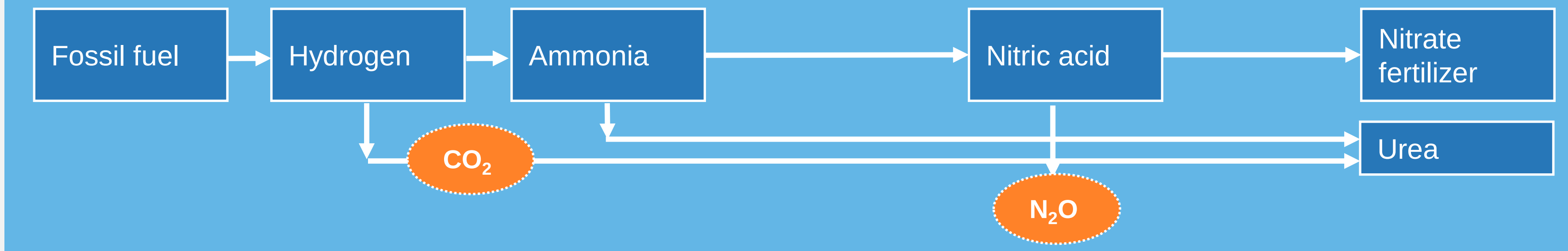
Examples of nitrogen abatement measures per sector

Sector	Measure
Agricultural sector	**Nitrogen testing**: Soil and plant nitrogen testing
	Nitrogen application: Split application using controlled-release fertilizers; urease and nitrification inhibitors; reduced application rates; and increased manure recycling
	Crop management: Integrating nitrogen-fixing crops in rotations; reduced tillage; and the use of cover crops
	Livestock diets: Optimizing protein intake
	Grazing: Rotational grazing
	Manure storage/process: Solid/slurry separation; storage under dry conditions and rapid drying; anaerobic digestion.
	Drainage control: Buffer strips
	Planning: Integration of crop and livestock production
Chemical sector	**Adipic acid production**: Catalytic reduction and thermal destruction
	Nitric acid production: Catalytic reduction and thermal destruction
Waste sector	**Wastewater**: Process optimization to increase the N2 /N2 O ratio

Source: GLOBAL NITROUS OXIDE ASSESSMENT, UN environment program

Emissions in the production process occur mainly in the ammonia production step, catalyst technology invented by Yara has almost eliminated N_2O emissions

Standard fertilizer production



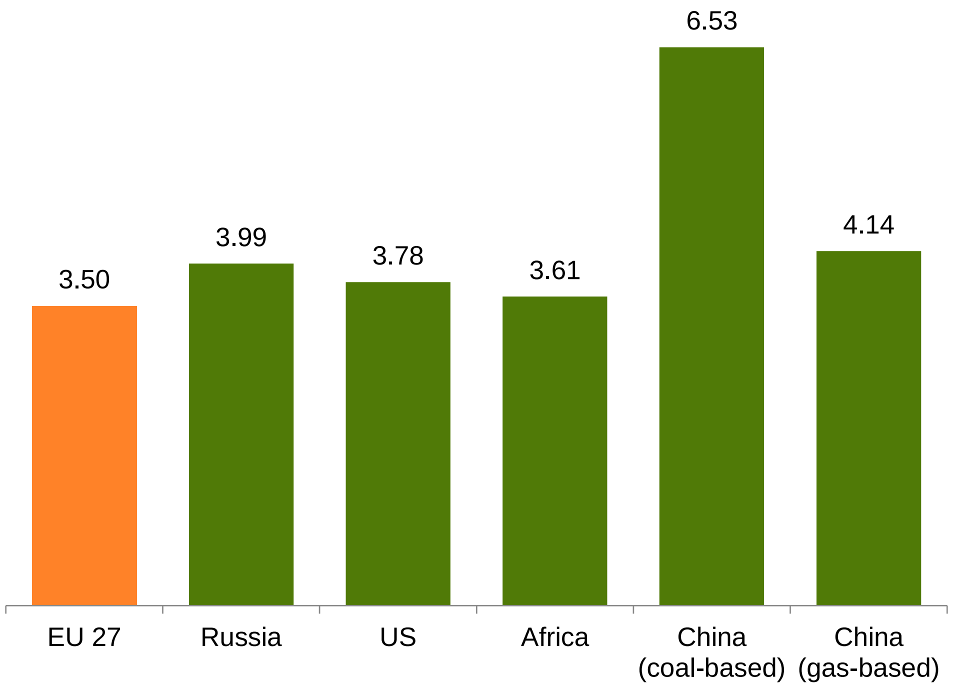
Emissions	1.8-.2.4 mt CO_2 per mt ammonia *)	0.03 -0.2 mt CO_2e per**) tonne nitric acid
Decarbonization routes	• Carbon capture and storage (blue ammonia) • Replace fossil fuel with hydrogen from electrolysis (green ammonia)	• Catalyst abatement technology

*) Source: IFA
**) Source BAT (Best Available Techniques) Large Volume Inorganic Chemicals Ammonia, Acids and Fertilizers (2007) new plants

Carbon footprint of fertilizer production differs by region - Europe is the most efficient

Urea

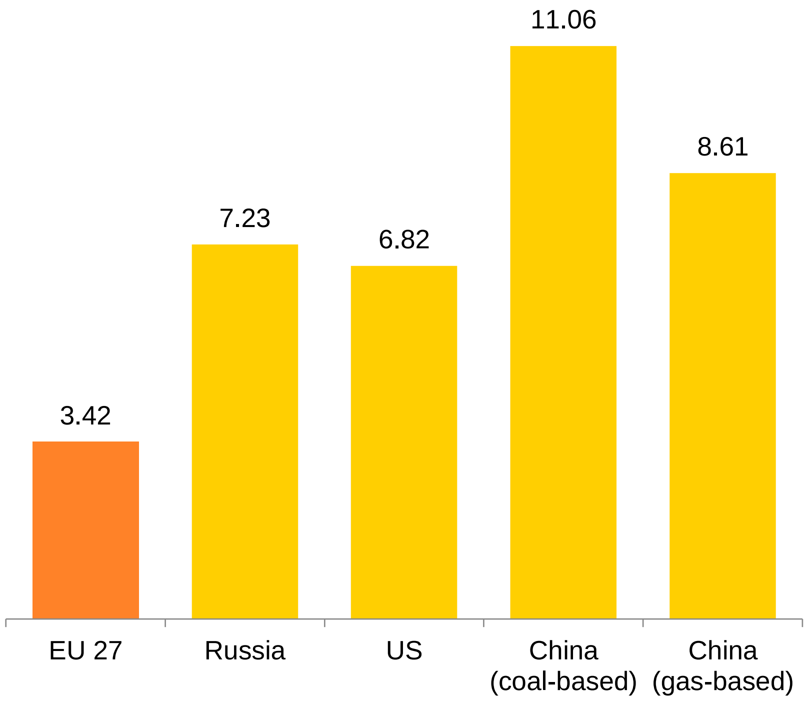
kg CO_2 per kg urea nitrogen (including CO_2 embedded in Urea)



Source: Fertilizers Europe (2016) for production in 2014

Ammonium nitrate

kg CO_2 equivalents per kg AN nitrogen

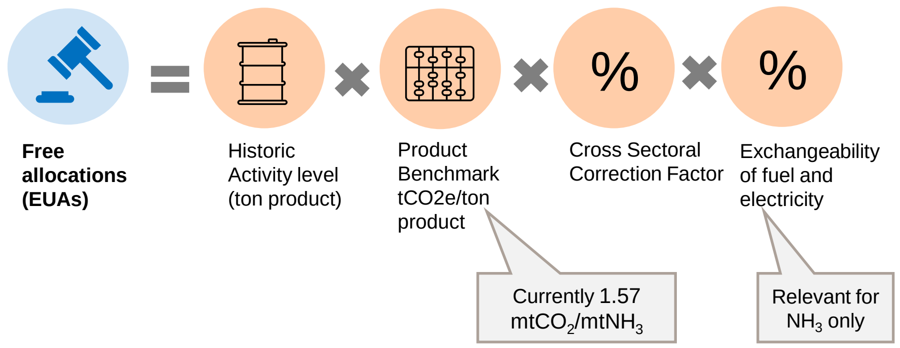


Source: Fertilizers Europe (2016) for production of granulated AN in 2014

Carbon cost exposure to increase as free allocations are gradually reduced

Free allowance currently covering majority of EU ETS cost for European producers

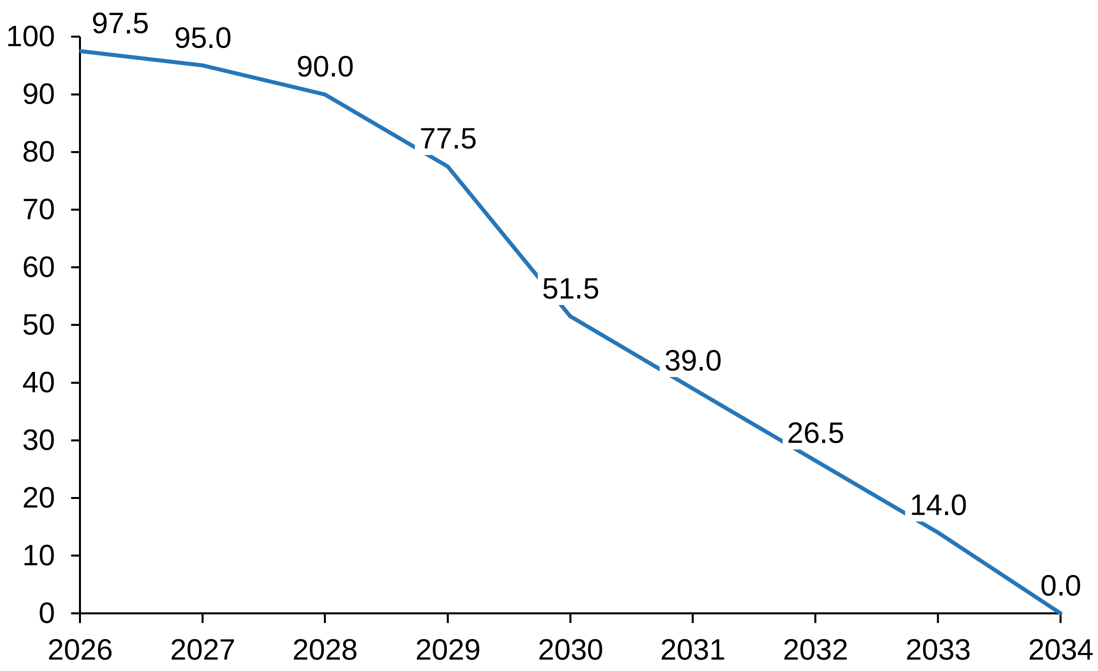
- European ammonia production is exposed to a carbon/EU ETS cost, while imported ammonia and other fertilizer products are not
- Producer located in Europe currently receives free allowances based on:



- With the implementation of CBAM from 2026-2034 both EU produced and imported products will be subject to the same carbon costs

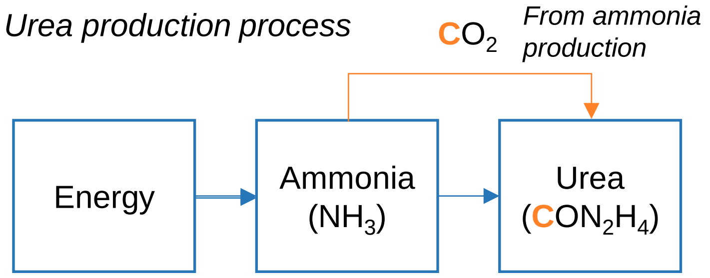
Phased implementation of CBAM will mirror the gradual phase-out of free allocations

Free allocation (% of original allocation)



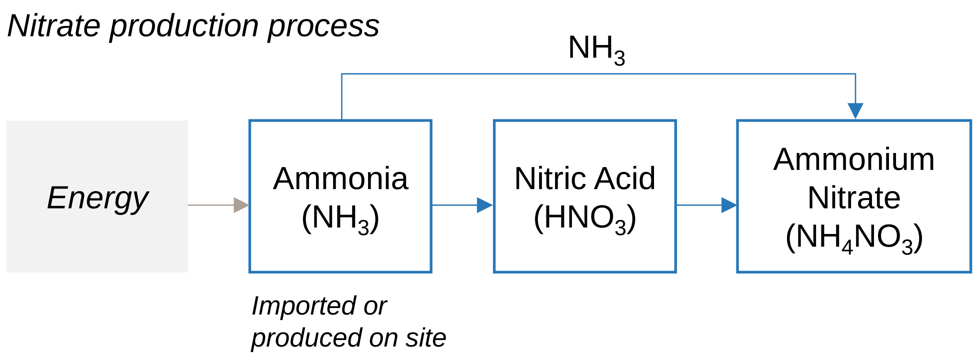
Nitrates and NPK are ideally suited for decarbonization

Urea contains carbon and can not become carbon free



- Urea (CON_2H_4) is carbon-stabilized ammonia and can not become carbon free
  - ~0.7 tons CO_2 per tonne urea is emitted when urea is applied on the field
- Access to renewable carbon is required to decarbonize urea. Renewable carbon can stem from organic waste materials or CO2 captured from biogenic sources. However, these sources are limited, geographically dispersed and challenging to scale
- Urea plants are located next to an ammonia plant as the CO_2 in the ammonia production is used to produce urea

Nitrates and NPK do not contain carbon



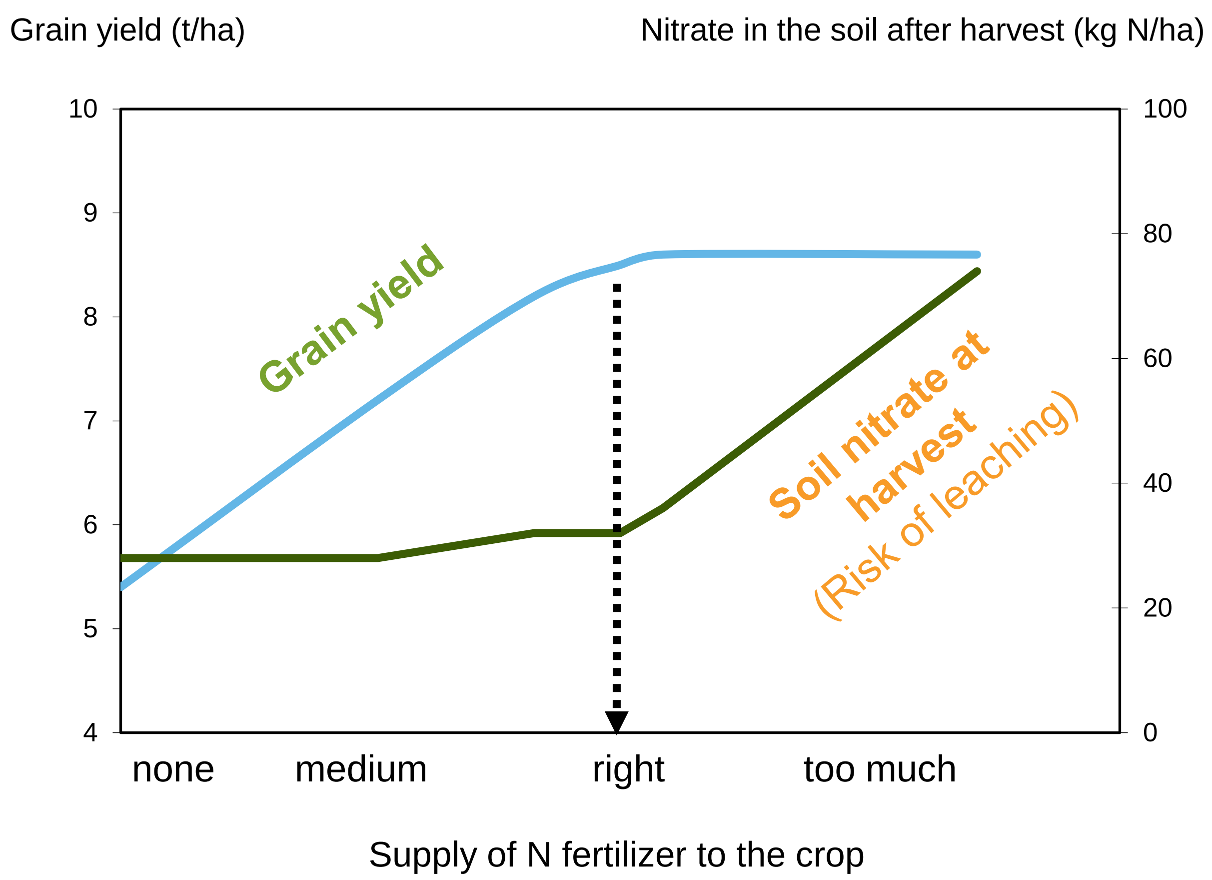
- Nitrates (NH_4NO_3) and NPK[1] do not contain carbon and carbon is not an integral part of the production process
- Nitrate and NPK plants are often operated as stand alone plants as the production process is not dependent on having an adjacent ammonia plant (or another source of CO_2)
- The molecules of low-carbon ammonia are the same indepentent of production process and as such, the productoin of nitrates and NPKs can be decarbonized by upgrading from low-carbon ammonia

1) Phosacid and Nitrophosphate based compound NPK

Other environmental topics

Leaching: The right nitrogen fertilizer rate is key to avoid nitrate leaching

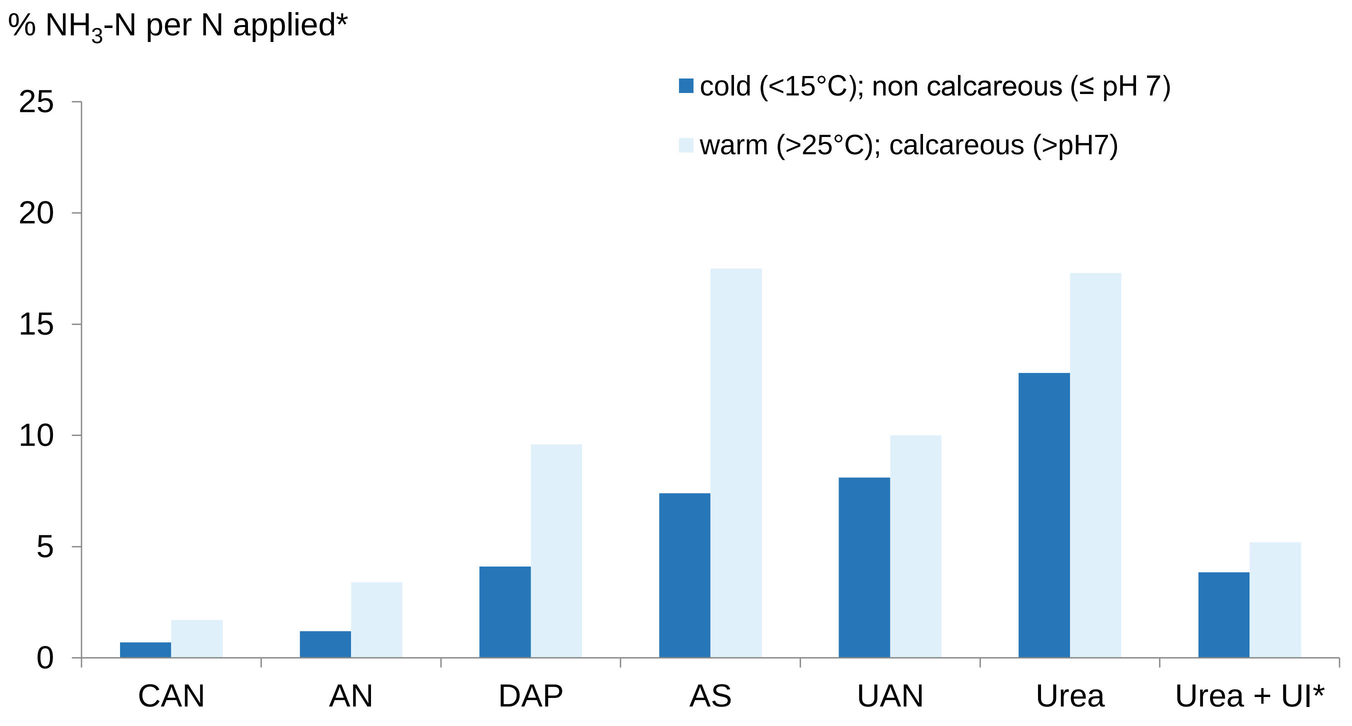
- Leaching of nitrate into groundwater affects water quality and can contribute to eutrophication[1]
- Oversupply of organic and mineral nitrogen fertilizer is the main driver for nitrate leaching
- Nitrogen fertilizer application according to crop demand does not increase the risk of nitrate leaching
- The risk of nitrate leaching increases only when too much N fertilizer has been applied



1) Excessive richness of nutrients in a lake of another body of water

Ammonia volatilization: Choosing the right nitrogen fertilizer is key to avoiding ammonia volatilization losses

- Volatilization of ammonia gas affects air quality and induces soil acidification
- The use of organic or urea-based nitrogen fertilizer is the main driver for ammonia losses
- Nitrate-based N fertilizer or immediate incorporation of urea into the soil avoids volatilization losses
- Urease inhibitor is a chemical compound which delays the conversion of urea to ammonium

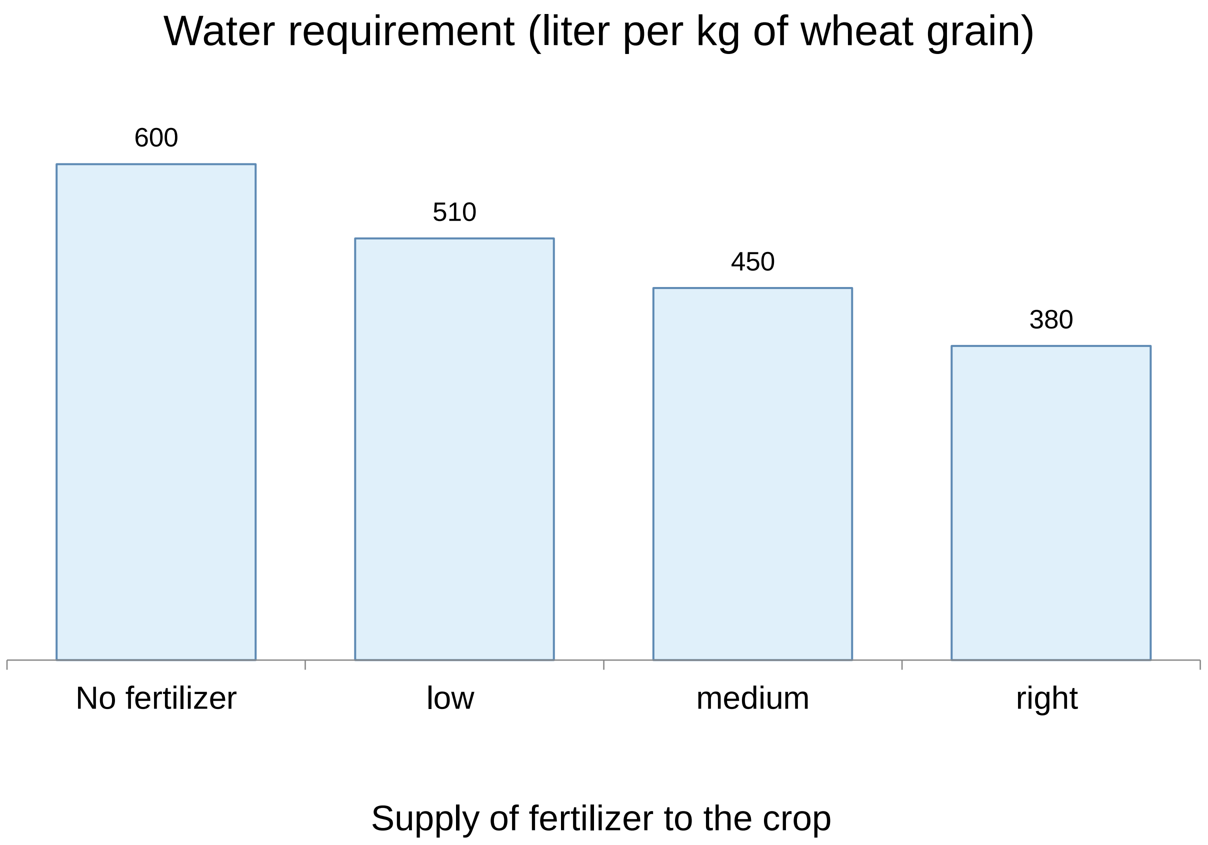


* Urea + Urease Inhibitor (Urea + UI) assuming 70% reduction of ammonia emissions

**NH_3-N per N applied* is the amount of nitrogen as ammonia (NH_3) released per tonne of nitrogen applied
Source: http://www.eea.europa.eu/publications/emep-eea-guidebook-2016

Water: Good crop nutrition enables increased water efficiency: “more crop per drop”

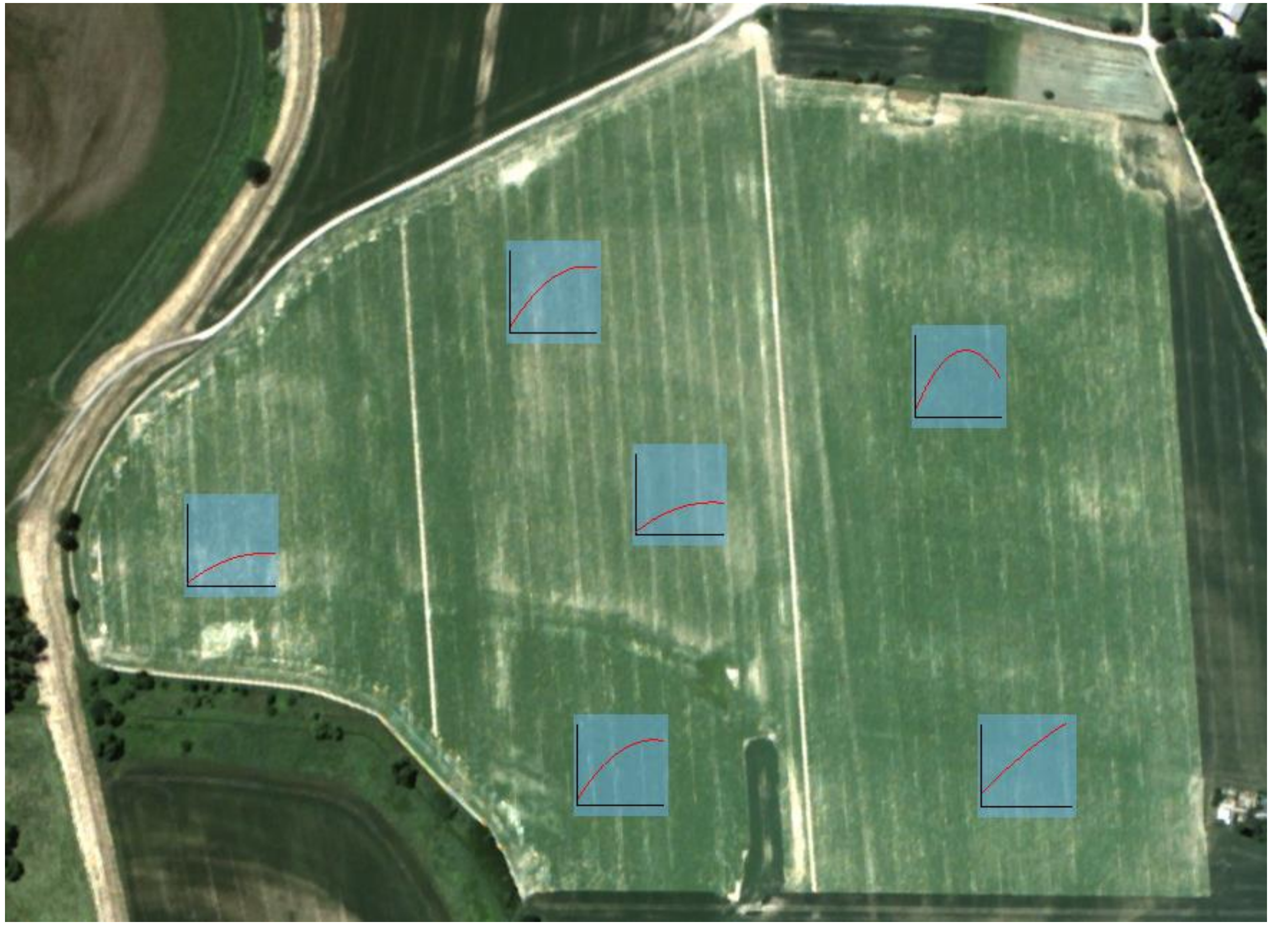
- Water is a key input for crop growth
- About 70% of global water consumption is for agriculture
- Optimized crop nutrition improves water use efficiency, mainly because a well-nourished crop creates a soil cover which reduce evaporation of water from the soil



Source: Yara research

Precision farming

Precision farming: applying the right nutrients in the right quantity at the right time



- Growth conditions within fields are heterogeneous, affecting the crop yield and fertilizer demand
- Estimation of the nitrogen status of crops is a requirement to respond to this heterogeneity
- Digital tools enable growers to estimate the nitrogen status of crops and use this information to determine how much fertilizer to apply and when to apply it

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- **Benefits of precision farming** include higher yields, improved crop quality, lower emissions and other environmental impacts and cost savings for the farmer

Digital crop sensing tools enable variable rate nitrogen application


N-Tester BT


Photoanalysis


Digital Leaf Color Chart (DLCC)

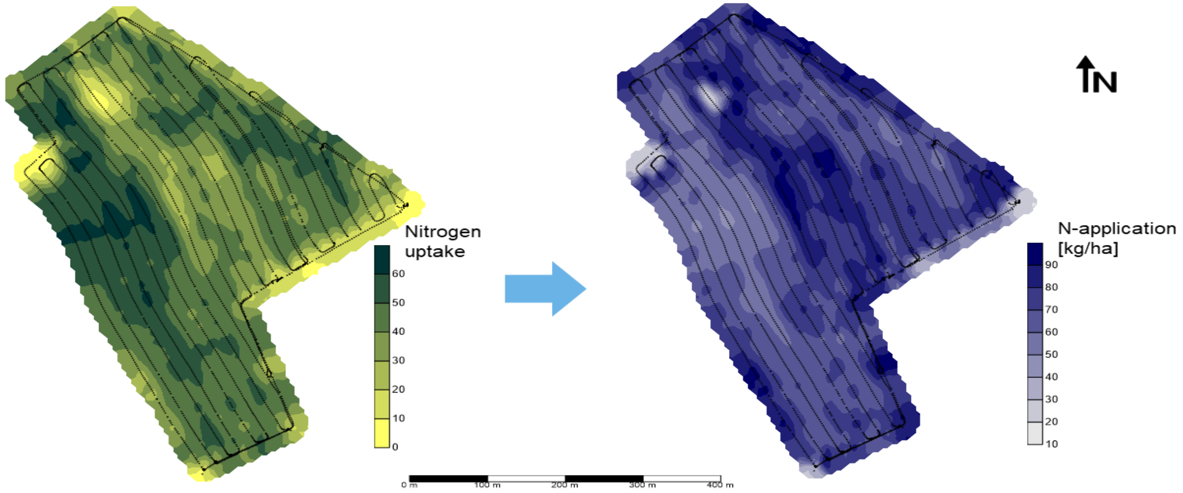

N-Sensor ALS2


Atfarm

Examples of digital solutions provided by Yara

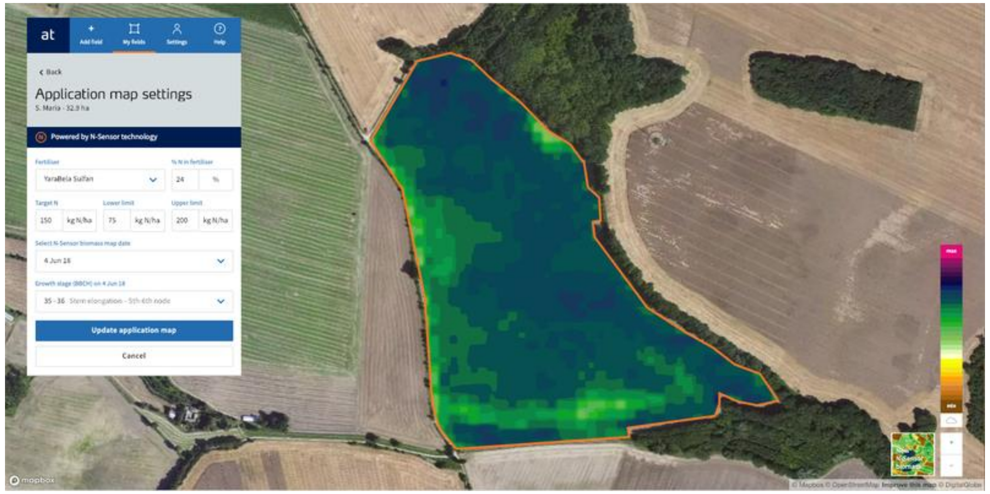
N-sensor

- Measures crop nitrogen uptake and creates a prescription map for variable rate application



AtFarm

- Atfarm uses state-of-the-art satellite imagery combined with Yara's expertise and products to create variable rate fertilizer application maps.
- Proof points; up to 6% yield gain, up to -12% fertilizer use[1], up to -20% carbon emissions from fertilizer[1]



1) By using best practices and solutions that exist today, farmers* can already in average reduce nutrient losses by 20%, increase yields and incomes by 5-7% and reduce their carbon footprint related to mineral fertilization up to 20%**
*Assumption are built with major crops in major EU countries (e.g. cereals)
**CFP considers mineral fertilizers produced with BAT-Best Available Technology, as mineral fertilizers without BAT may have around +30-40% carbon footprint. It does not consider the potential of using carbon sequestration farming practices

YARA

Repeated field trials confirm that variable rate nitrogen fertilization has multiple benefits

Replicated trials to estimate the effect of variable rate nitrogen fertilization compared to a uniform nitrogen fertilization

Trials: Winter wheat

Yield:	+3.6%
Nitrogen rate:	-2%
Nitrogen surplus:	-10 kg/ha

Trials: Winter oilseed rape

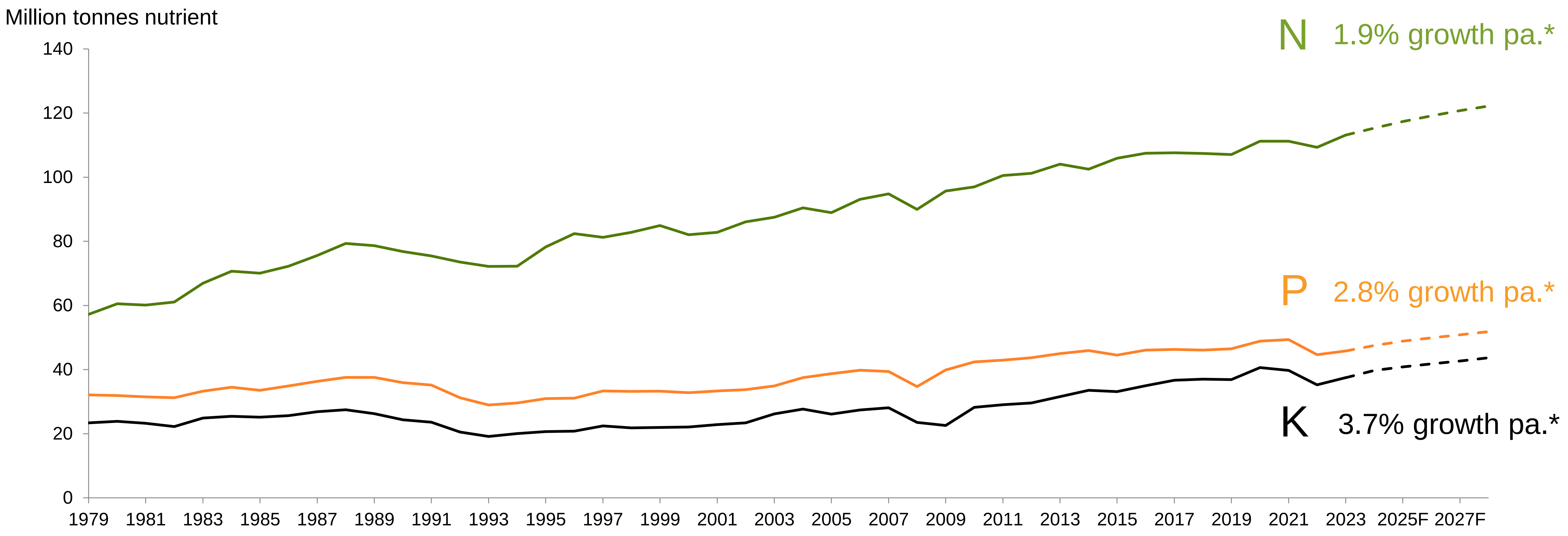
Yield:	+4.4%
Nitrogen rate:	-6%
Nitrogen surplus:	-18 kg/ha

→ *Improved crop yield, reduced nitrogen fertilizer rate and higher nutrient use efficiency*

Source: Agri Con GmbH

The fertilizer industry

Global consumption trend per nutrient

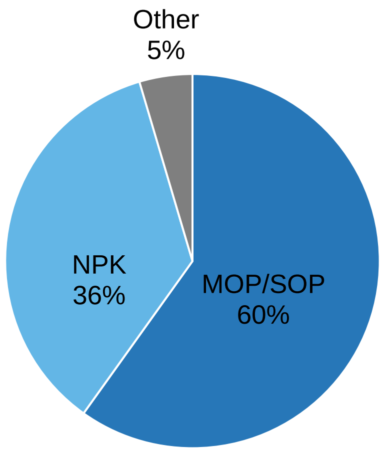


* CAGR avg. 2022-2023 to 2028

Source: IFA 2023

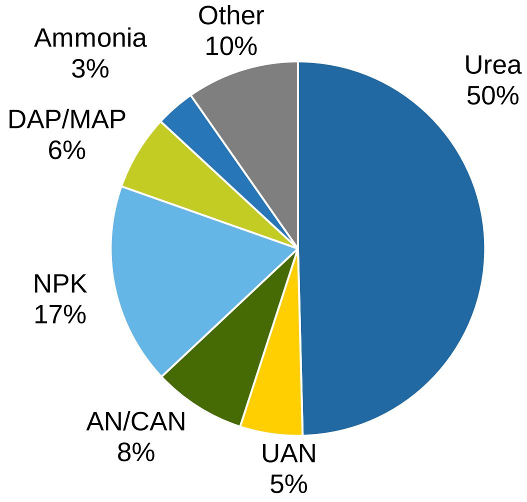
Key global fertilizer products

Potash K_2O



35 million tonnes

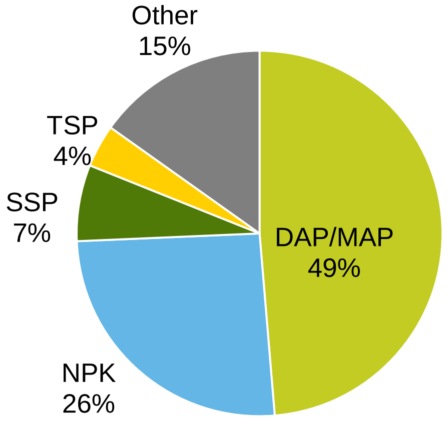
Nitrogen N



109 million tonnes*

* Does not include industrial nitrogen applications

Phosphate P2O5



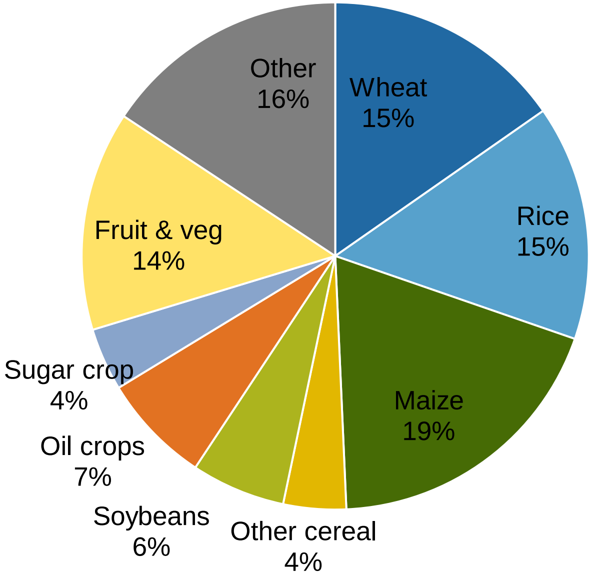
44 million tonnes

Source: IFA 2023, data for 2022

Nutrient application by crop

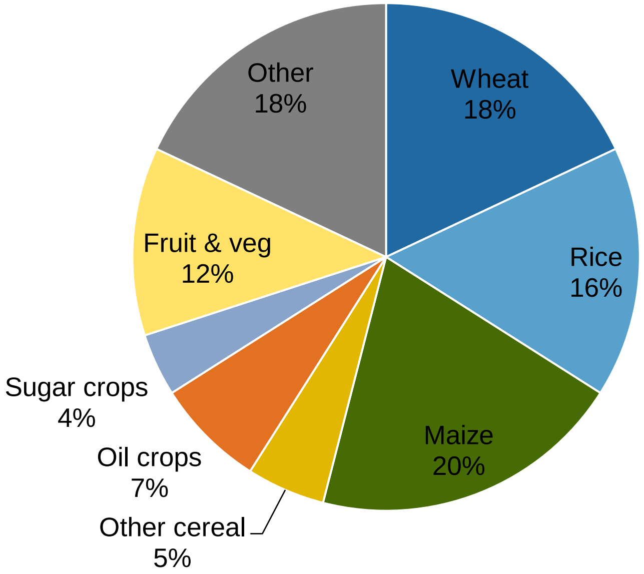
N + P + K

By tonnes nutrient



Nitrogen

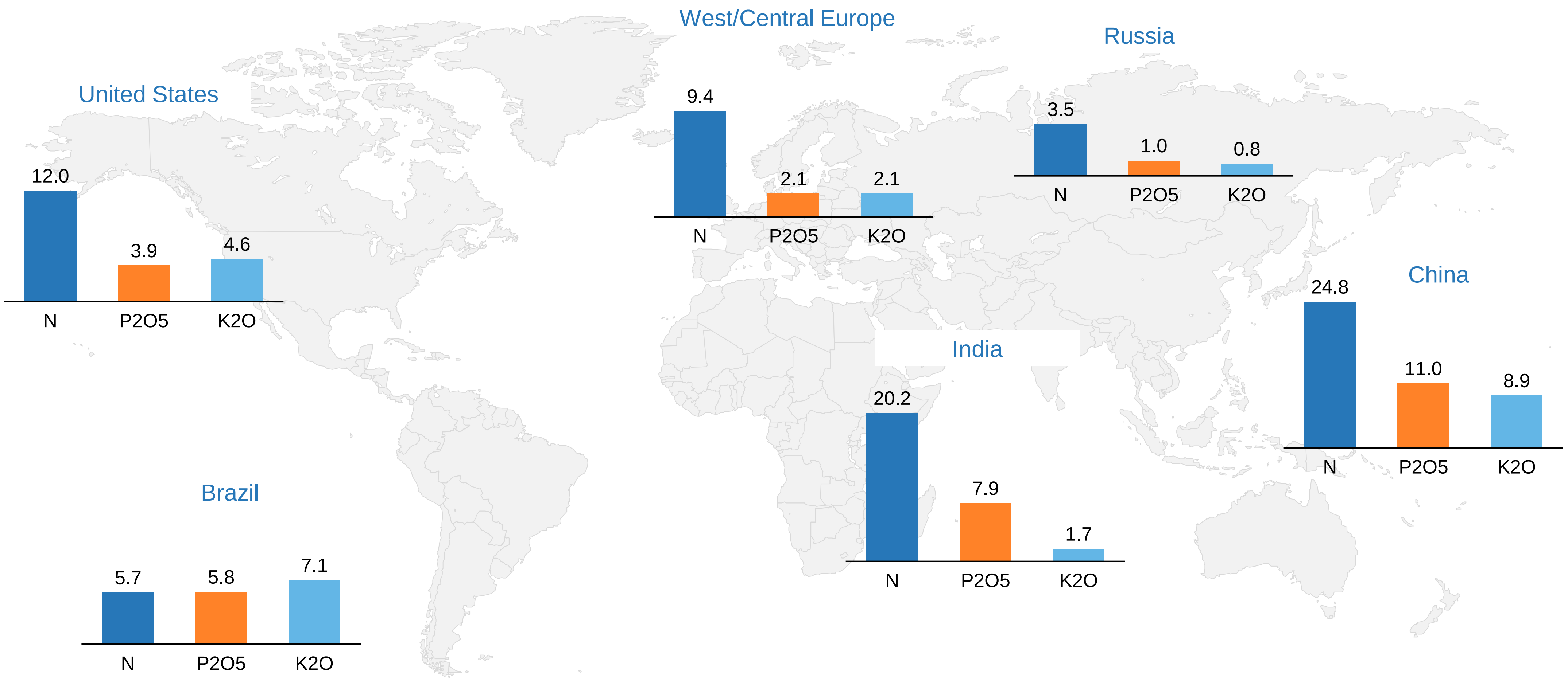
By tonnes nutrient



Source: IFA (2020/21)

Fertilizer consumption by region – 5 key markets

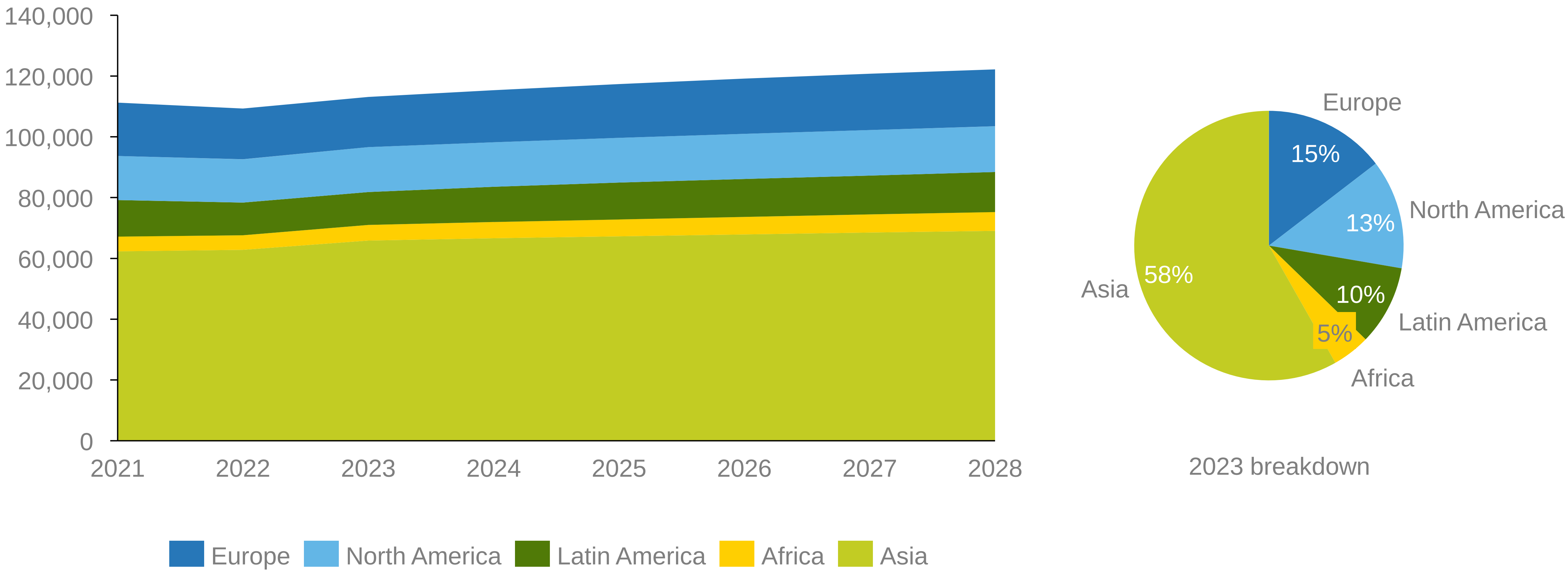
Million tons nutrient consumption



Source: IFA 2023, data for 2020

Nitrogen consumption in key regions

IFA consumption forecast, kt nitrogen

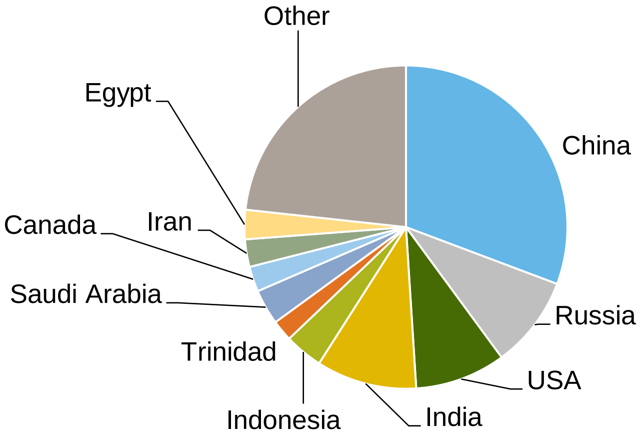


Source: IFA, May 2024

The N industry is fragmented, while the P and K industries are more concentrated

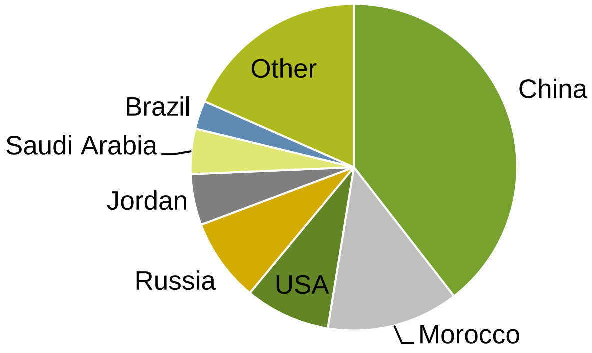
2023 figures[1], share of produced nutrient

Nitrogen (N)



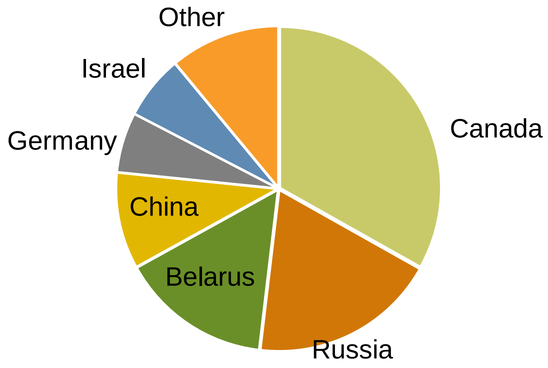
- Despite a consolidation trend, the industry is still highly fragmented
- The world largest nitrogen producers are CF, Yara, Nutrien, Ostchem, Adnoc/Fertiglobe, TogliattiAzot, Koch and Eurochem

Phosphate (P)



- More concentrated than N-industry
- The biggest producers are Guizhou Phosphorus Chemical Group in China, Nutrien and Mosaic in USA, OCP in Morocco, Ma'aden in Saudi Arabia and Phosagro in Russia

Potash (K)



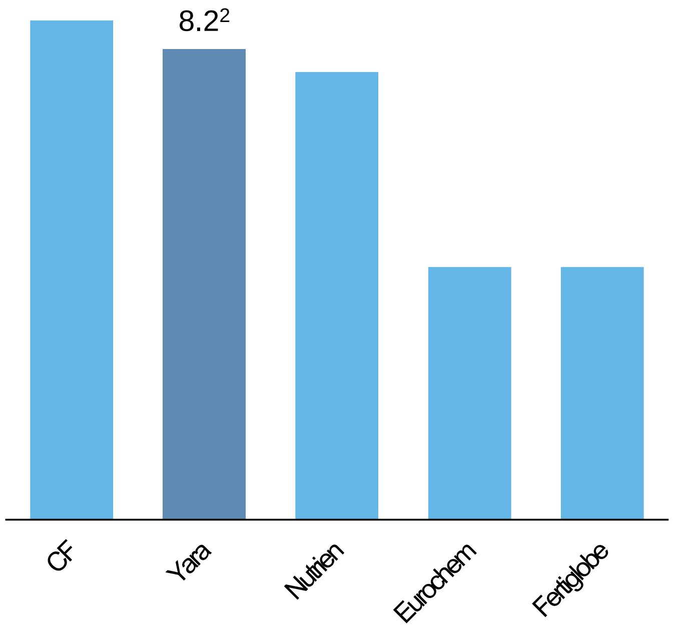
- Highly concentrated industry, with top 3 producing countries representing appx 70% of global market
- The main producers in Canada are Nutrien and Mosaic, Belaruskali in Belarus, Uralkali in Russia and K+S in Germany

1) Source: IFA

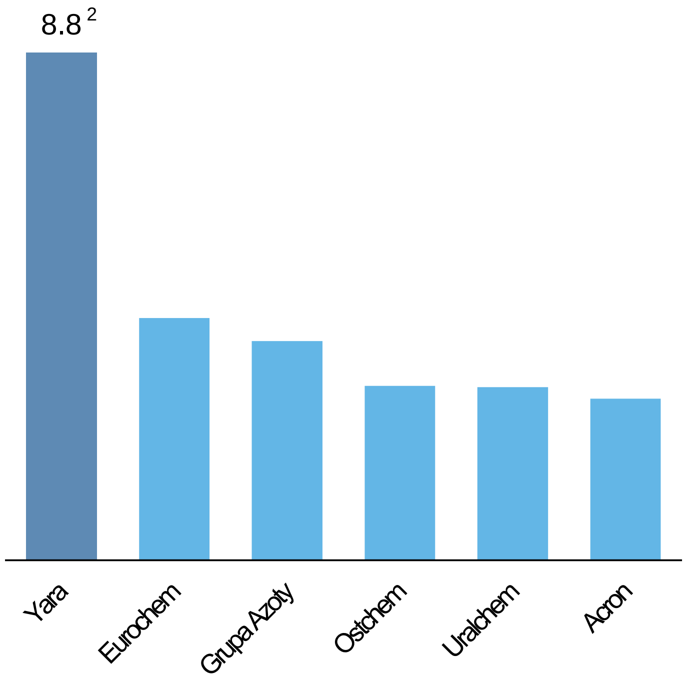
Yara – the leading crop nutrition company

2023 production capacity, excl. Chinese producers[1] (mill. tonnes)

Global no. 2 in ammonia

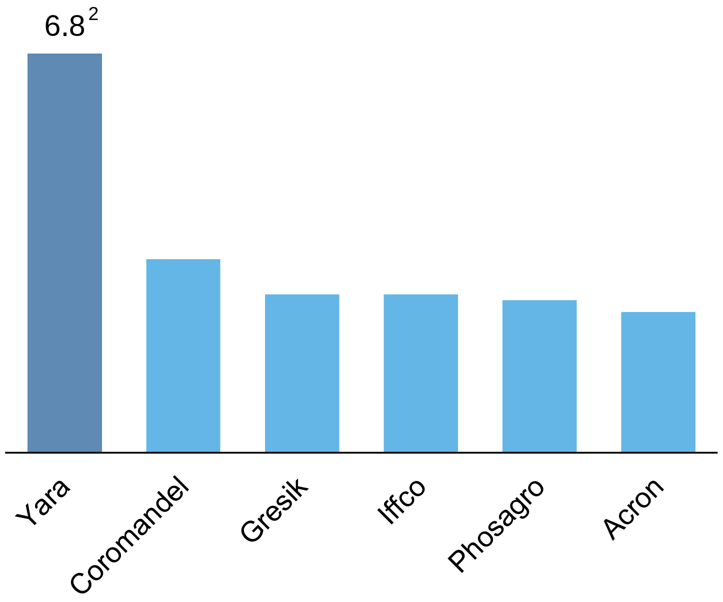


Global no. 1 in nitrates



* Incl. TAN and CN

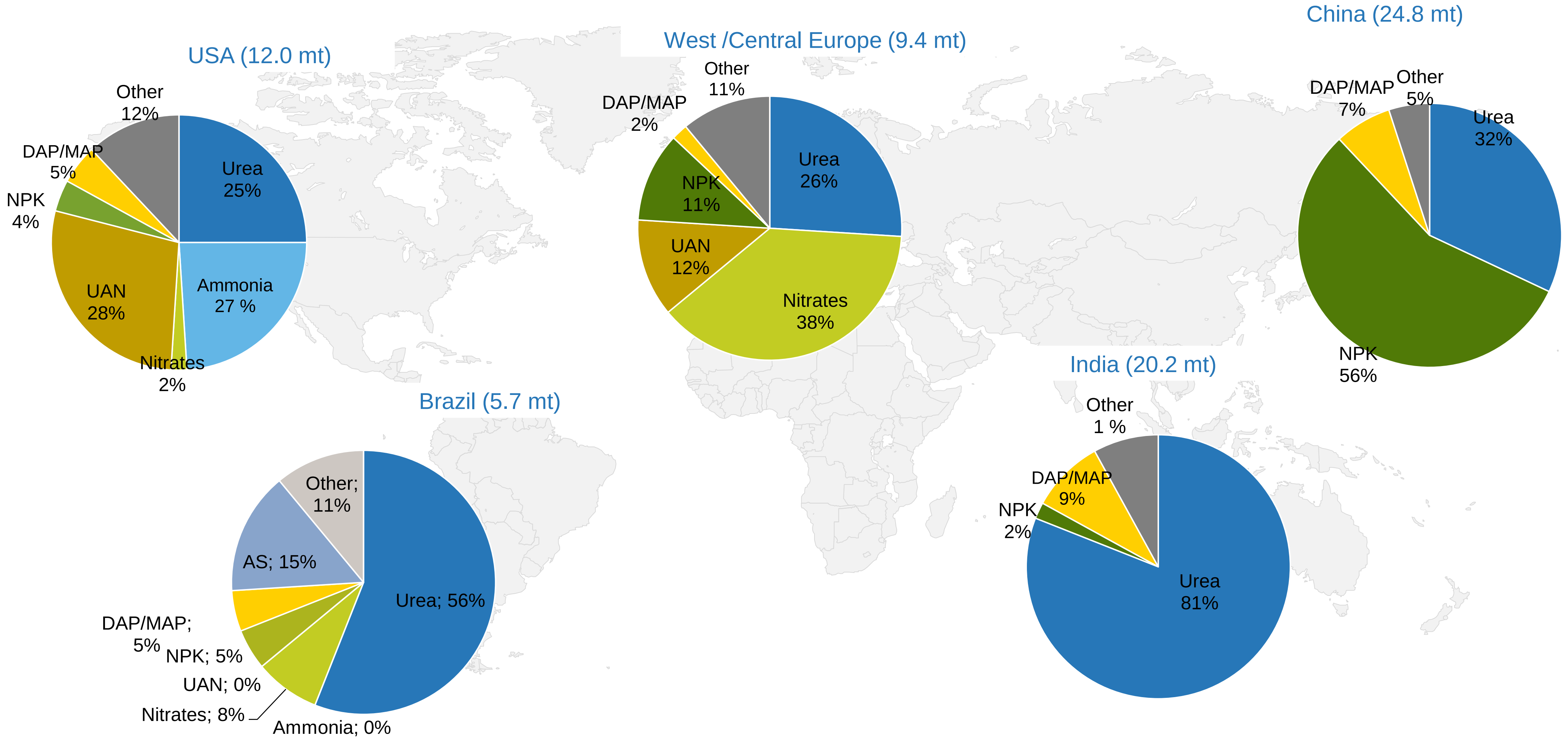
Global no. 1 in NPK



* Compound NPK, excl. blends

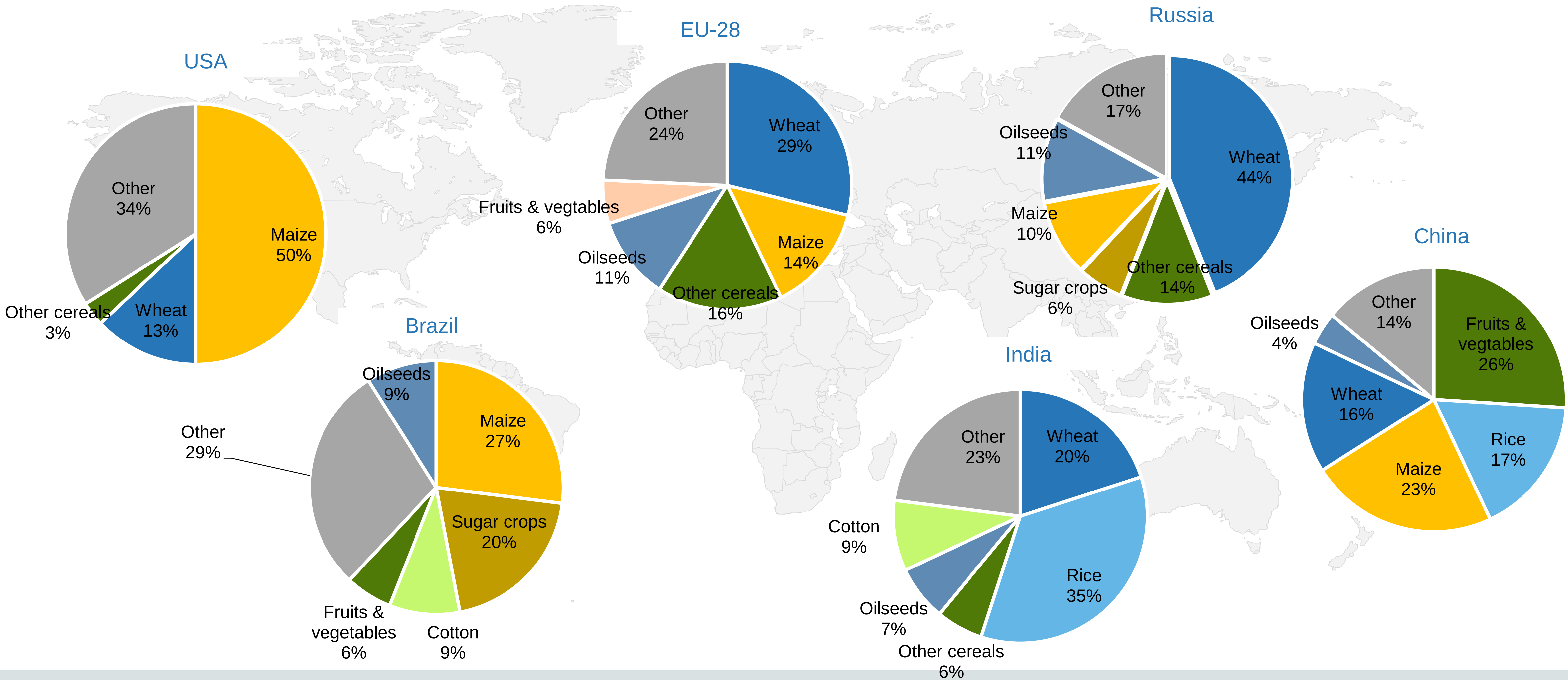
Source: Yara estimates, company info
1) Incl. companies' shares of JVs
2) Yara capacity as of February 2025

Nitrogen fertilizer application by region and product



Source: IFA 2024, data for 2022

Nitrogen fertilizer application by region and crop

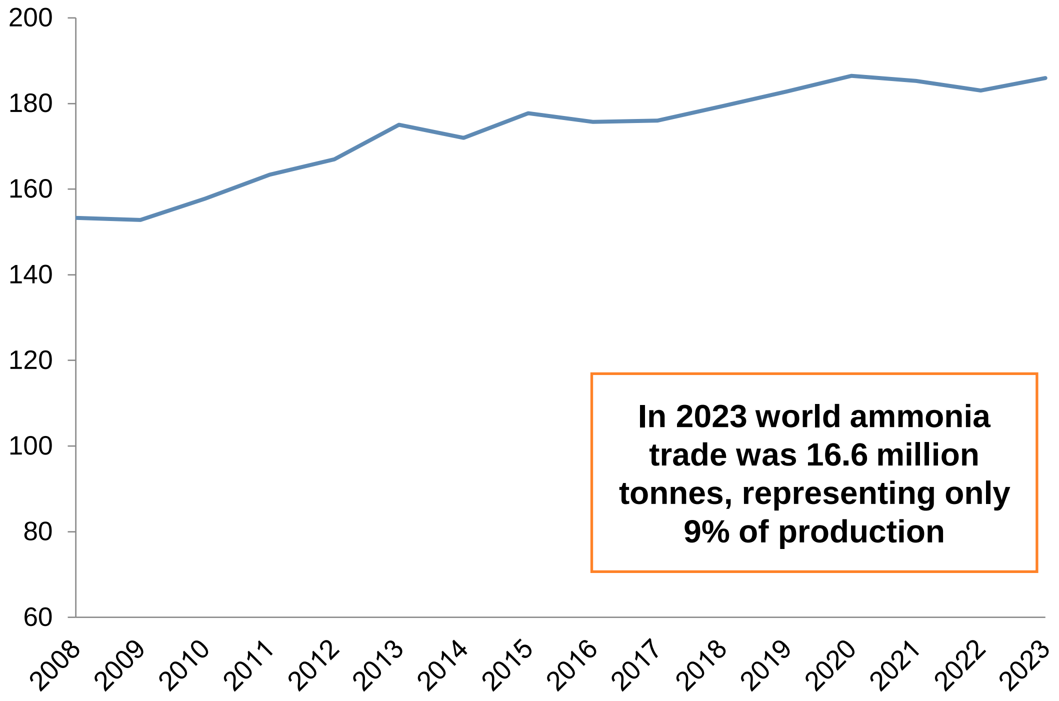


Ammonia

Global ammonia production was 186 million tons in 2023

Million tonnes

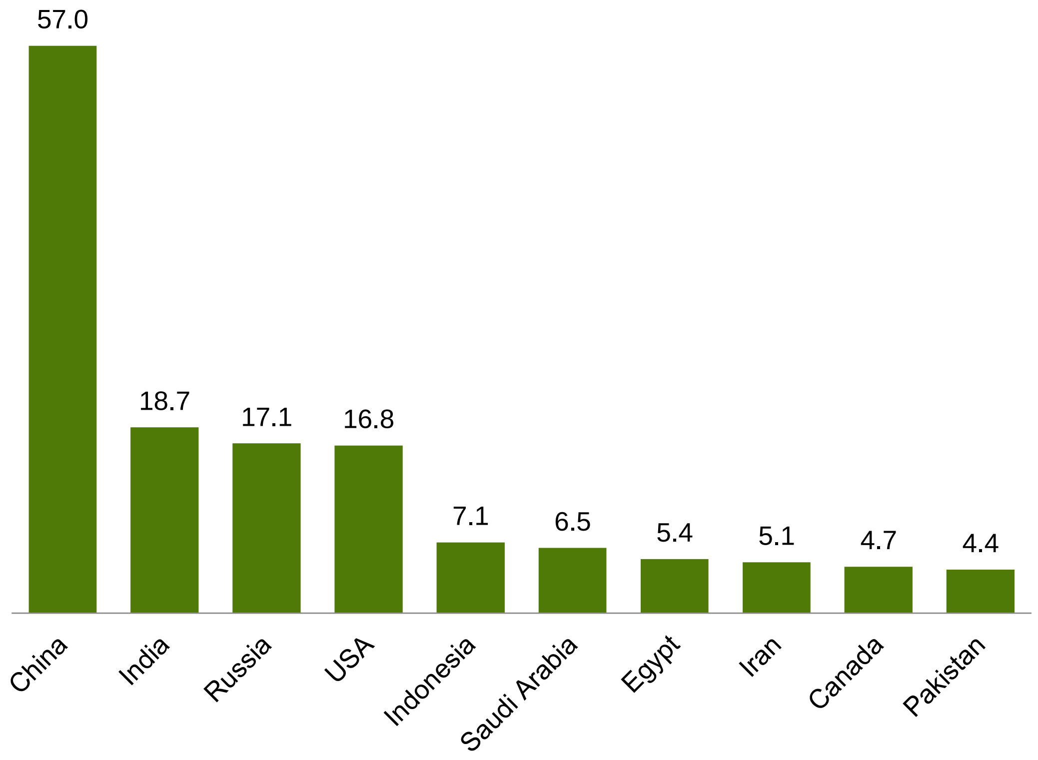
Total production



2013-2023 trend growth rate = 0.8%/year

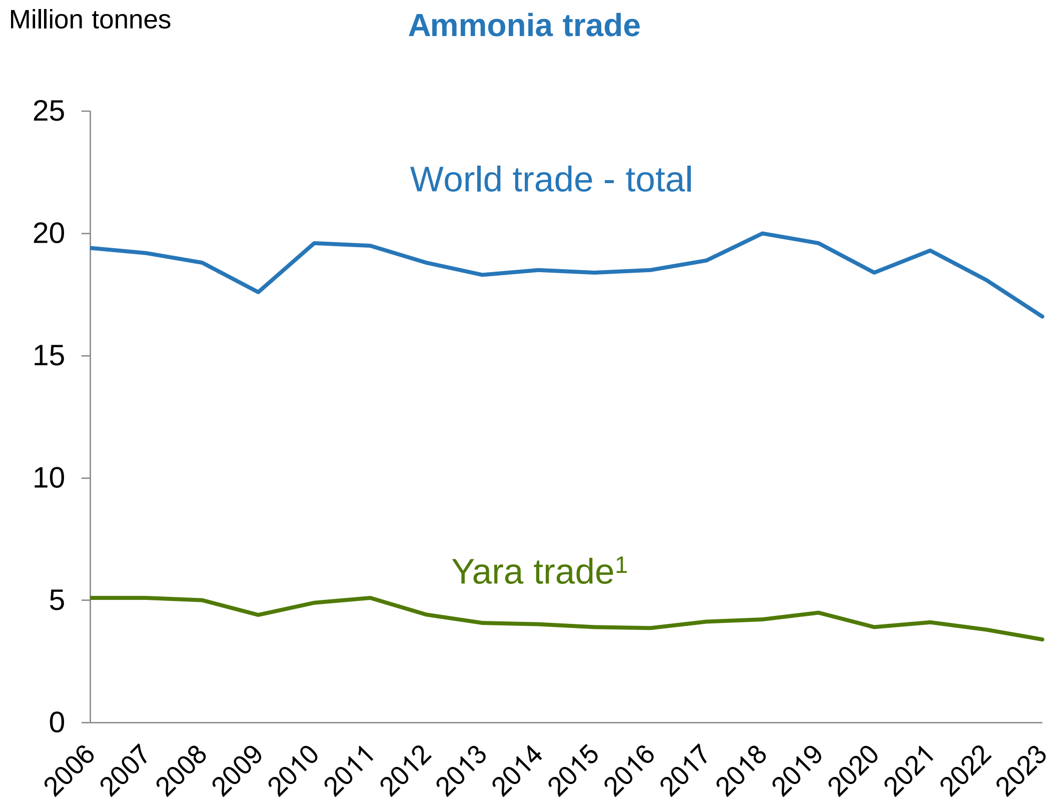
Million tonnes

10 largest producers (2023)

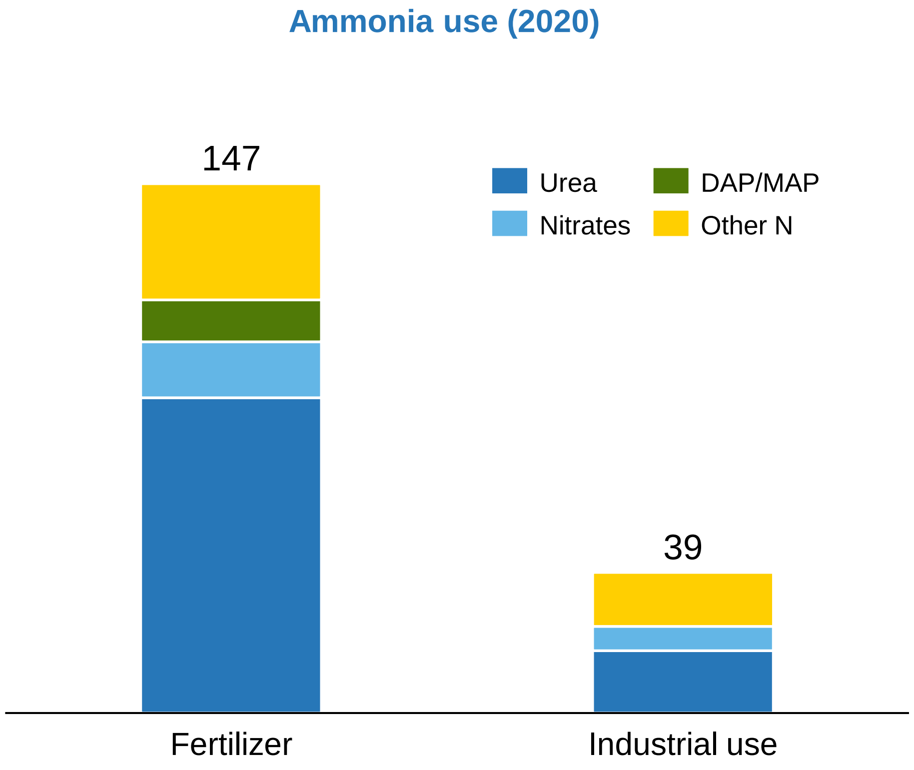


Source: IFA 2023

Most of global ammonia production is upgraded to urea and other finished fertilizer, only 9% of production is traded



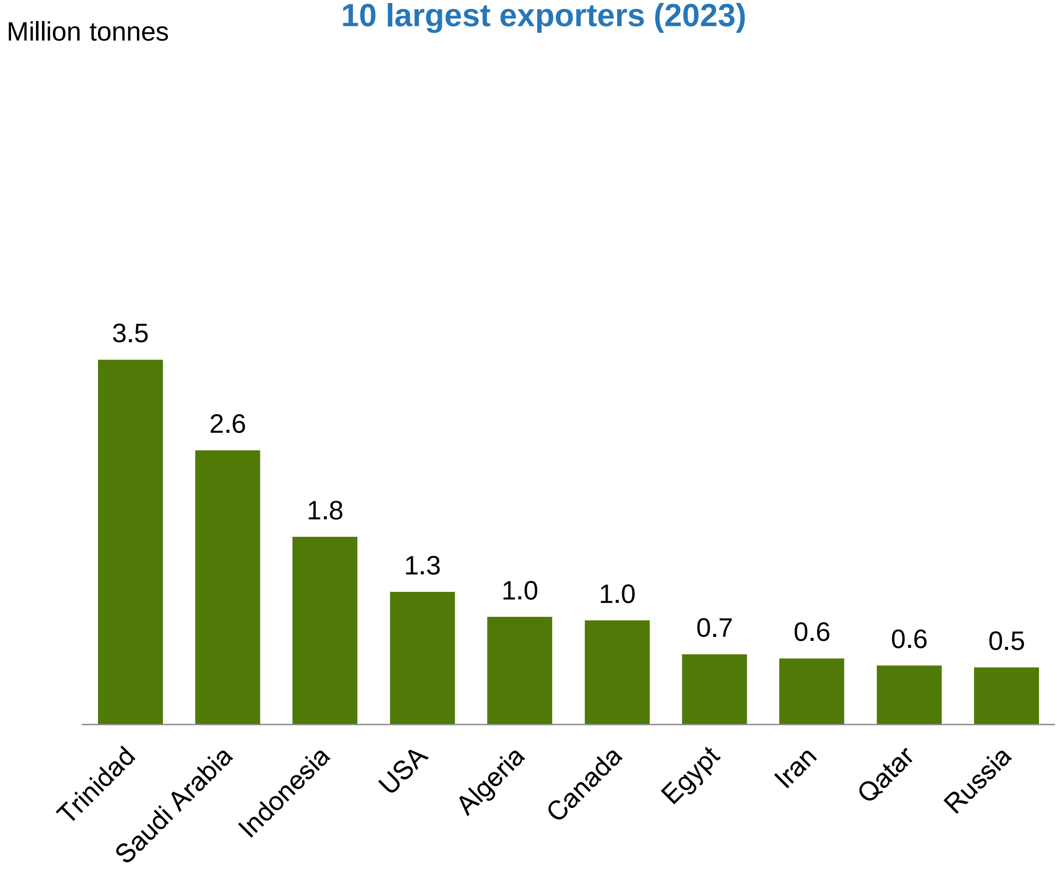
Source: Yara, IFA

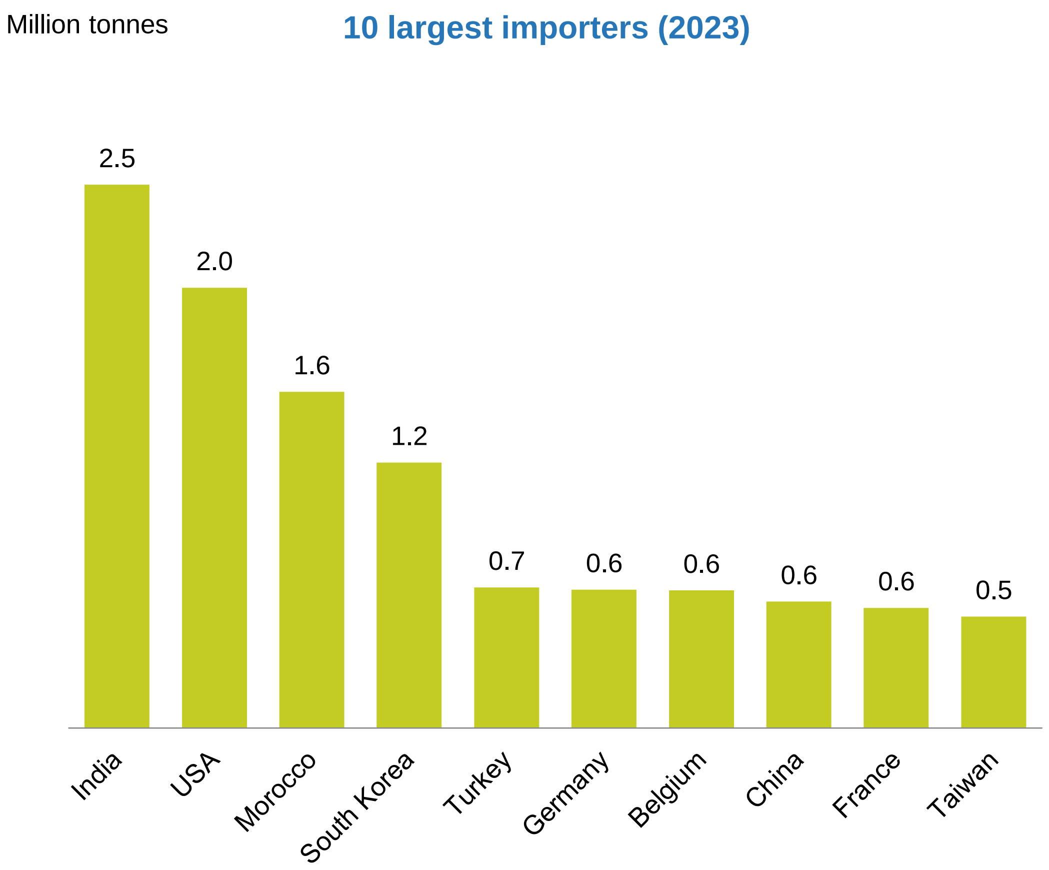


Source: Fertecon

1) From 2019 Yara trade is based on sales volumes in the Yara Clean Ammonia ("YCA") reporting segment, which leads to some minor variations compared with previous years.

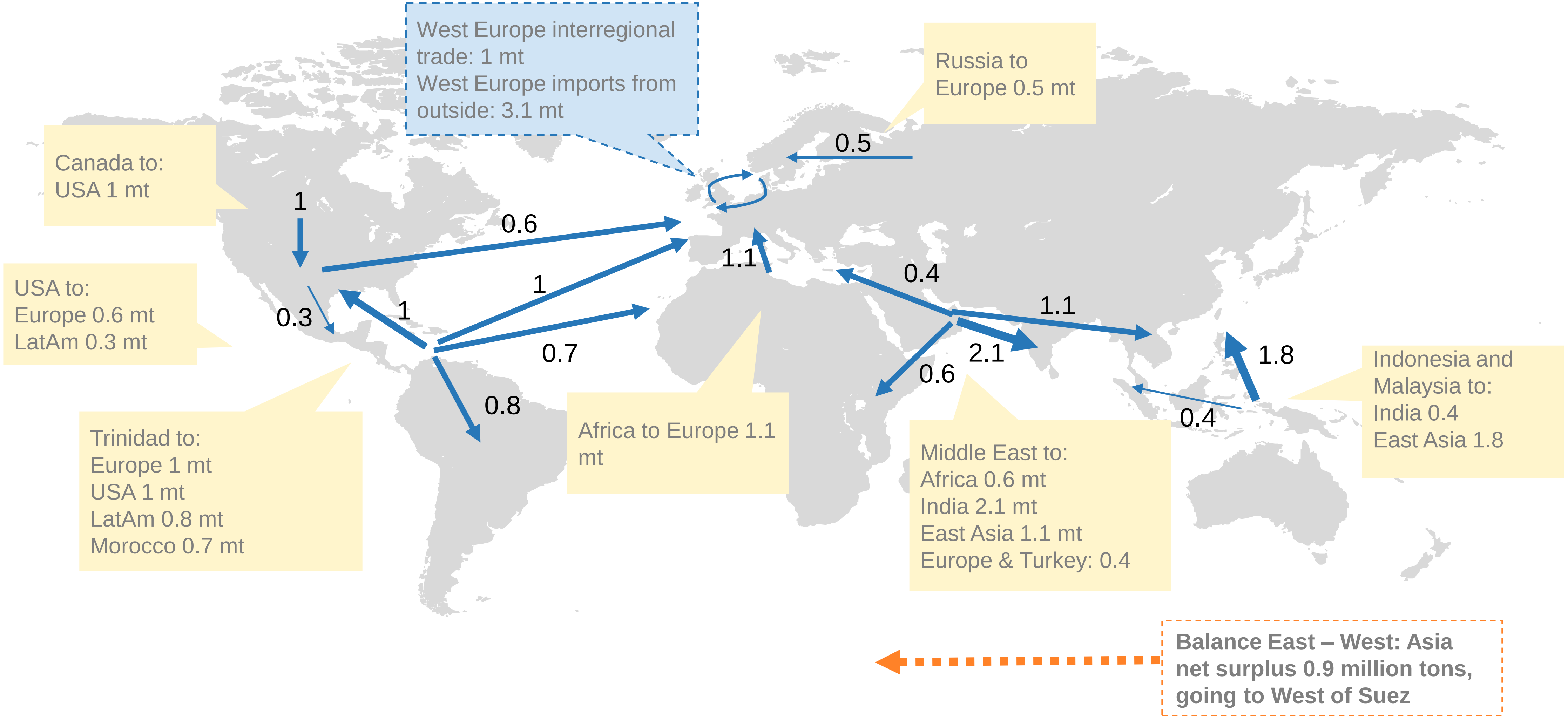
Global ammonia trade





Source: IFA

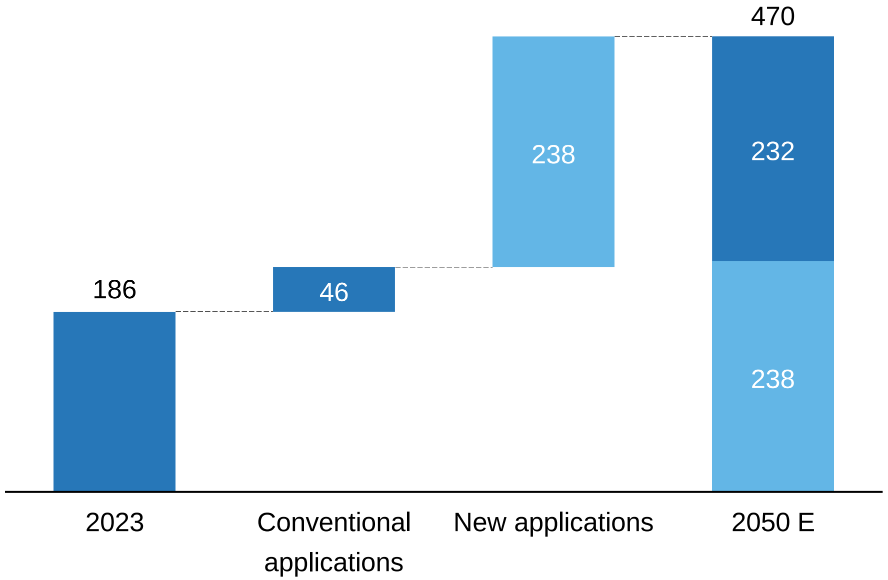
Main ammonia flows 2023



Significant expected ammonia demand driven by a mix of conventional and new applications

Demand for ammonia is expected to grow significantly

Million tonnes



- Global ammonia production was 186 million tons in 2023
- The majority of produced ammonia is further upgraded to different finished products
- World ammonia trade was 16.6 million tons, representing only 9% of production

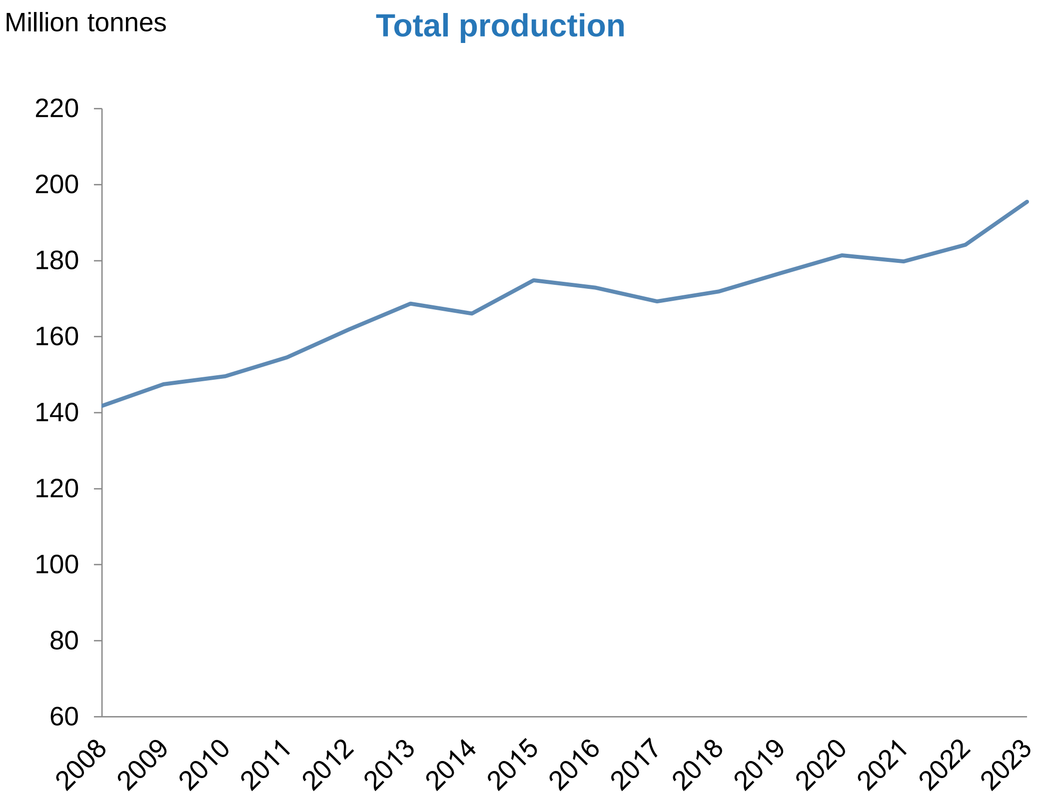
Strong regulatory drivers supporting demand growth

	Main customers	Customers needs	Key drivers
Global Shipping Fuel	• Bulk and container	• Decarbonize shipping fuel	• FuelEU Maritime • IMO • Voluntary / end-user
Asian Power generation	• Power Generation companies	• Decarbonize power generation • Replace coal	• Gvmt CfD (Japan) • Gvmt Auction (South Korea) • Voluntary / end-user
European fertilizers	• Fertilizer producers	• Decarbonize • Produce fertilizers with lower carbon footpring	• CBAM • RED III industry target • Voluntary / end-user
European industry and cracking	• Ammonia crackers with refineries as their end customers	• Decarbonize refinery process and the refined products, avoid penalties • Potential heat and power	• RED III transport target • CBAM • Industry target (steel) • Voluntary / end-user

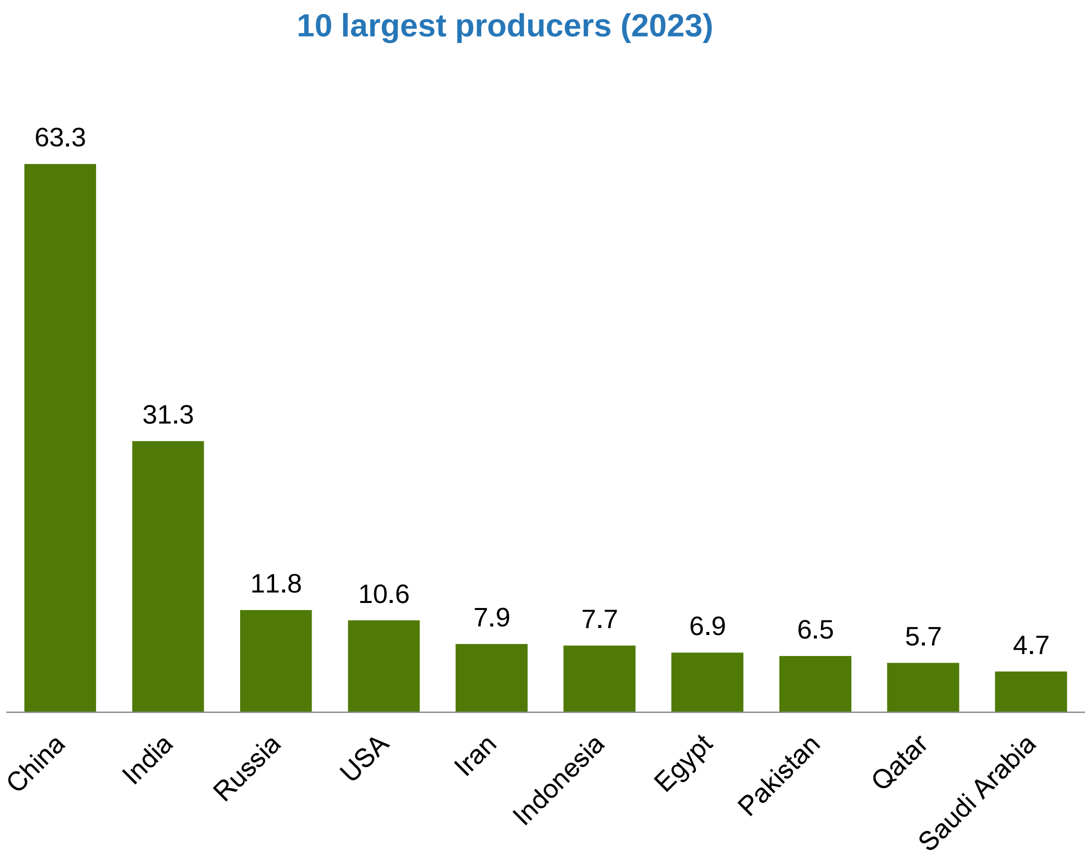
1) Source: Arkwright market study 2021; Extracts from IFASTAT, International Fertilizer Association. From YCA CMD

Urea

Global urea production

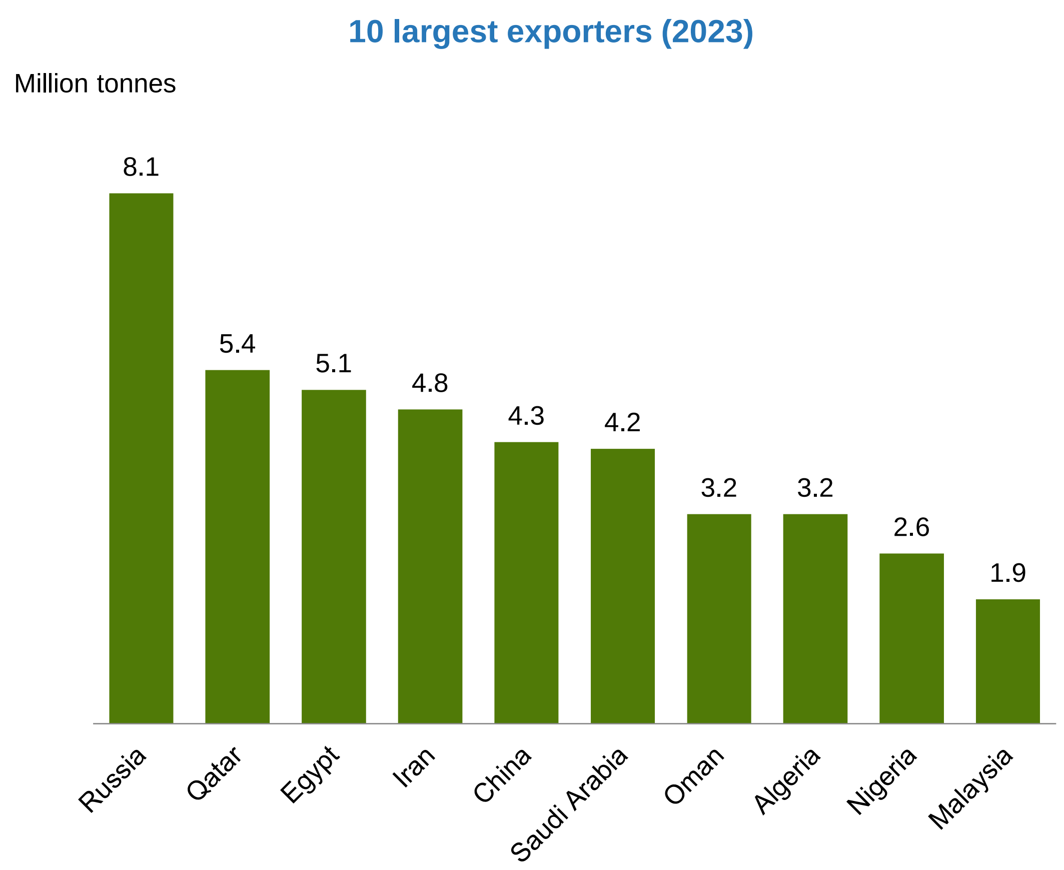


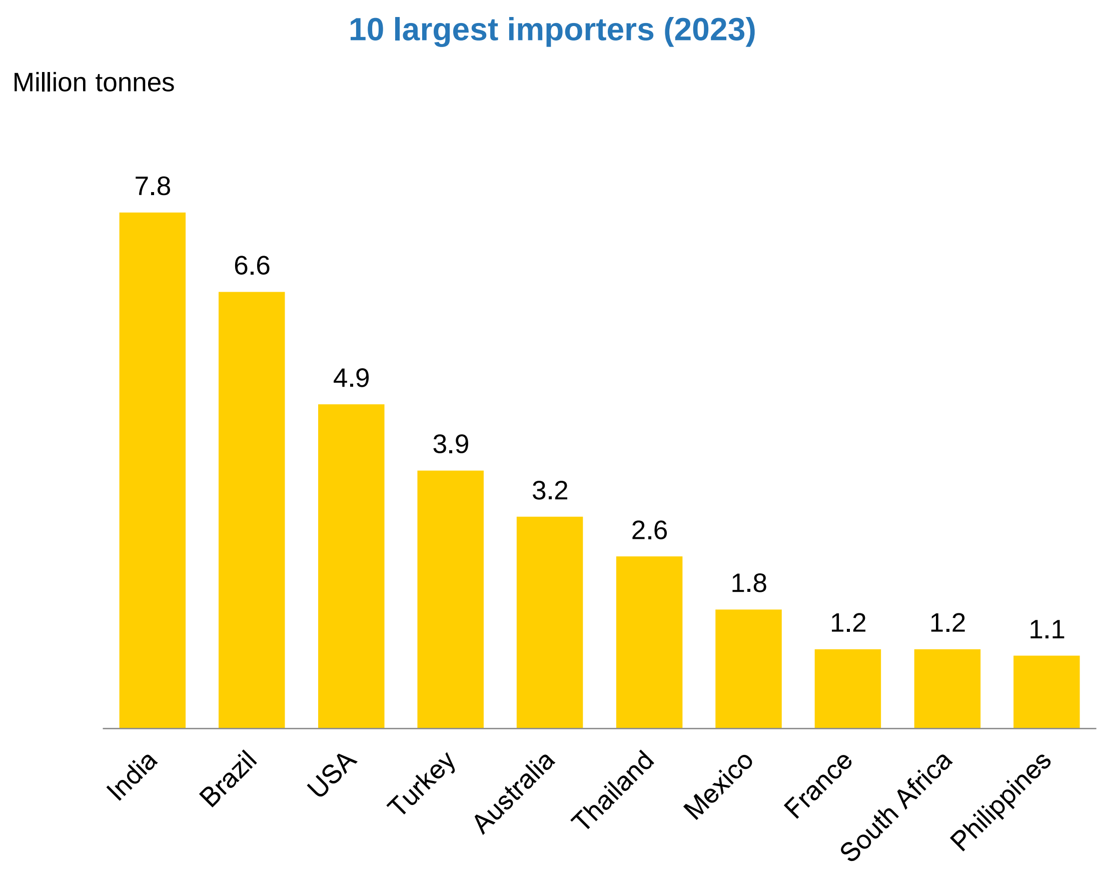
2013-2023 trend growth rate = 1.3% p.a.



Source: IFA 2023

Global trade of urea in 2023 was 55.1 million tonnes

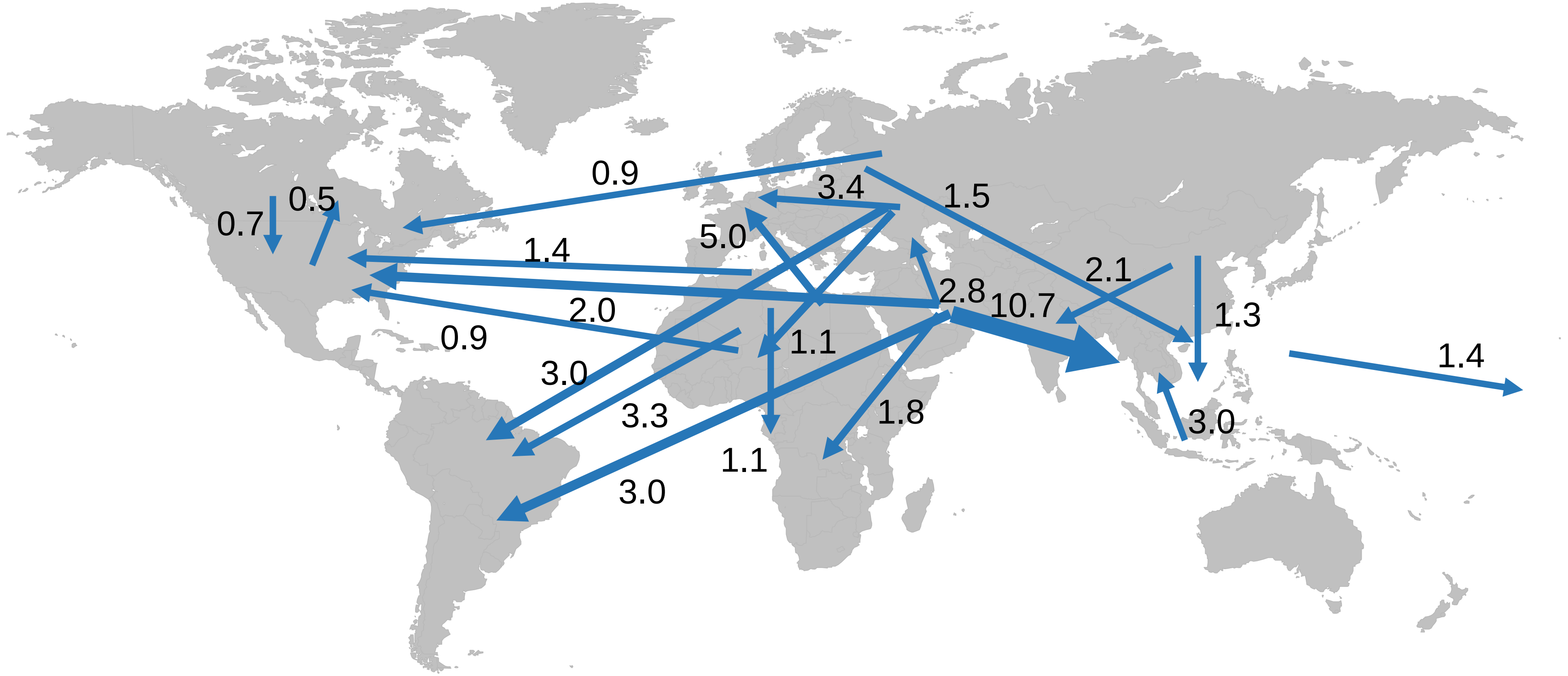




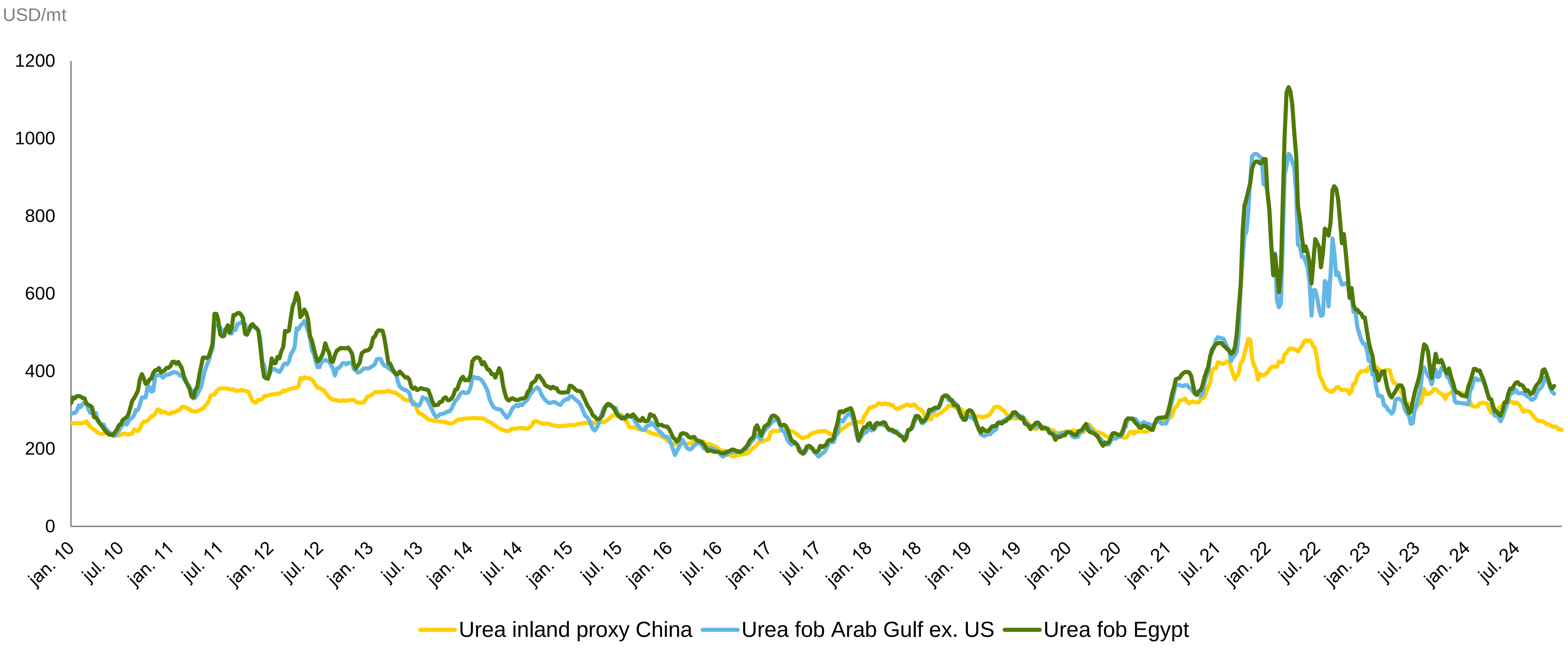
Source: IFA 2023

Main urea flows 2023

Million tonnes



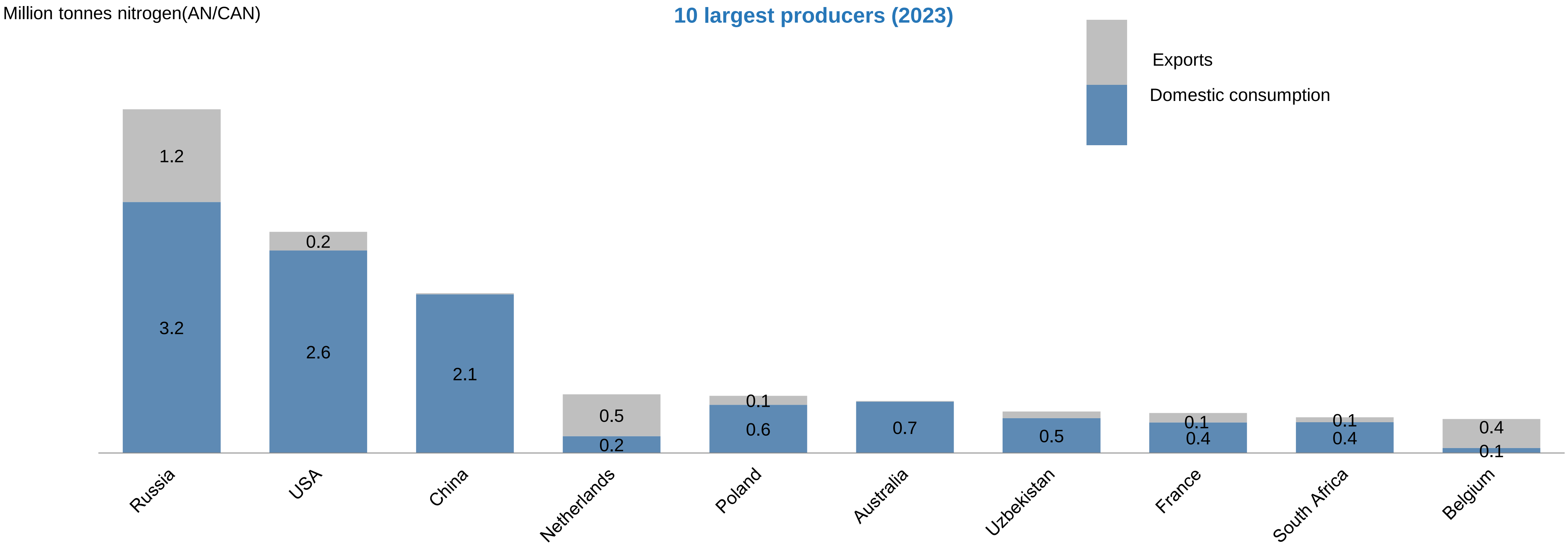
Urea prices remain high, but down from exceptionally high levels in 2022



YARA

Nitrates

Global nitrate production was 19.1 million tons of nitrogen in 2023



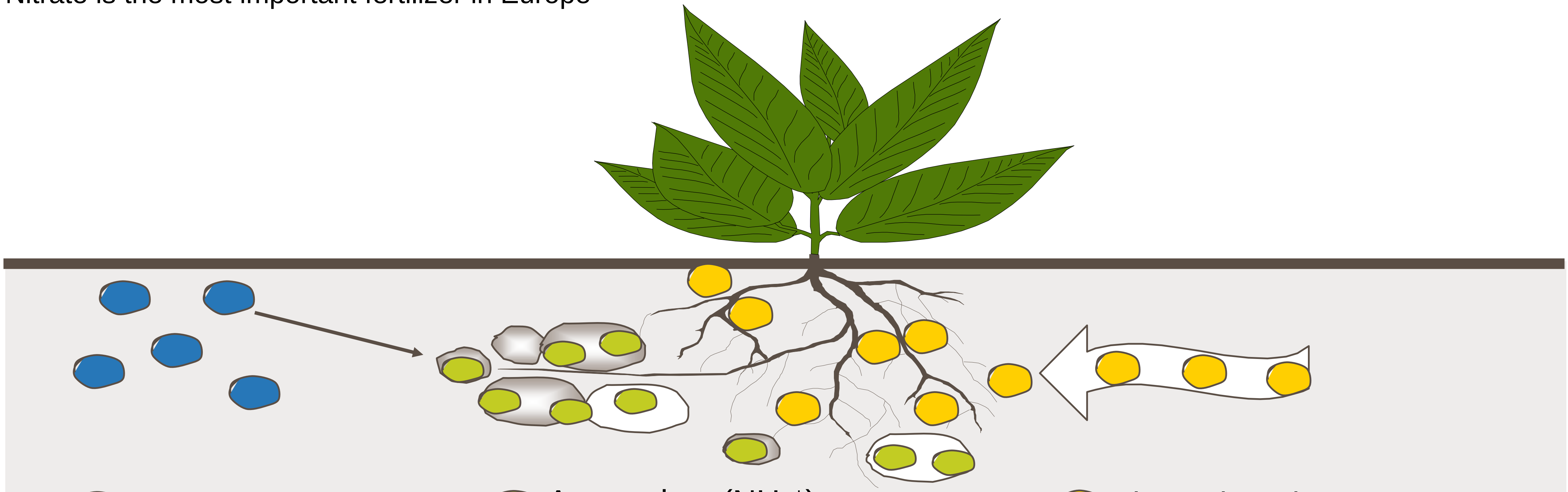
Source: IFA, AN/CAN including nitrate part of UAN, as are industrial grades

Nitrates are products with a nitrate content of 50 % or more

N fertilizer	N content	Nitrate (% of total N)	Other nutrients
CAN (calcium ammonium nitrate)	27%	50%	4% MgO
AN (ammonium nitrate)	33.5%	50%	
NPK	various	about 50%	P & K
CN (calcium nitrate)	15.5%	93%	19% Ca
Urea	46%	0%	
UAN (liquid urea ammonium nitrate)	28%	25%	
ASN (ammonium sulfate nitrate)	26%	25%	13% S
AS (ammonium sulfate)	21%	0%	24% S

Nitrates vs. urea

Nitrate is the most important fertilizer in Europe



Urea (CON_2H_4)

Urea-N needs to be converted into ammonium-N before it is plant available.

Ammonium (NH_4^+)

Ammonium-N is fixed onto clay minerals in the soil and therefore immobile. The plant roots have to grow actively towards the nutrient.

Nitrate (NO_3^-)

Nitrate-N is always dissolved in the soil water and is transported passively together with the water into the plant root. Thus, nitrate is rapidly effective.

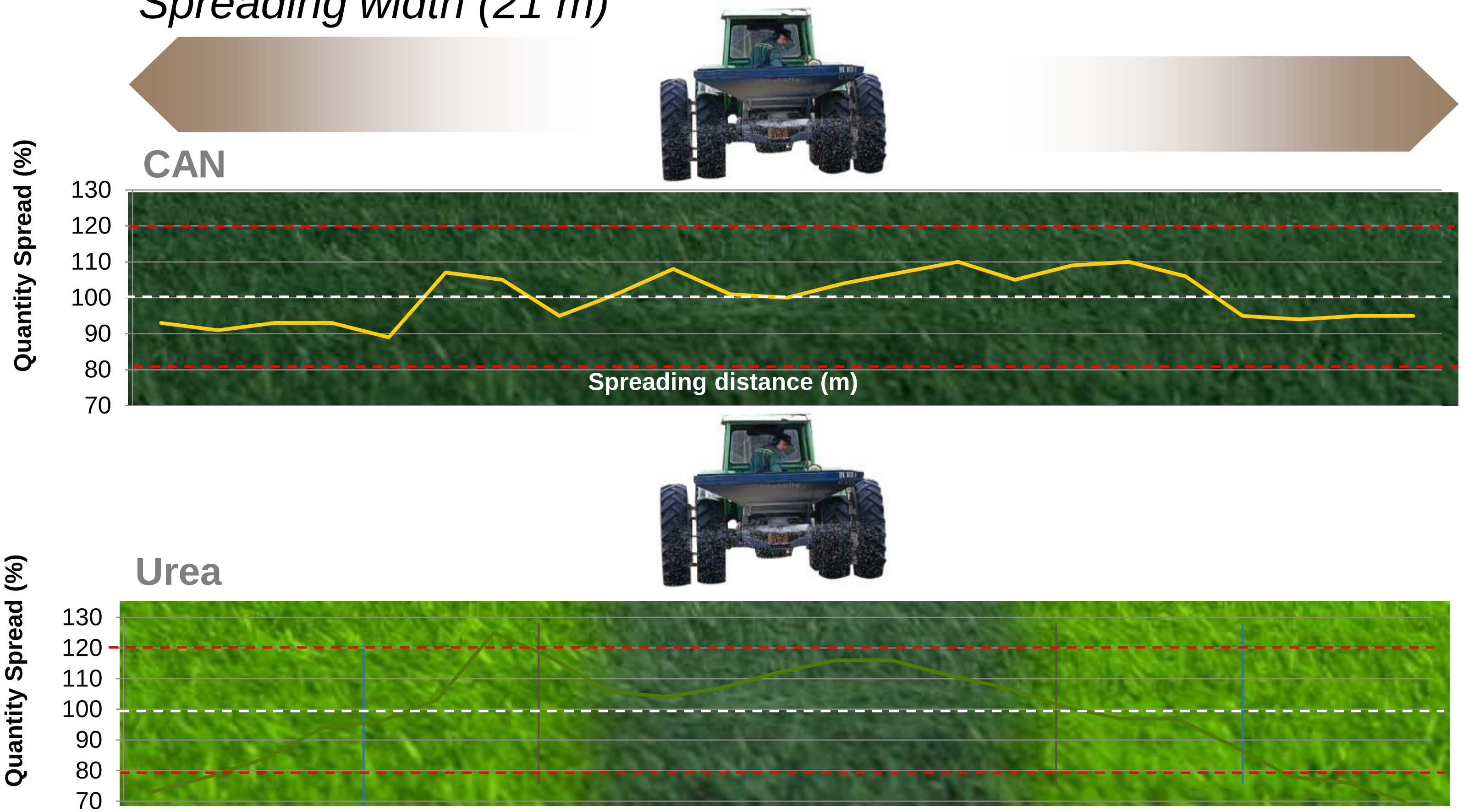
Better spreading with nitrates

The poor spreading patterns with Urea cause striped fields and considerable yield loss

Spreading width (21 m)

Good uniformity with CAN:

Lower uniformity with Urea:



Due to better spreading quality of CAN a higher yield equivalent is achieved in field trials

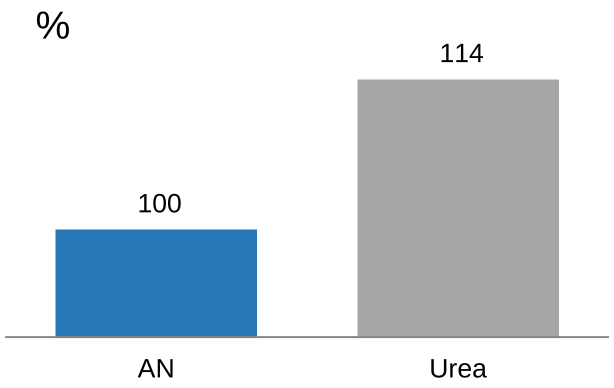
Source: Yara research, trial studies in Germany (n=112, 2007-2017) on different soil types

YARA

Nitrate outperformance compared with commodity nitrogen products

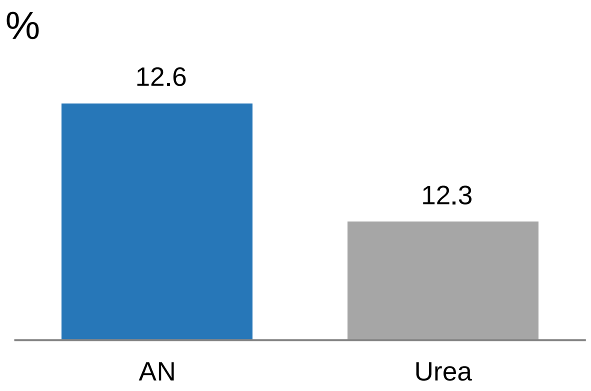
Trial results for arable crops (cereals, UK)

Extra N required for same yield



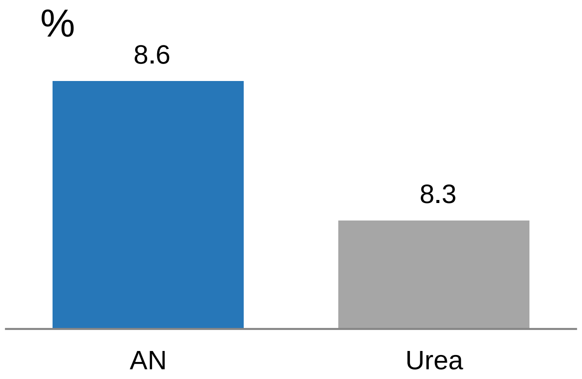
To maintain the same yield, significantly more nitrogen was needed from urea than from ammonium nitrate

Protein content at identical N rate



Protein content was significantly lower on fields fertilized with urea than with ammonium nitrate

Yield at identical N rate



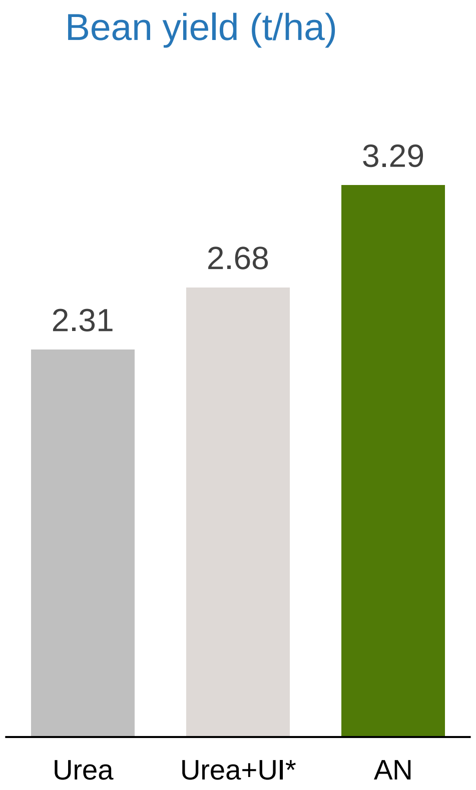
Yield was also significantly lower with urea than with ammonium nitrate

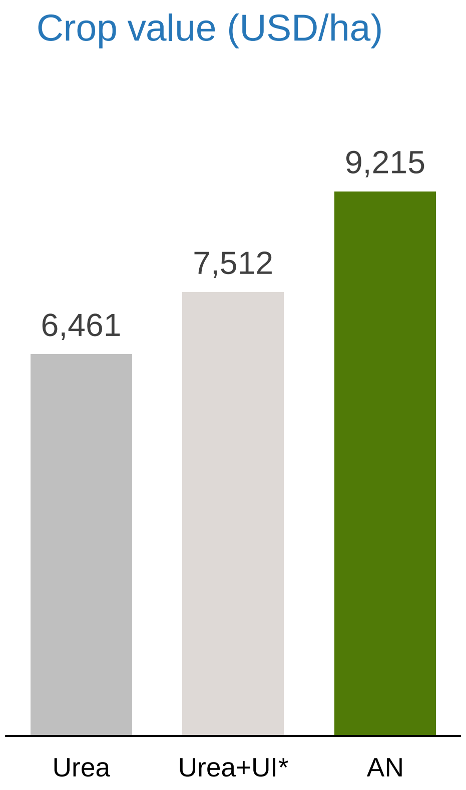
Source: DEFRA

Yield advantages with nitrates in tropical climate

Trial study in Brazil, higher coffee bean yield with nitrates as compared to urea

- Research shows that the benefits of nitrates are even more pronounced in the tropics than in colder climates
- Nitrates provide direct and efficient uptake of N

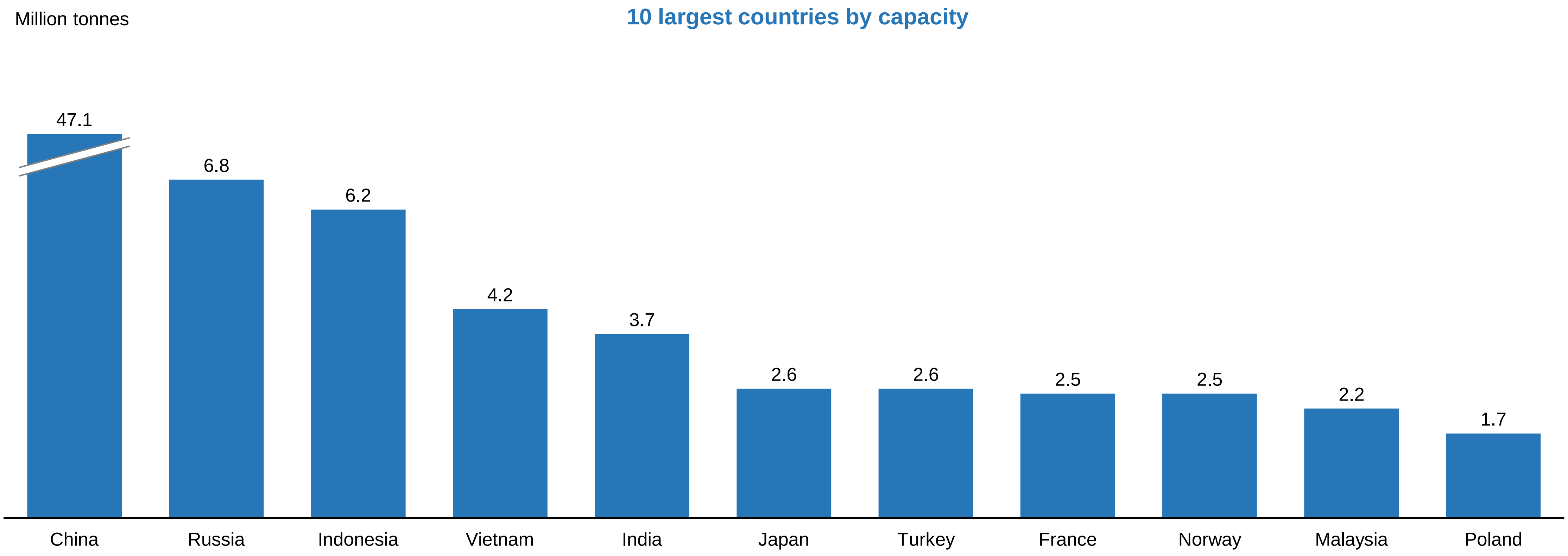




* UI = Urease Inhibitor
Source: trial 2018/2019 - Lavras University, Minas Gerais, Brazil & Yara Research

NPKs

Global compound NPK capacities



Source: IFA 2016, data for 2013/2014

Compound NPKs contain all nutrients in one particle

Compound NPKs

All nutrients in each and every particle

Even spreading of all nutrients

NPK bulk blends

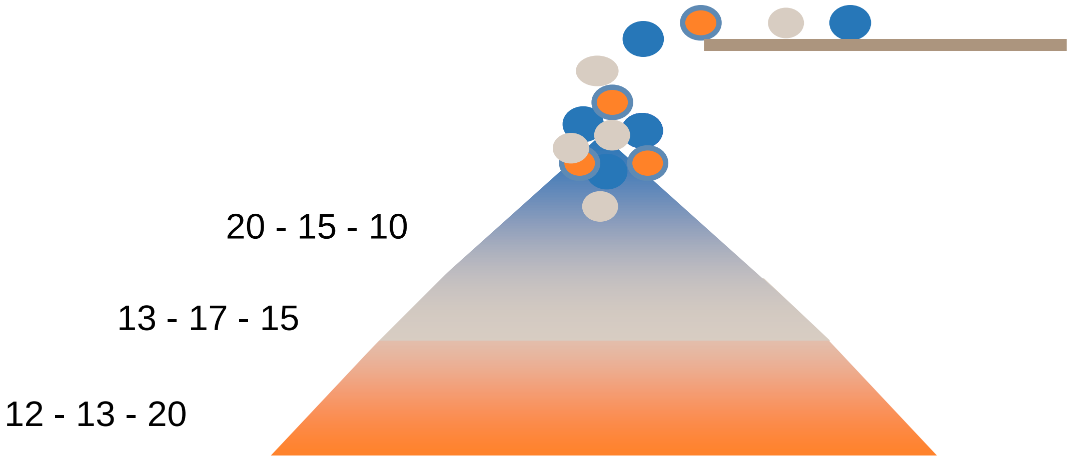
A mix of products with different spreading properties

Risk of segregation and uneven spreading

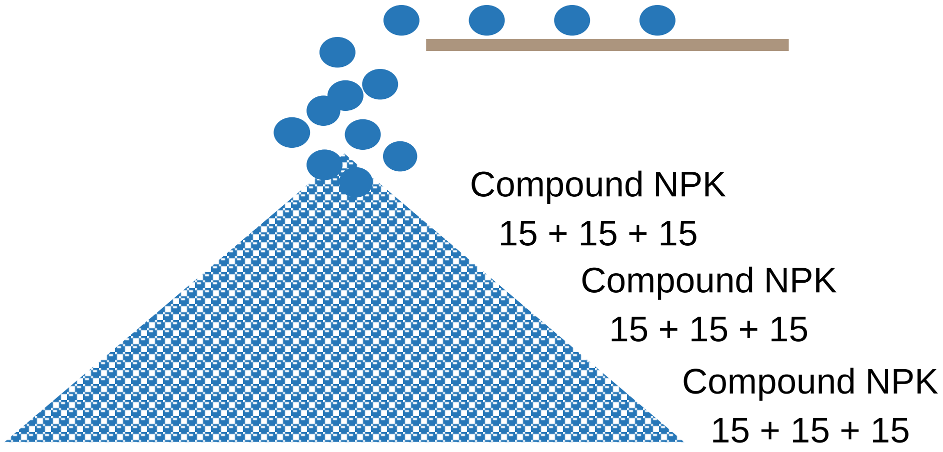
Bulk blend segregation during loading and unloading

Urea + DAP + MOP
15-15-15

Compound NPK
15-15-15



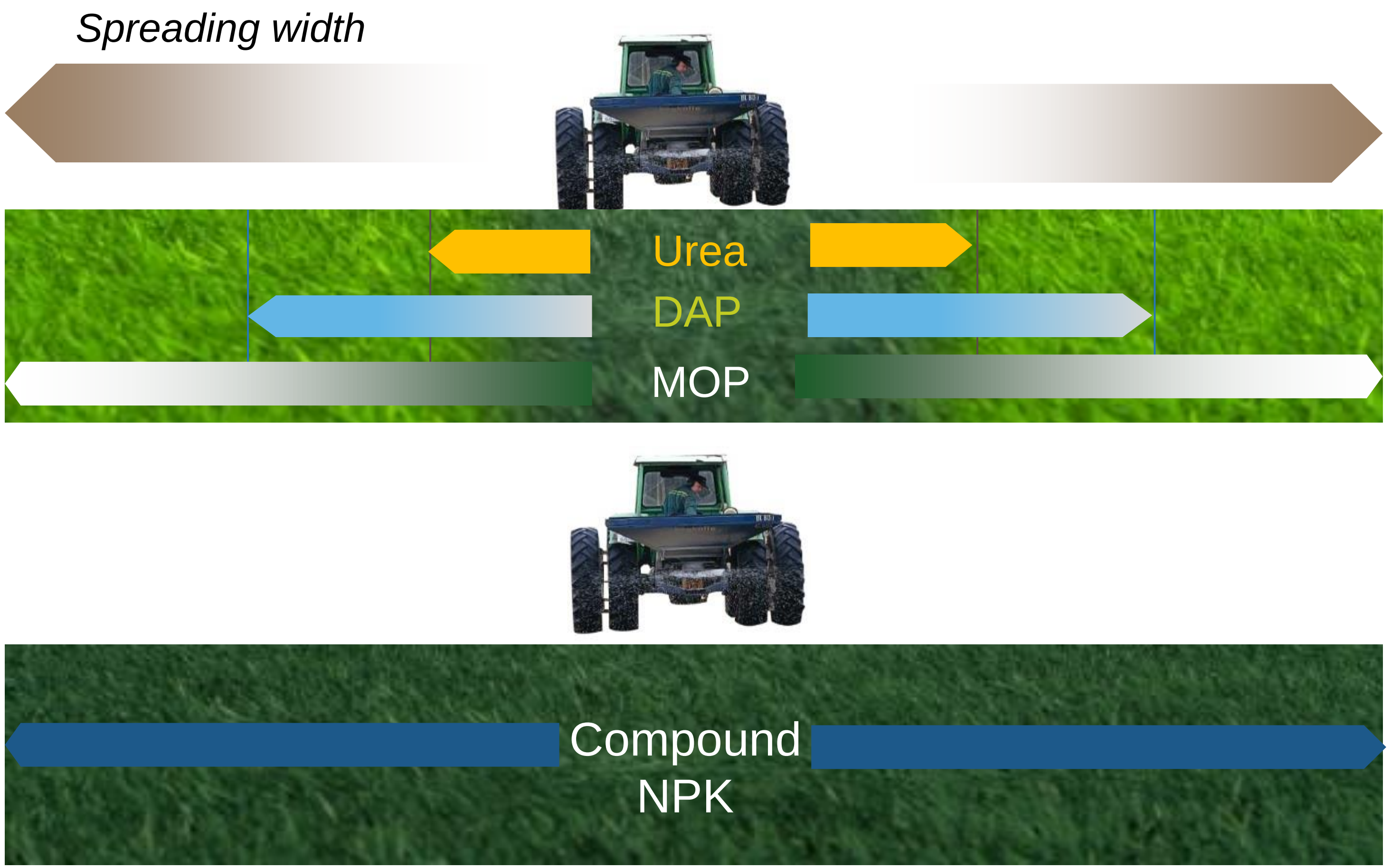
N – P_2O_5 – K_2O analysis
in a pile of poor quality blend



N – P_2O_5 – K_2O analysis
in a pile of compound NPK 15-15-15

→ Segregation due to differences in specific weight and granule size

Better spreading with compound NPKs



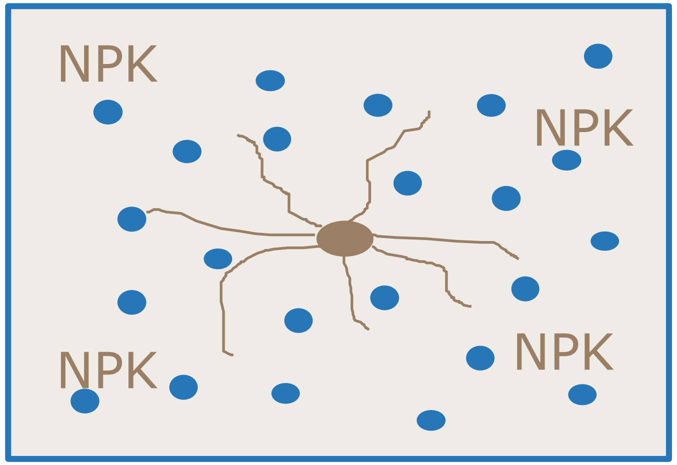
The spreading width of light particles like Urea is less than those of heavier particles like DAP and MOP

Poor spreading patterns cause striped fields and significant yield losses

Compound NPKs give excellent spatial distribution of nutrients and higher crop yields as a result

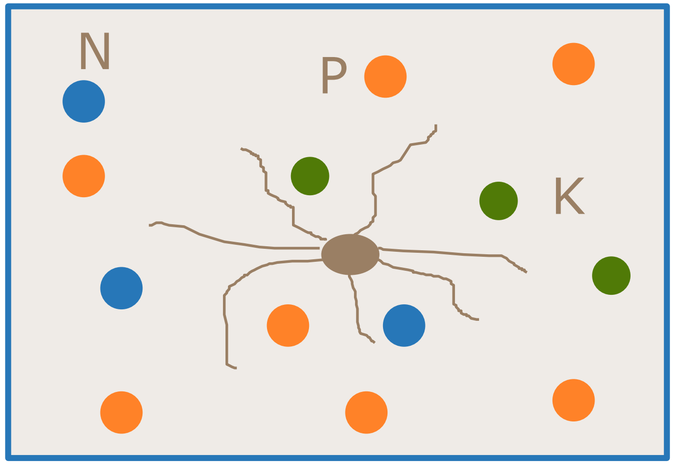
Compound NPKs
16+16+16

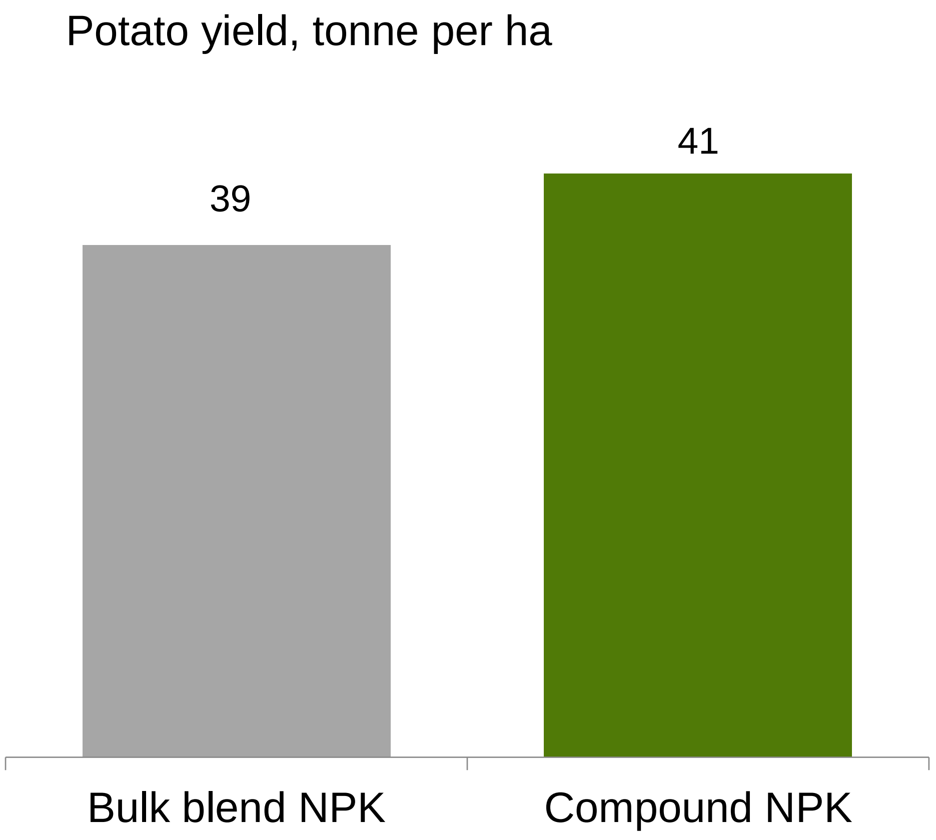
more particles and
better distribution



Bulk blend
Urea-DAP-MOP

fewer particles,
longer distance to roots



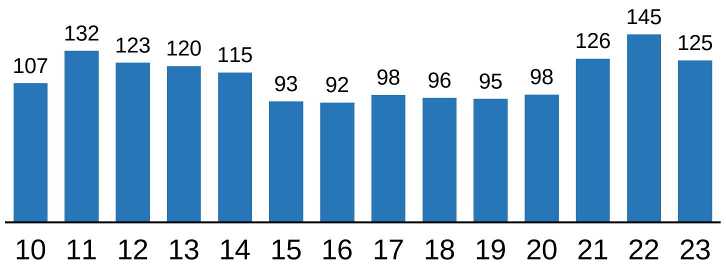


Source: Yara field trials, Hanninghof research center (9 harvest dates)

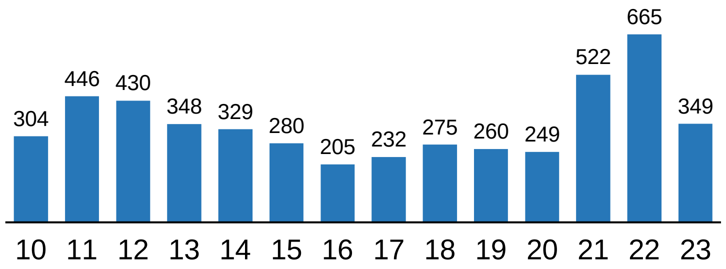
Industry value drivers

Fertilizer prices are cyclical

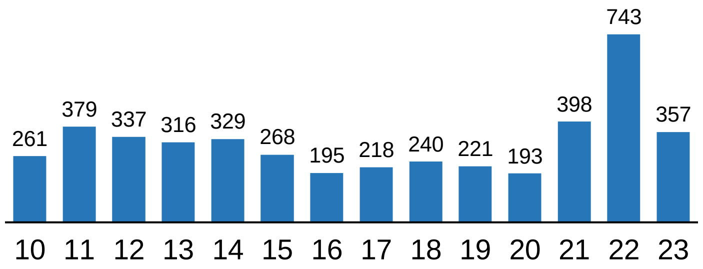
FAO Food price index (2014-2016=100)



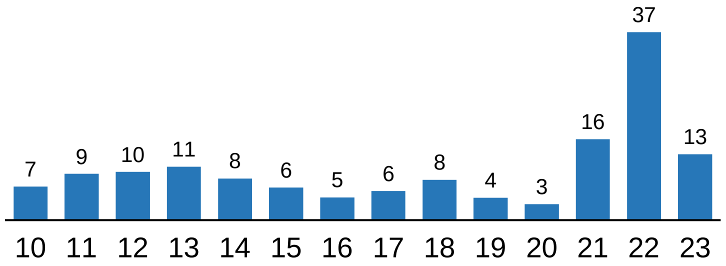
Urea granular FOB Arab Gulf ex. US (USD/t)



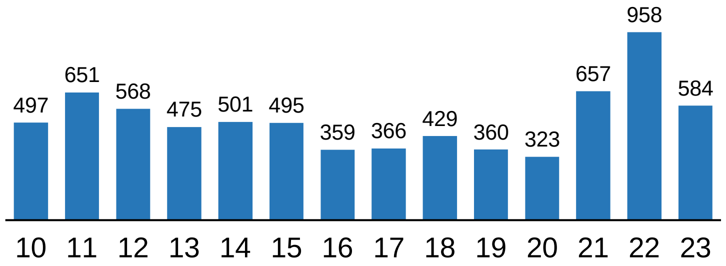
CAN cif Germany (USD/t)



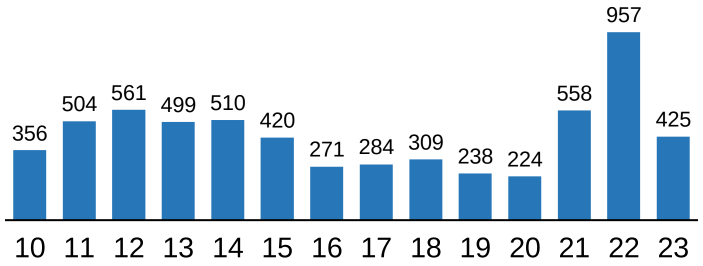
TTF (USD/MMBtu)



DAP FOB Morocco (USD/t)



Ammonia fob Arab Gulf (USD/t)



Source: Fertilizer market publications, World Bank

Nitrogen fertilizer value drivers

	Drivers:	Effect on:
Revenue drivers:	Global urea demand vs. supply	Urea price
	"Marginal producer" production costs	Supply-driven urea price
	Crop prices/grain inventories	Urea demand / demand-driven urea price
	New urea capacity vs. closures	Urea supply
	Urea price	Most other nitrogen fertilizer prices
	Cash crop prices	Value-added fertilizer premiums
Cost drivers:	Gas demand vs. supply	Gas costs
	Manning and maintenance	Fixed costs
	Productivity and economies of scale	Unit cost
	Carbon cost (depending on region)	Unit cost

Drivers of demand

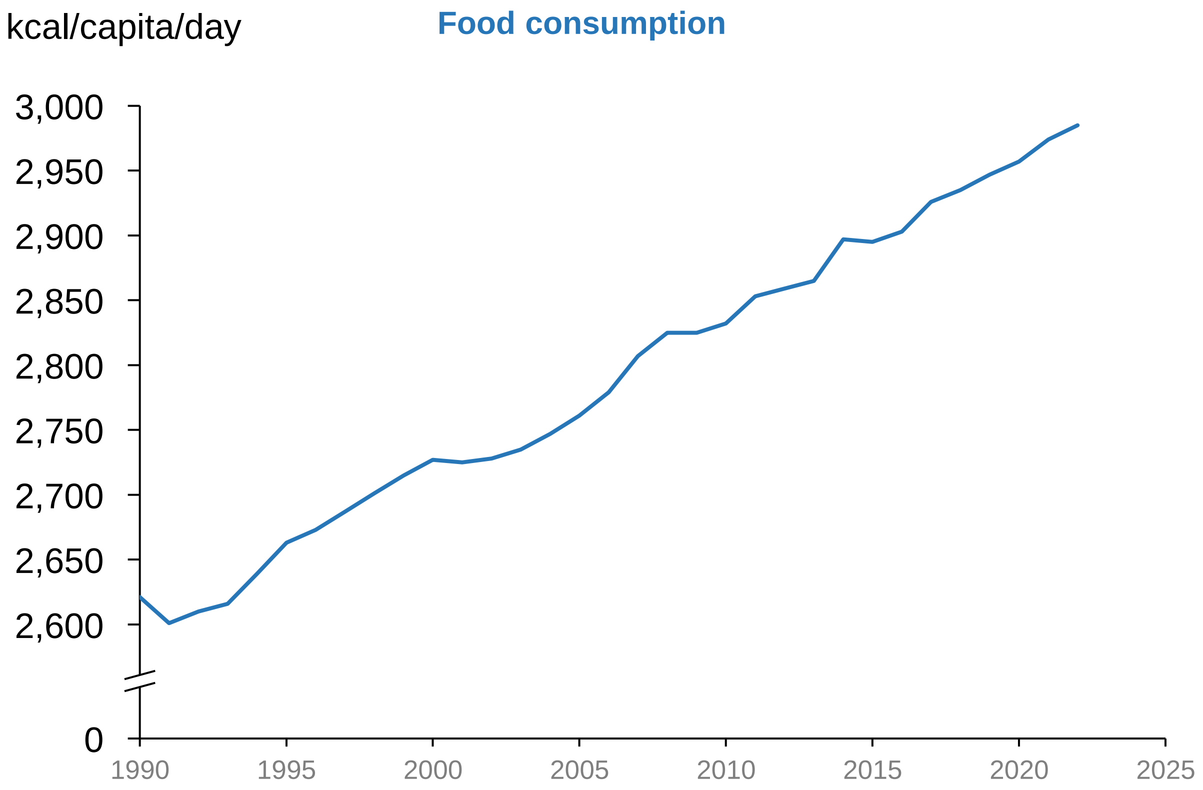
Drivers consumption growth

Fertilizer consumption is mainly driven by food demand

- Population growth
- Economic growth and diet changes
  - More protein-rich diets
  - More fruit and vegetables
  - Reduced hunger
- Nutrient use efficiency in farming
- Waste and loss across the food value chain

Industrial consumption is mainly driven by economic growth

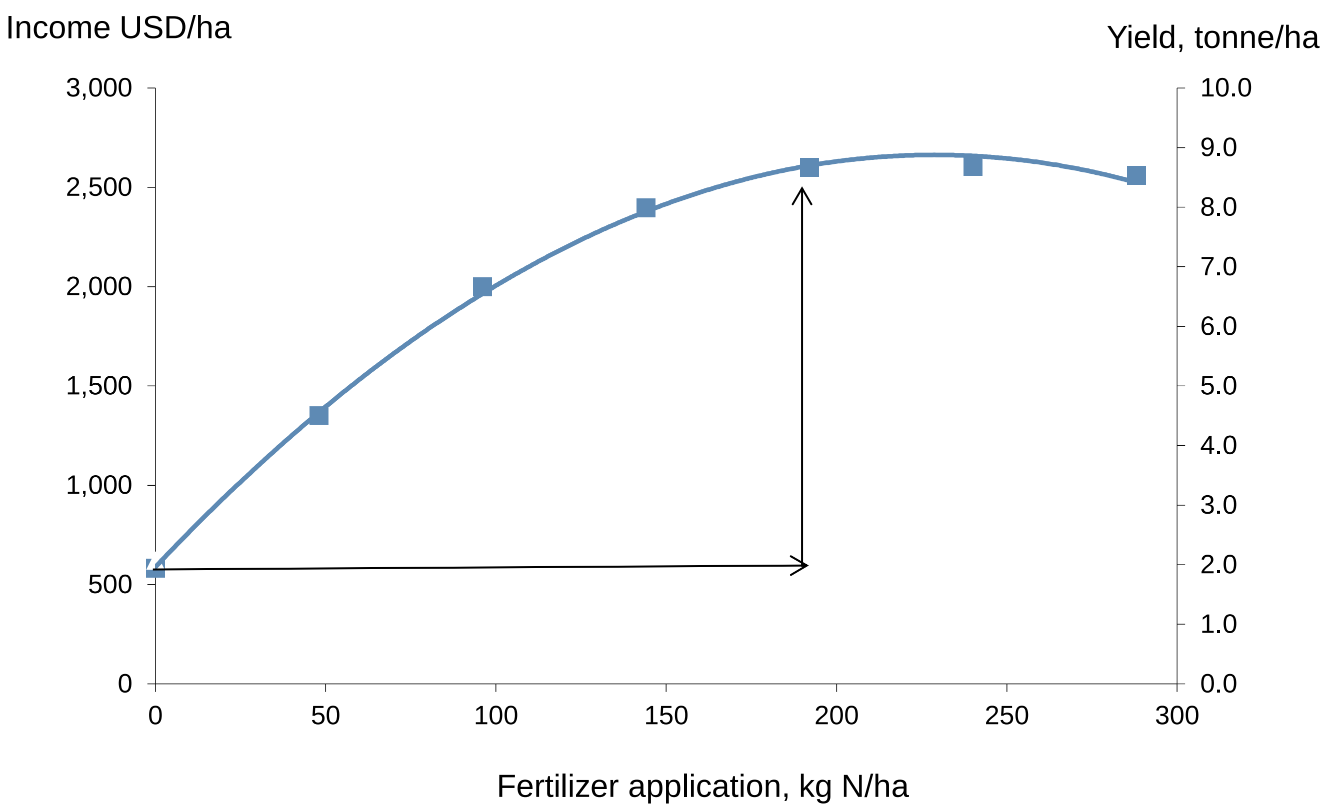
- Economic growth
- Environmental limits (e.g. reduction of NOx emissions)



Source: FAO, food supply kcal/capita/day

Profitability of investment in mineral fertilizers

Yield response (monetary value) to N fertilizer rate



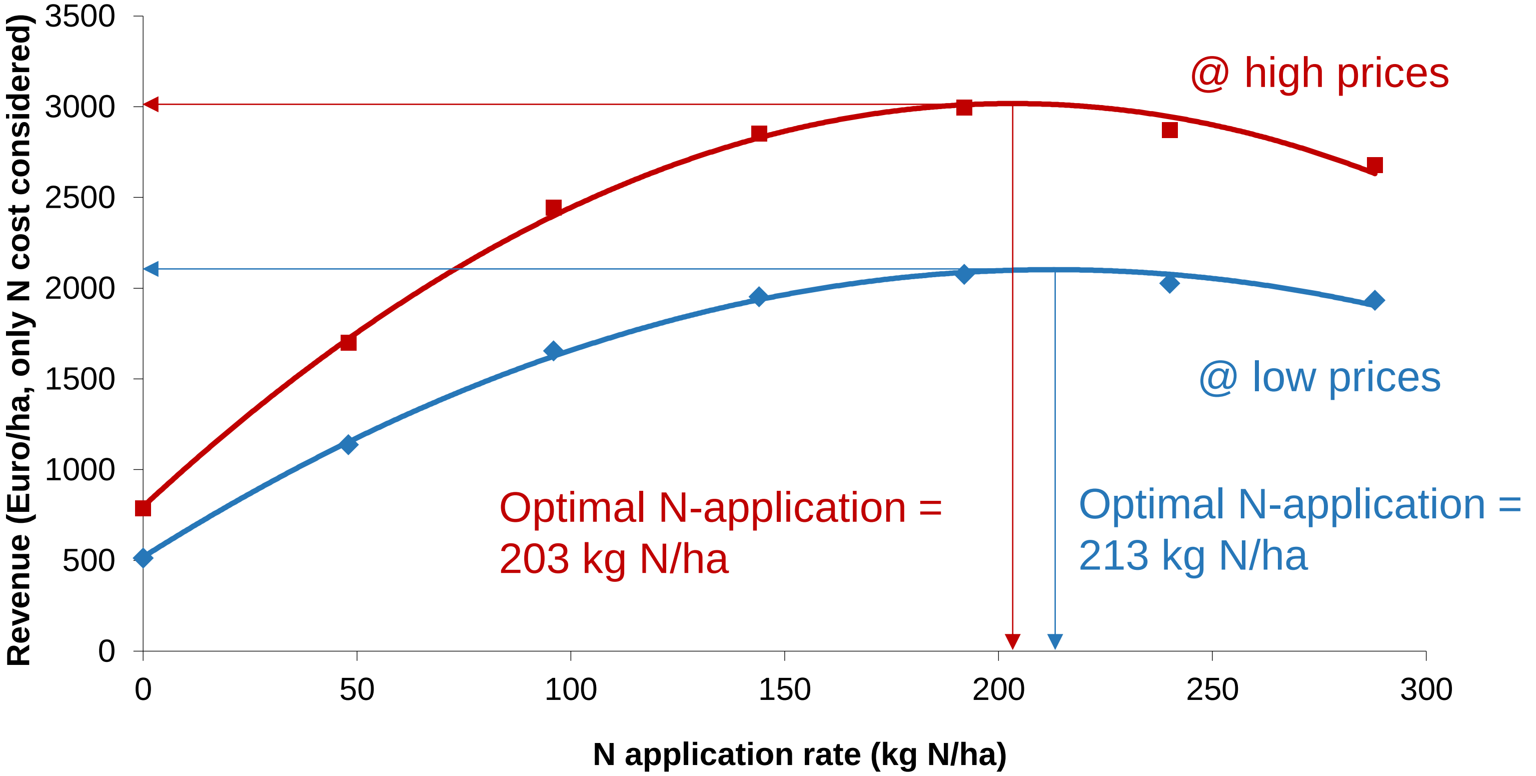
- The investment in nitrogen fertilizer is highly profitable for growers
- Fertilizer investment: 188 USD/ha
- Net return: 1,446 USD/ha
- **Net return ~ 7 x investment**

Source: Winter wheat yield data: Long term trial, Broadbalk, Rothamsted (since 1856).

Higher grain prices allow for increased nitrogen fertilizer values

- High crop prices provide much-needed incentives to farmers and global food production
- Farmers get the full revenue effect of yield improvement while fertilizer is a relatively smaller component of their margin, hence optimal nitrogen application is only slightly lower in this example with high prices vs a scenario with low prices.

Illustration of price impacts

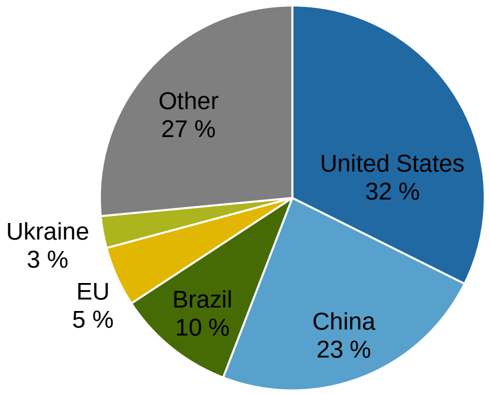


High prices (red line) = 381 EUR/t for grain and 1625 for urea, low prices (blue line) = 248 EUR/t for grain and 518 EUR/t urea.
Source: Winter wheat yield data: Long term trial, Broadbalk, Rothamsted (since 1856).

Key crops by region

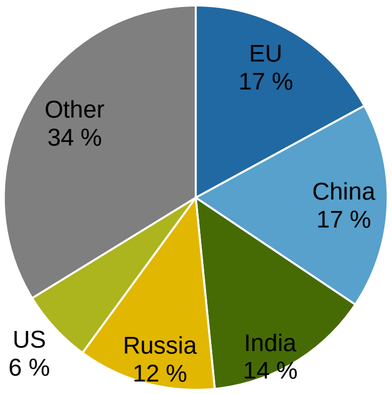
Global production:

Corn



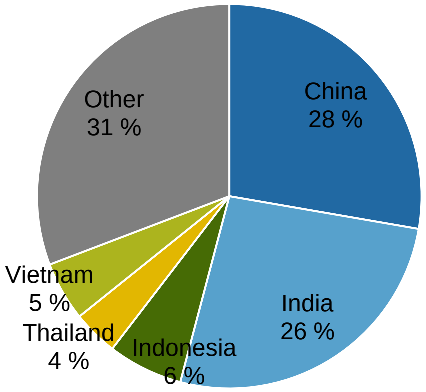
1,230 mt

Wheat



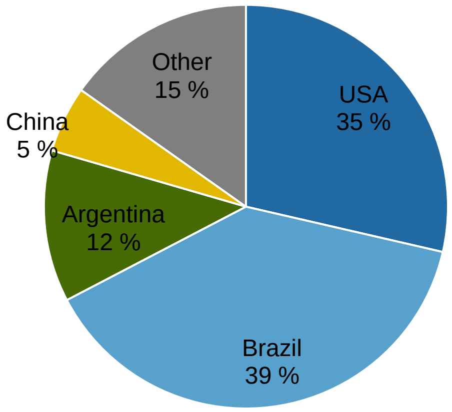
791 mt

Rice



523 mt

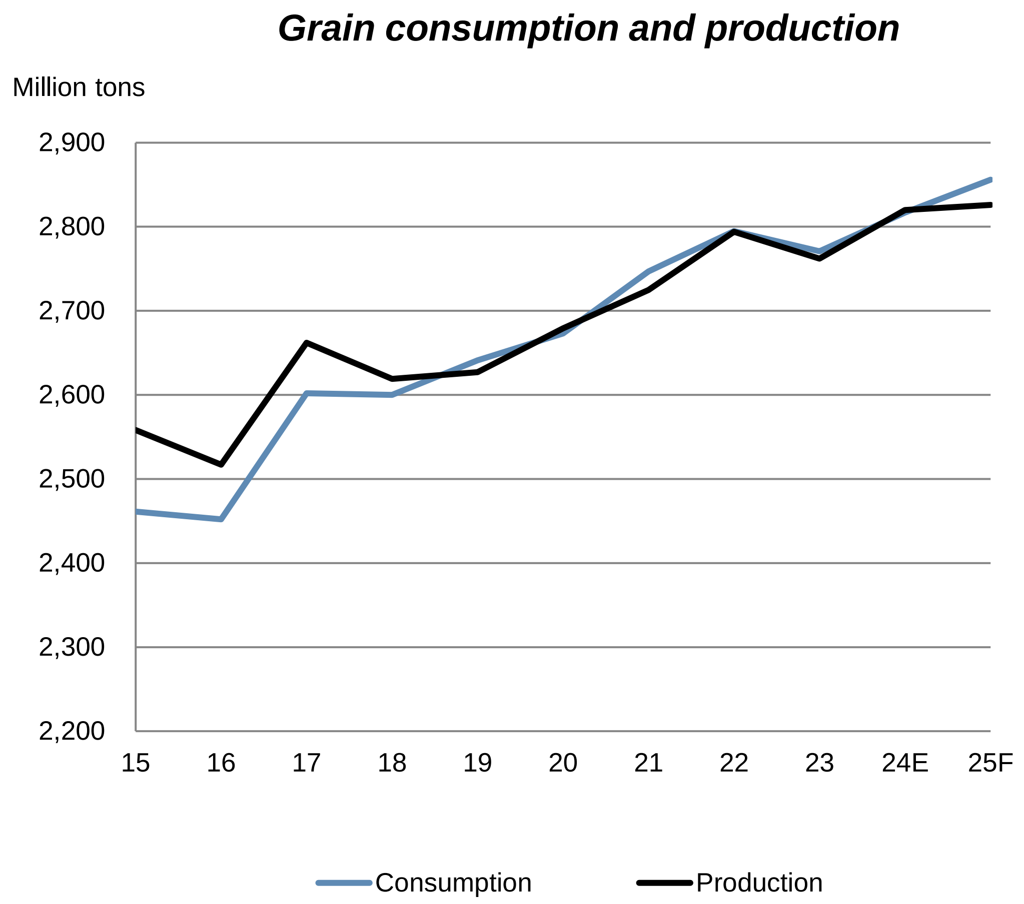
Soybeans

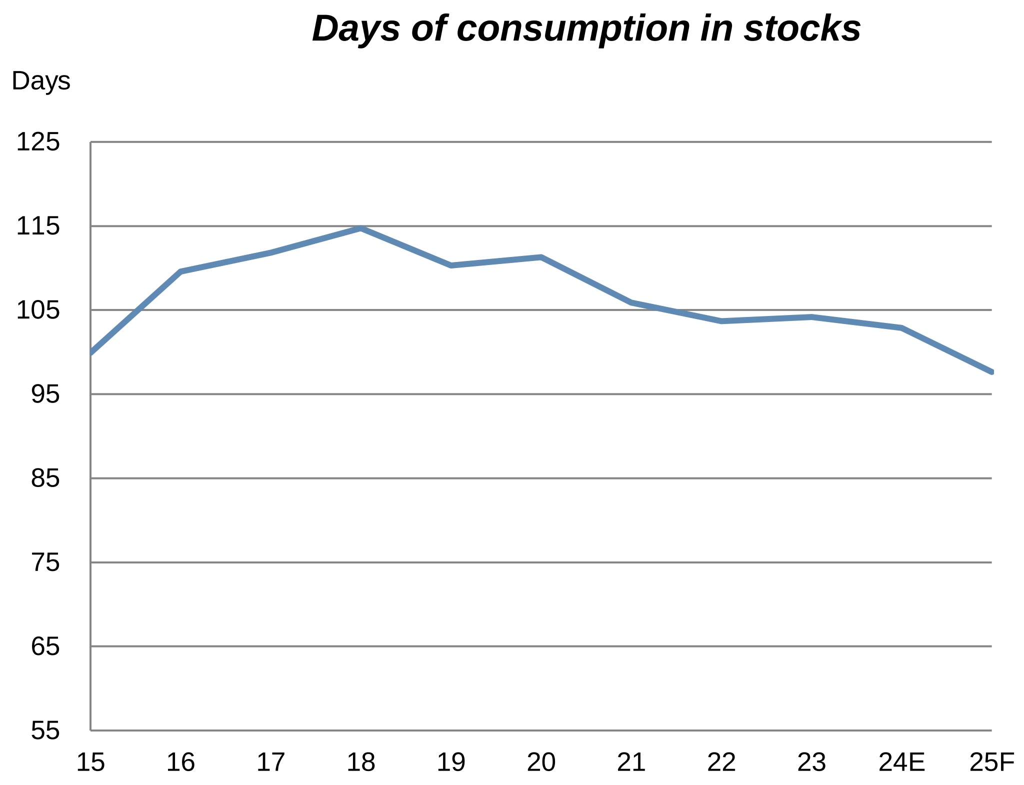


395 mt

Source: USDA December 2024, data for 2023/24 season

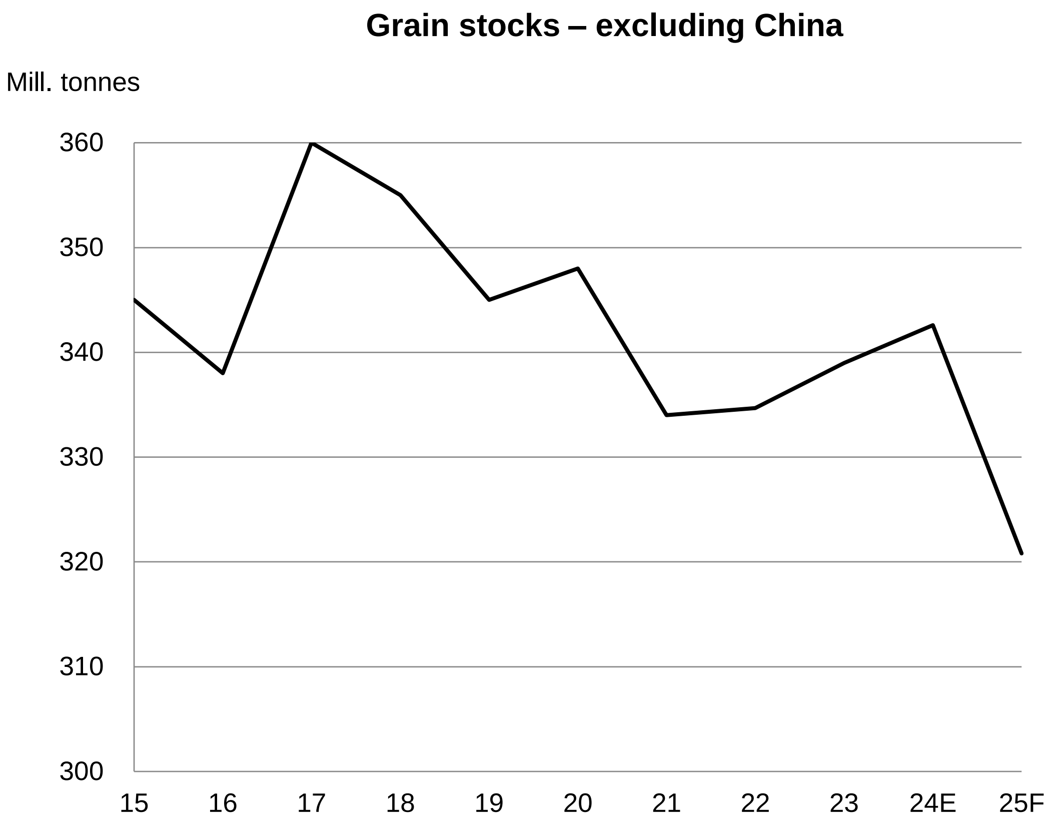
Grain production forecasted to fall short of consumption for the 2024/25 season – by 30 million tons





Source: USDA December 2024

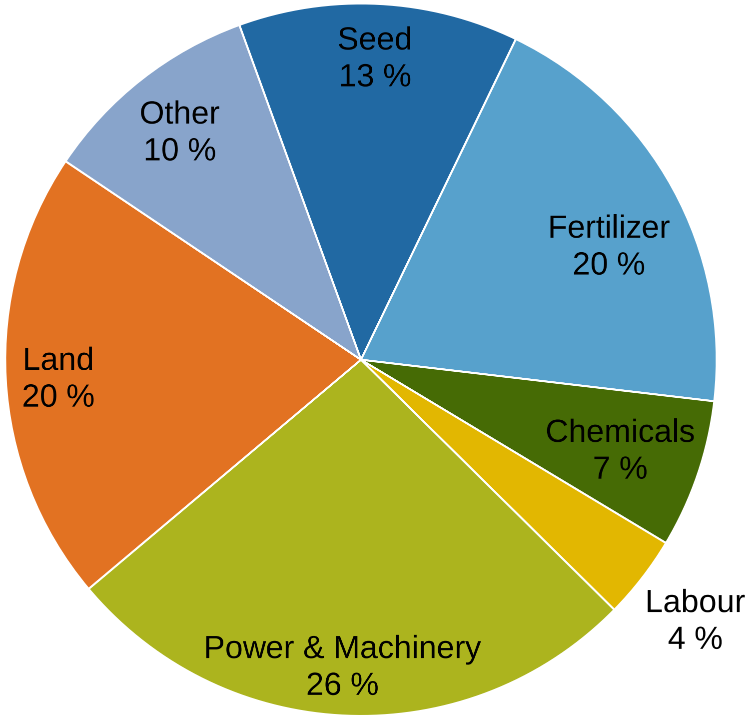
Grain inventories outside China, forecast is a sharp decline for 2024/25 (July–June)

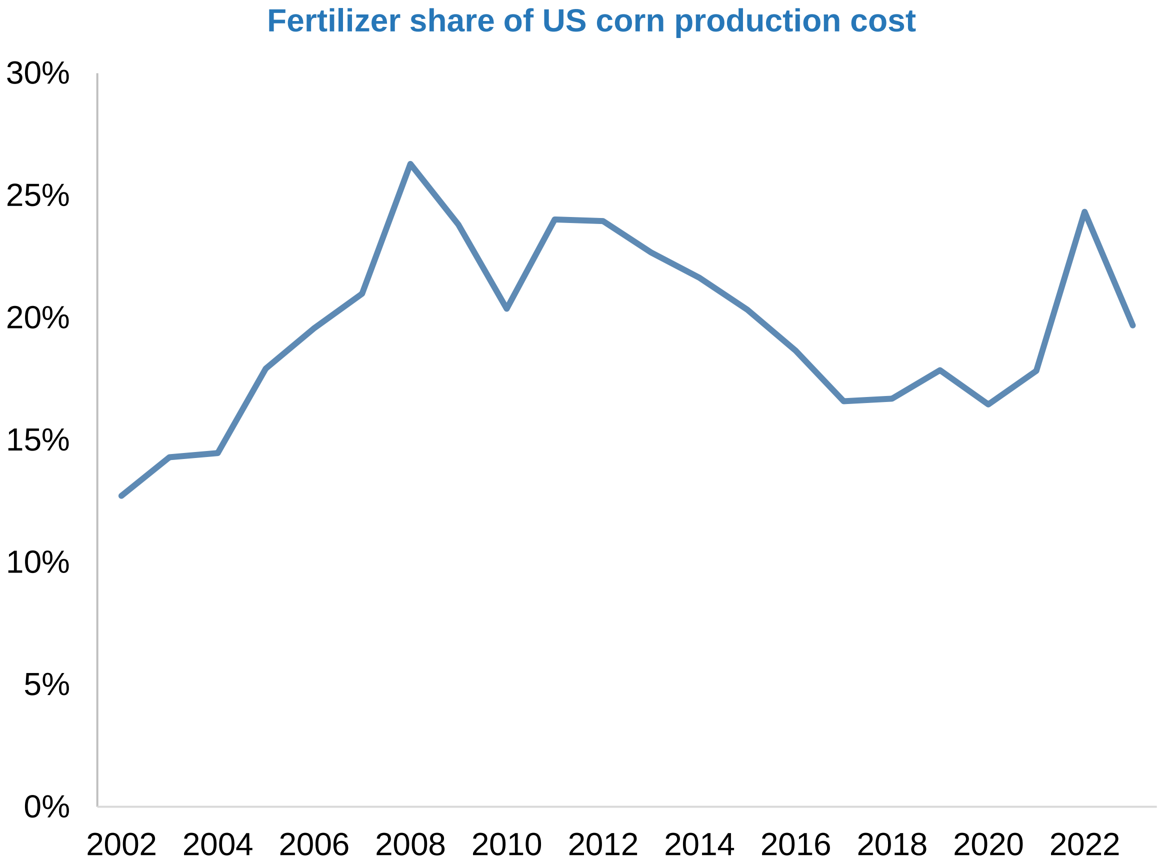


Source: USDA December 2024

Breakdown of grain production costs

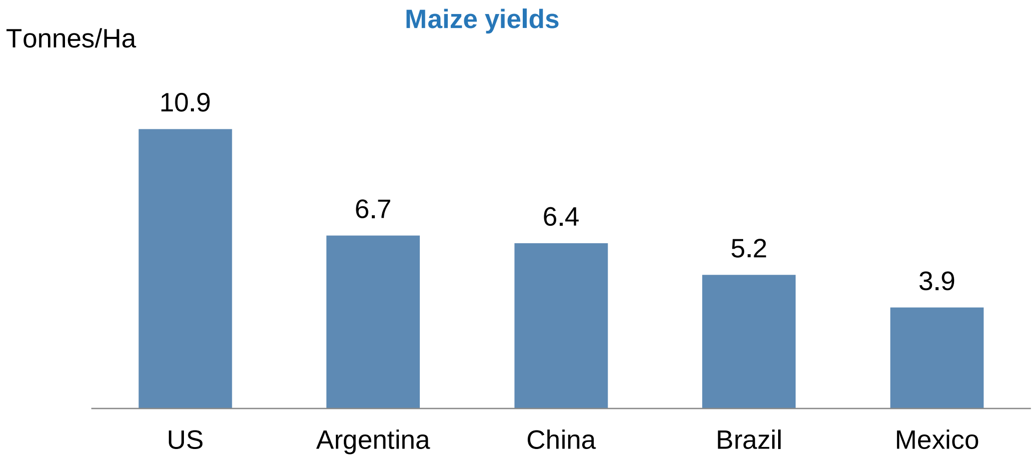
Example: 2023 average US corn production costs

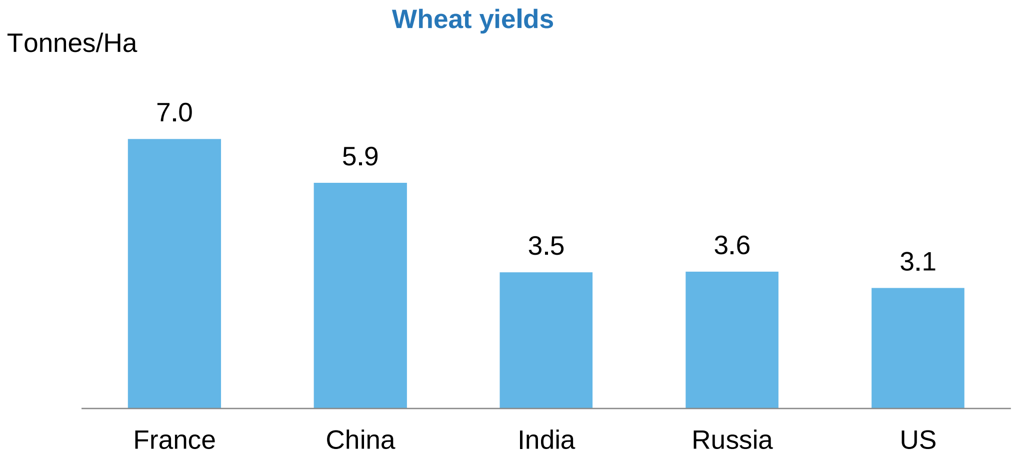


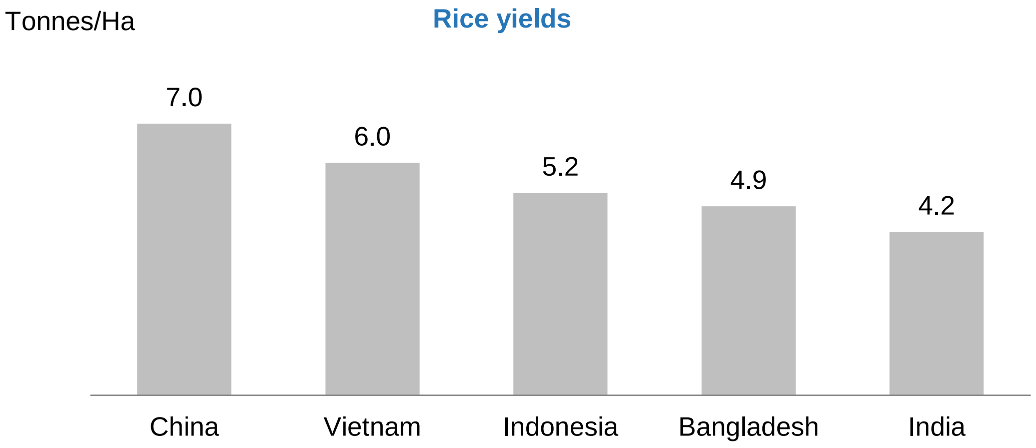


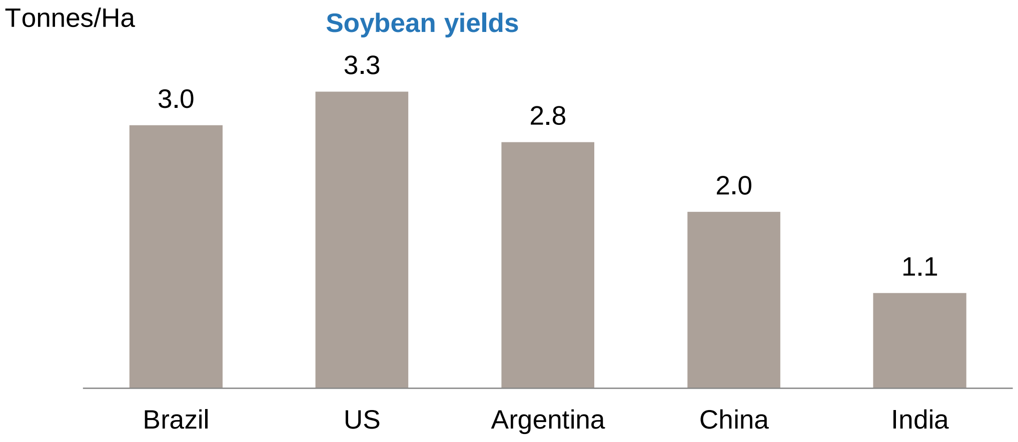
Source: USDA (Commodity costs and returns)

Large variations in grain yields across regions



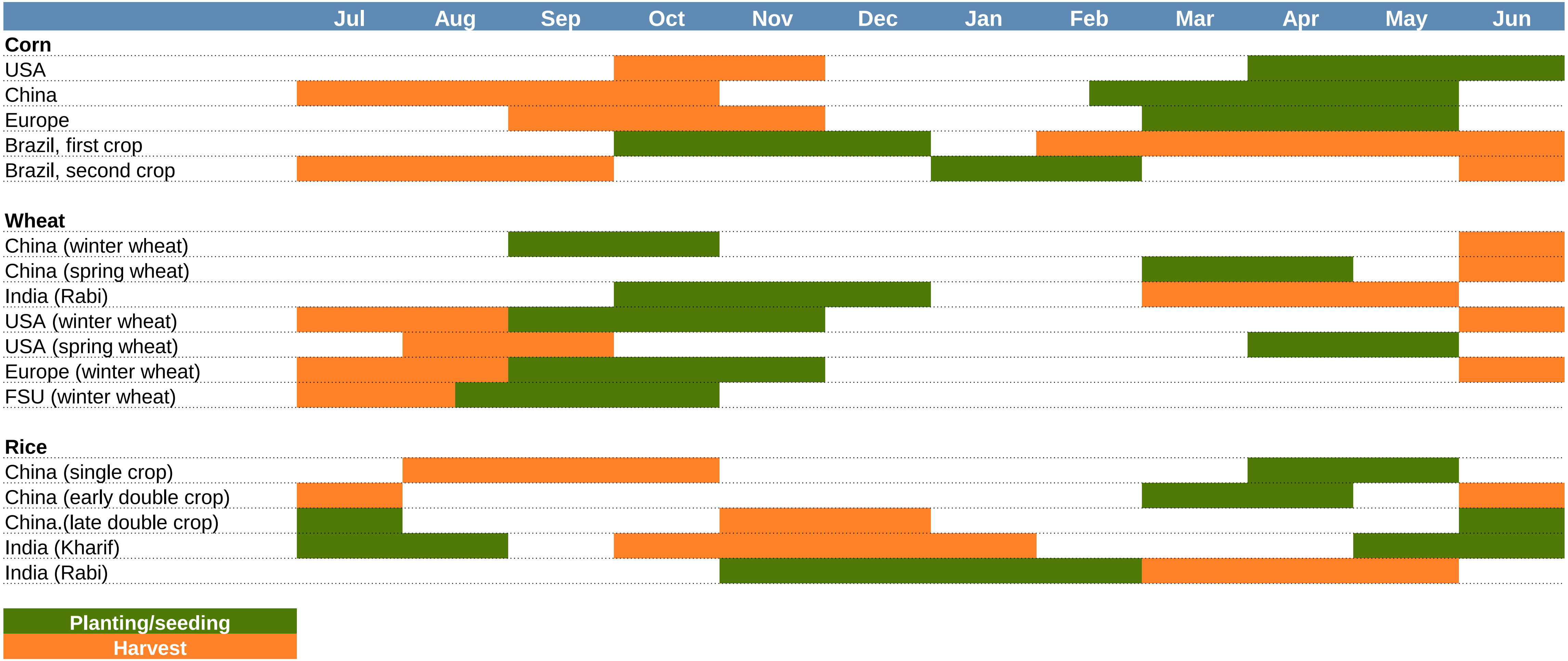






Source: FAOSTAT 2022

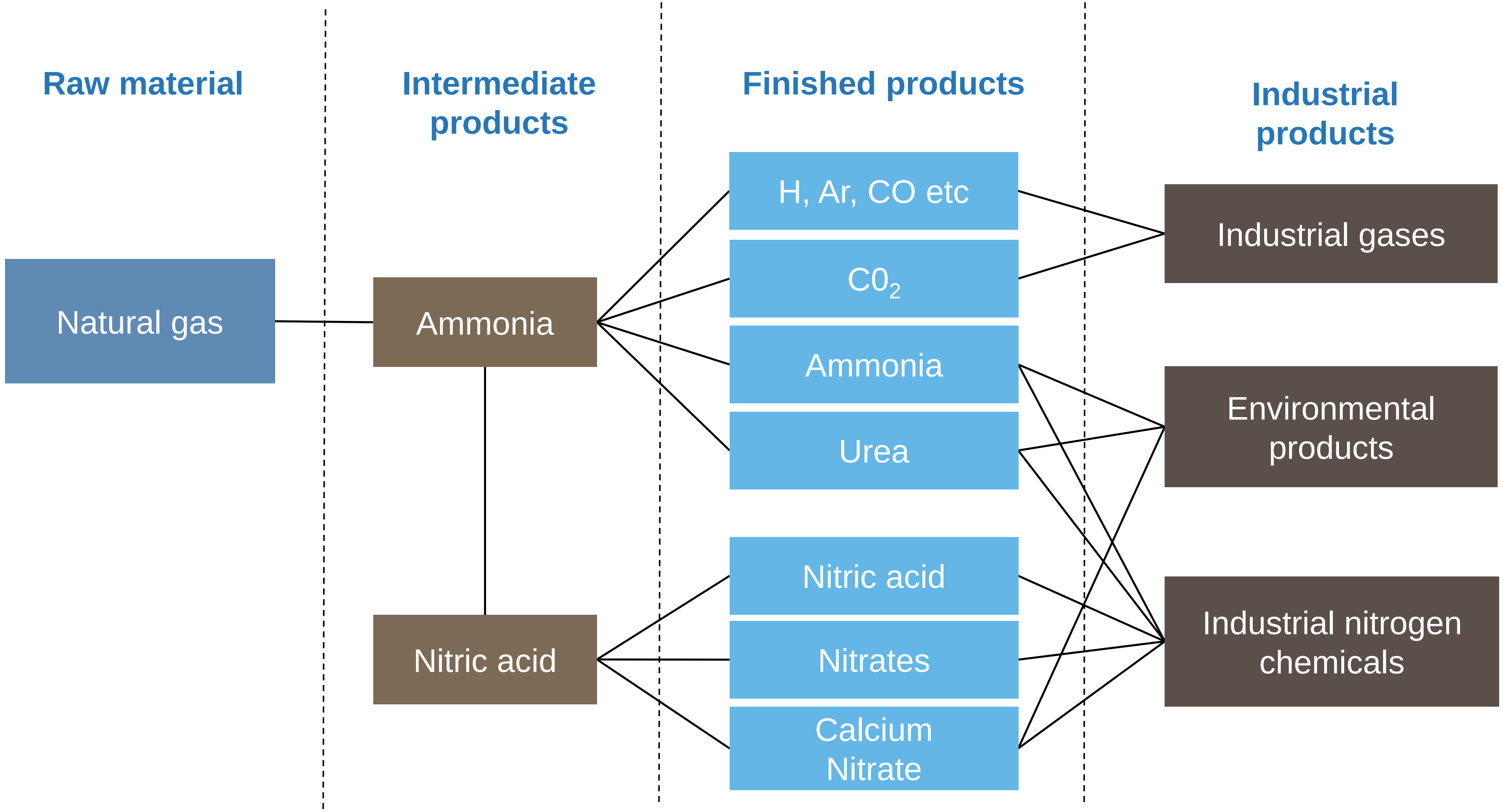
Seasonality in fertilizer consumption



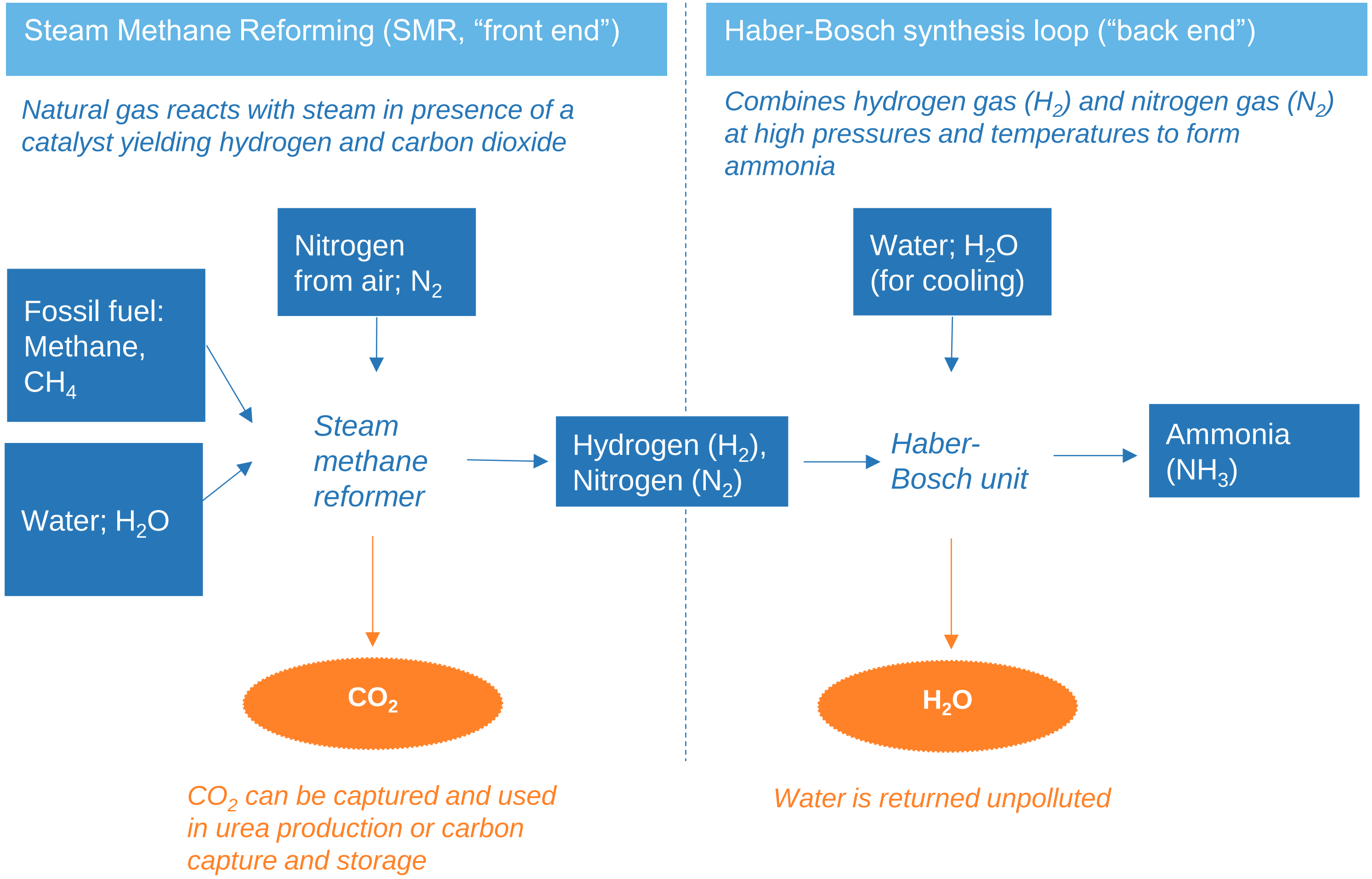
Source: USDA

Drivers of supply

Nitrogen value chain

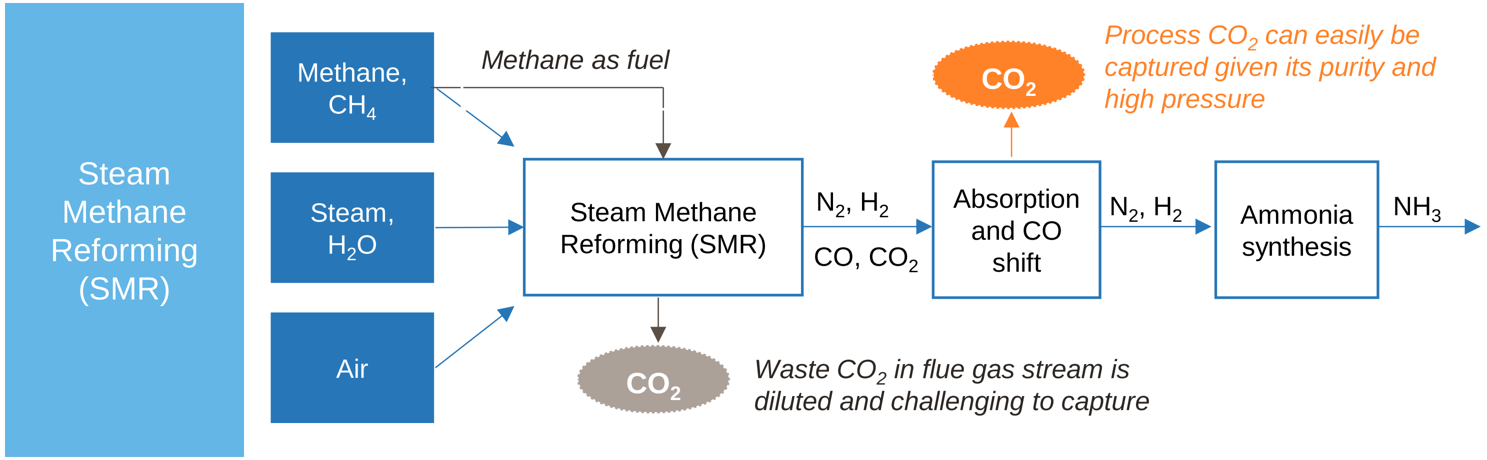


Ammonia production process based on natural gas

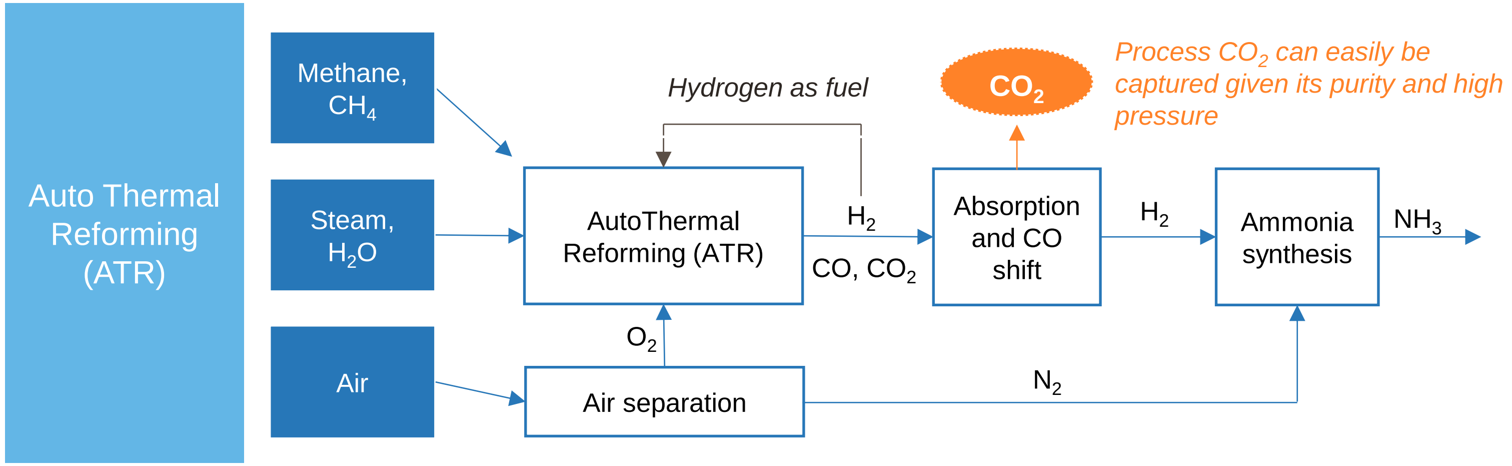


- Production process requires high pressure and temperatures
- Ammonia is a hazardous gas and requires expertise for safe handling
- At -33 degrees/pressure ammonia is a liquid and can be stored and transported in tanks / specialized vessels

Using ATR technology rather then SMR in the front-end of the ammonia plant increases the CO2 capture rate



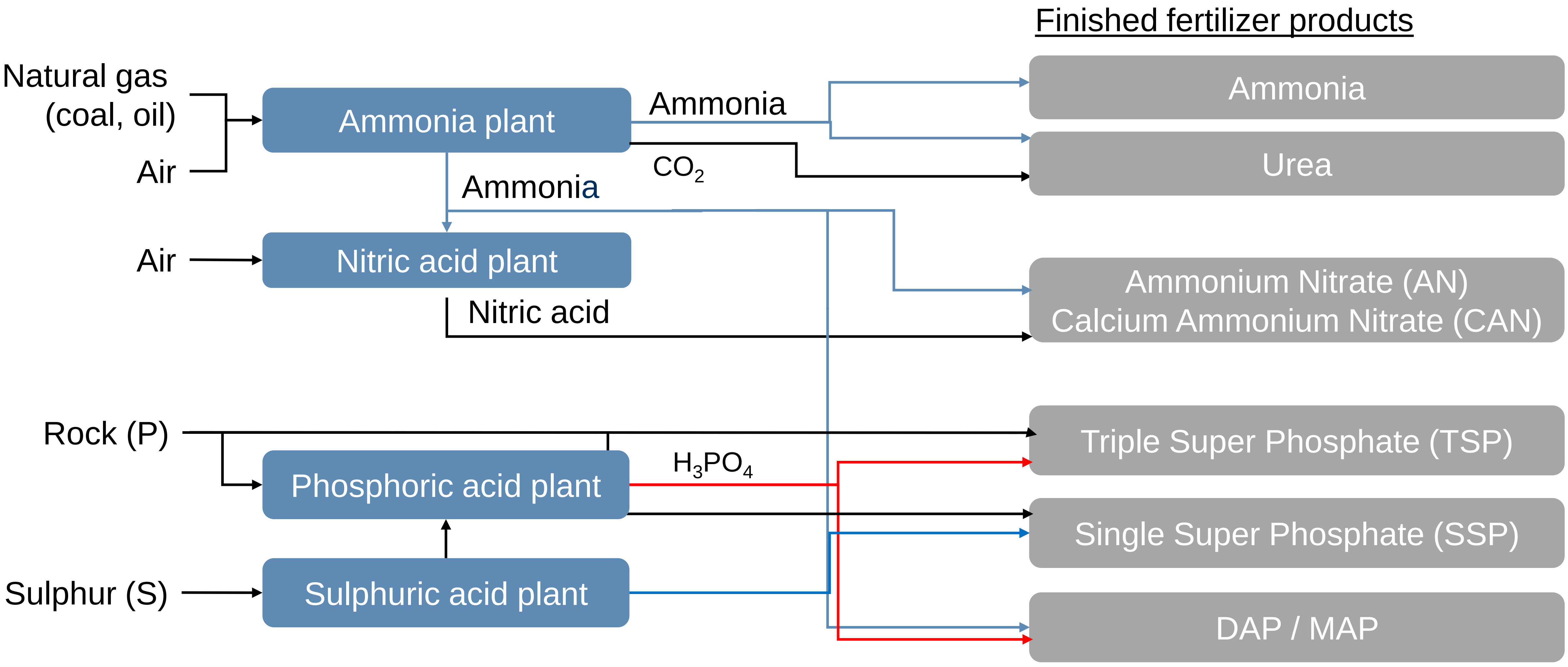
- SMR is the main production technology to produce ammonia outside of China
- Carbon capture can be installed to reduce emissions of CO_2 from the process, but due to the nature of the process **only 60-70% of CO_2 emissions can be captured** in an economically feasible way
- The reason is that the process has two separate streams of natural gas
  1. Process gas used as feedstock –> can easily be captured
  2. Waste CO_2 in flue gas -> difficult/expensive[1] to capture



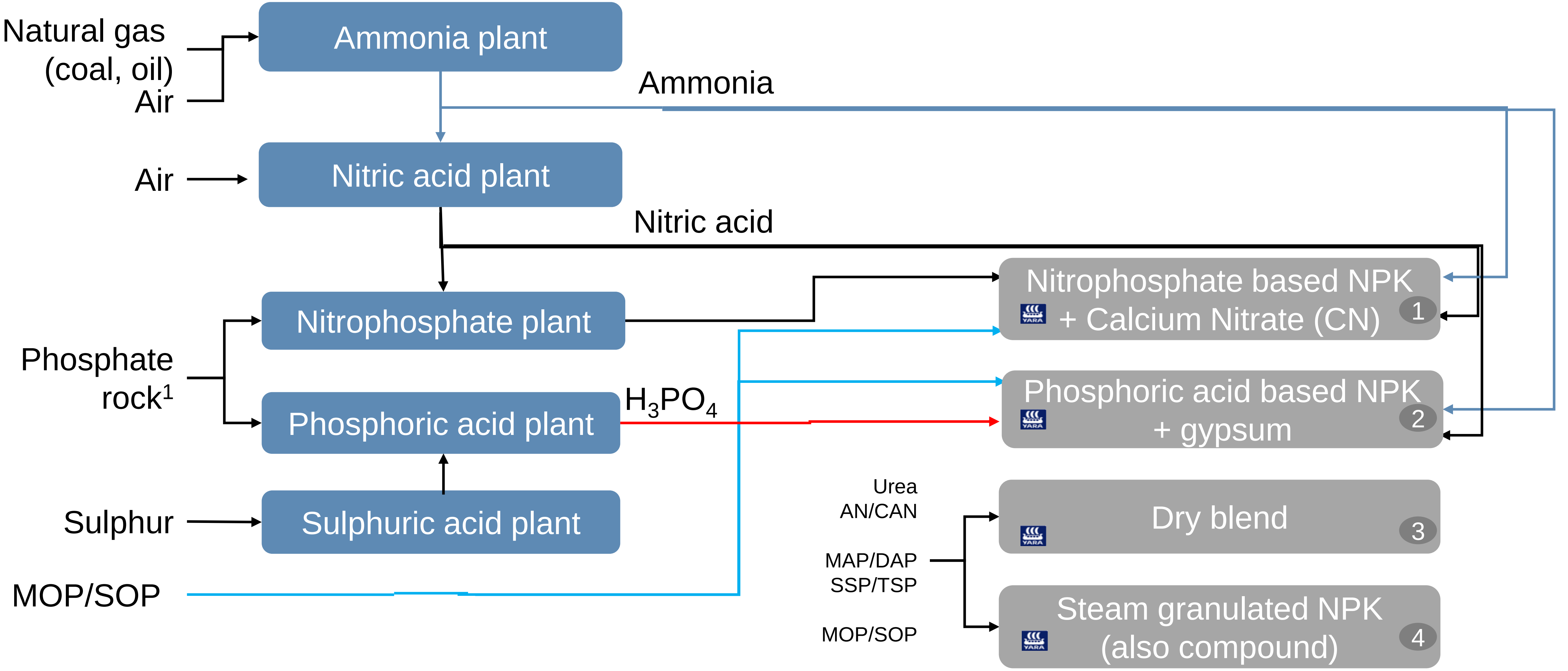
- ATR production process only have a single stream of CO_2 that can easily be captured making it ideal for carbon capture and storage (CCS)
- **ATR capture rates can be above 95% of emitted CO_2**
- SMR has historically been the preferred technology as ATR require larger quantities of methane feedstock and electrical energy

1) Could be captured using direct air capture. This is however expensive making it economically infeasible without a prohibitively high CO_2 cost

Fertilizer production routes

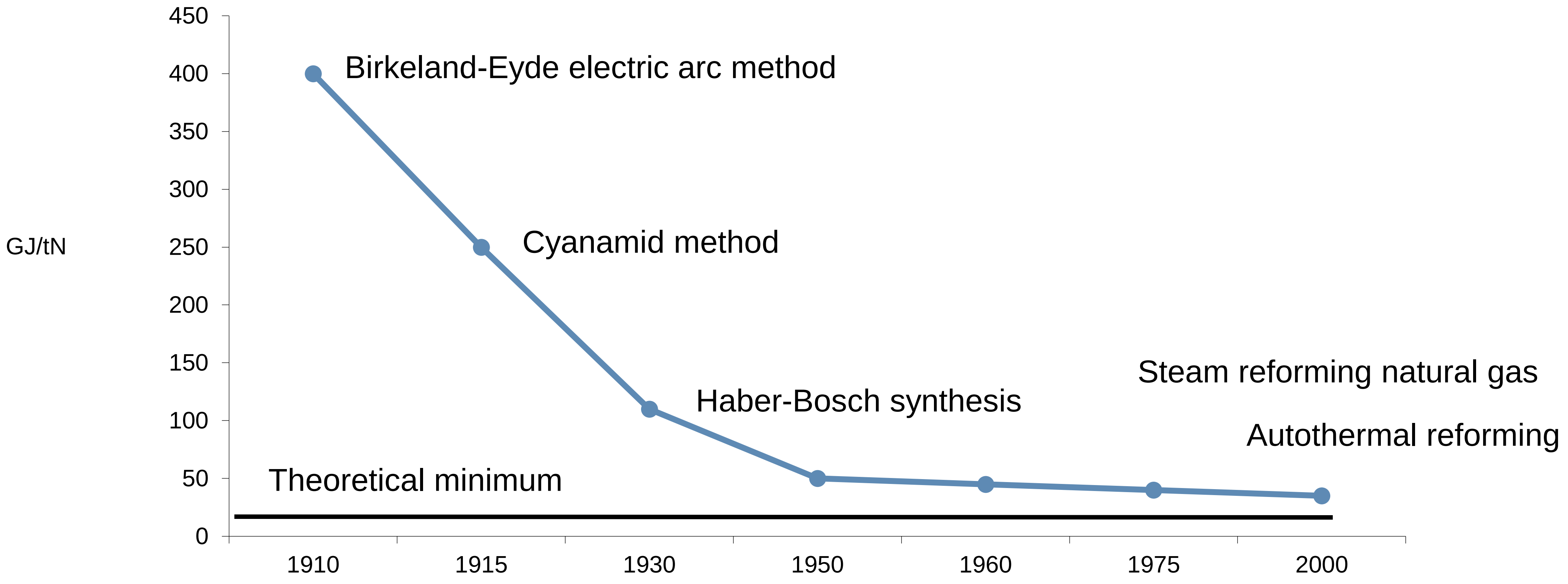


NPK production routes



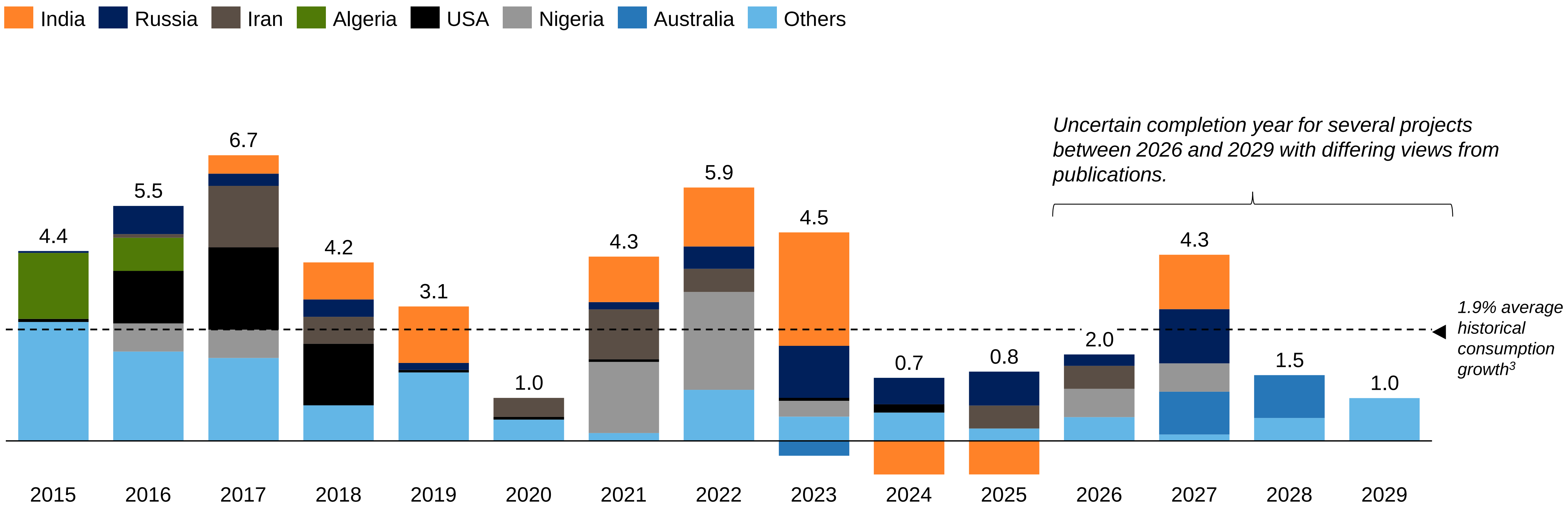
1. Igneous and calcined sedimentary

Nitrogen technology evolution



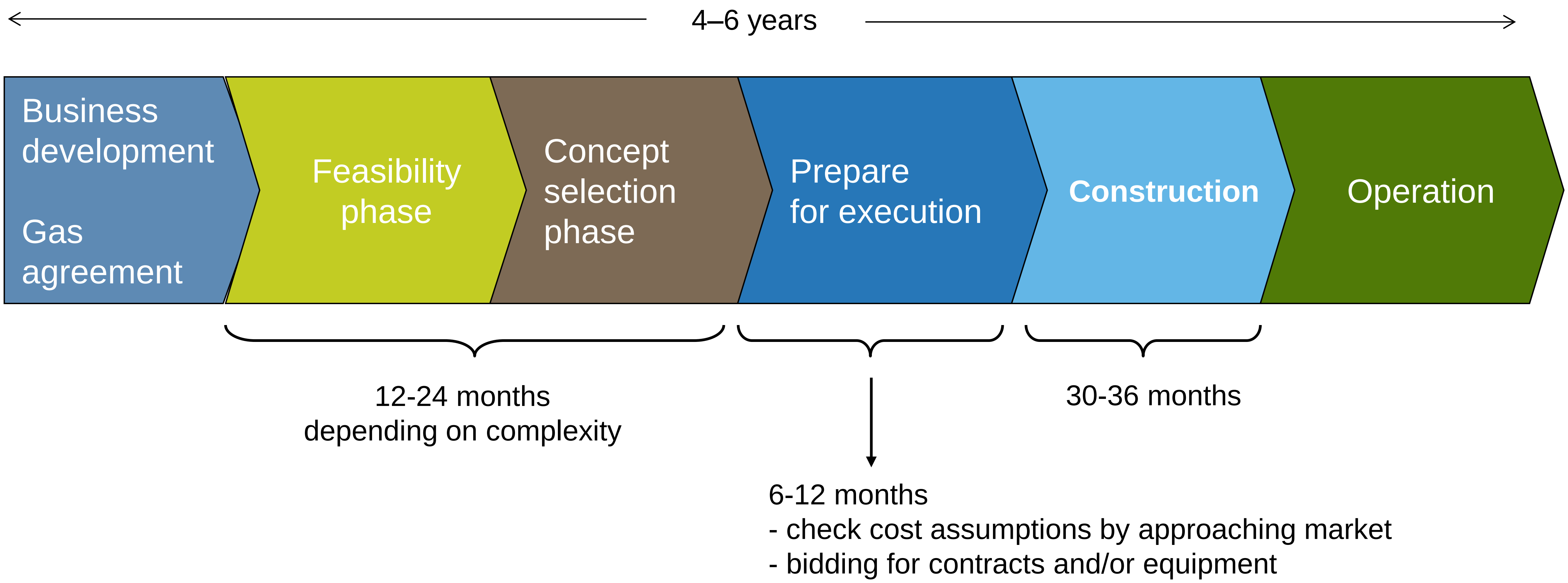
Peak of urea capacity additions is behind us

Global urea capacity additions ex. China [1,2] (mt)



1) Source: CRU March 2024
2) Future Urea projects assessed as "probable" or "firm" by CRU.
3) Growth calculated based on last 10 years up to 2023, equal to ~2.6 mt/year, from 2023 baseline (IFA) of 136.6 mt (global production + China trade). Trend growth rate held back by supply restrictions in 2021 and 2022

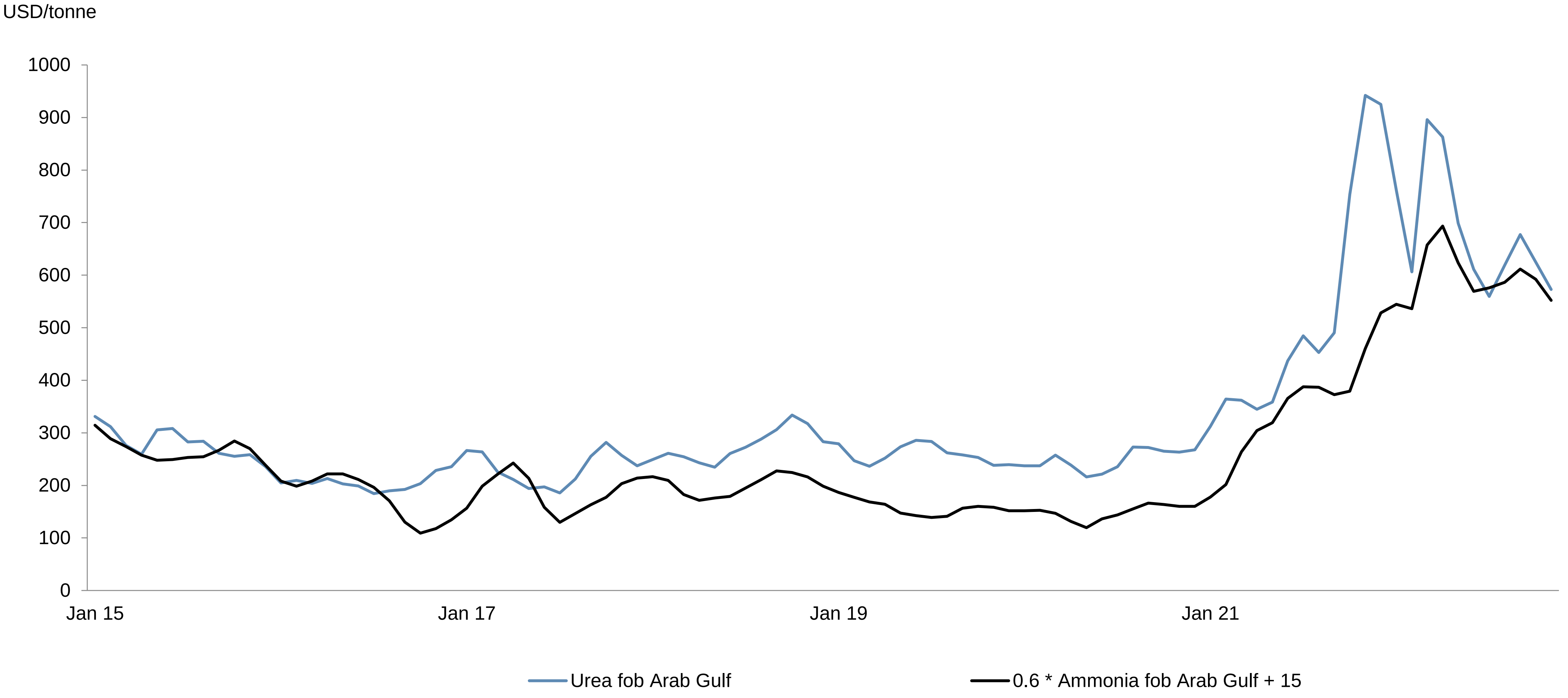
5-year typical construction time for nitrogen fertilizer projects*



* Ammonia and urea plant example

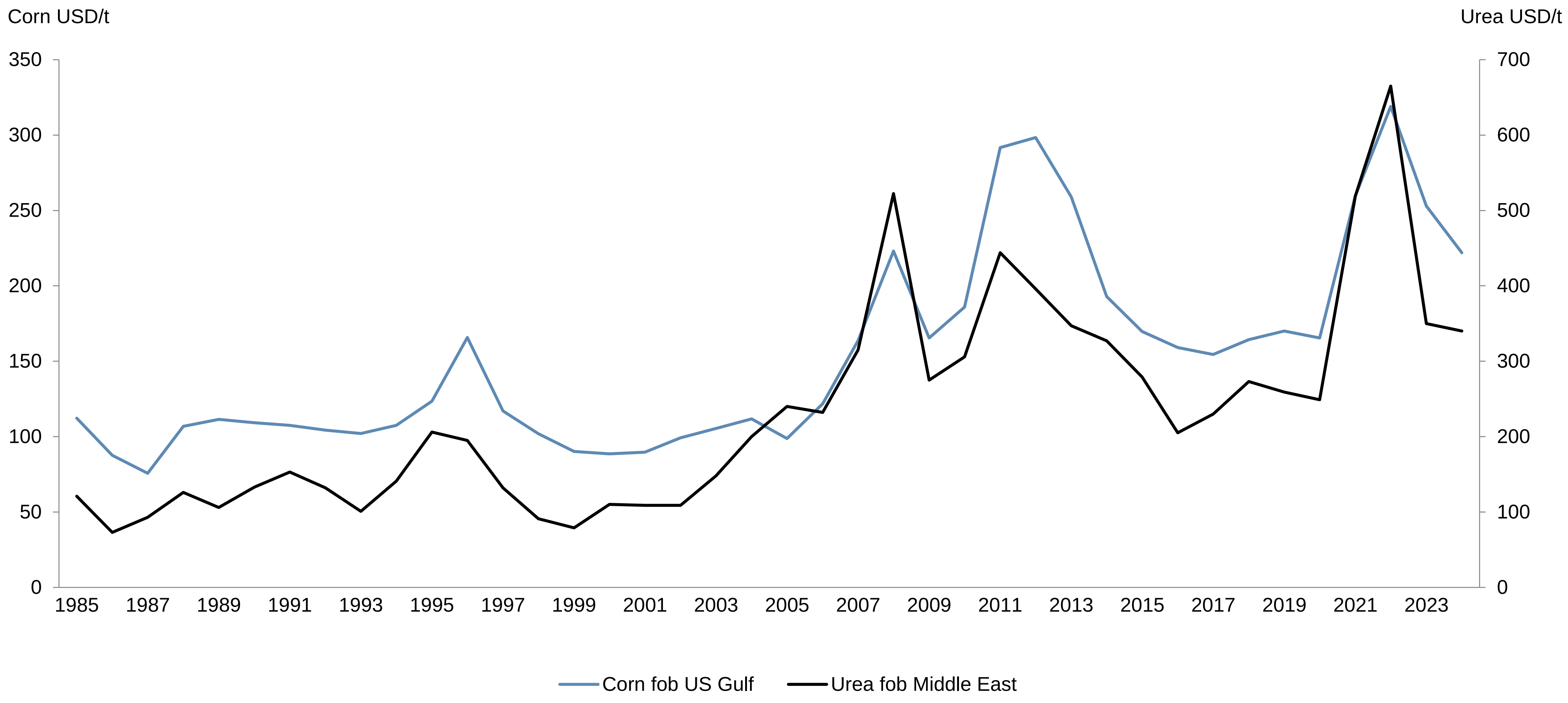
Price relations

Upgrading margins from ammonia to urea



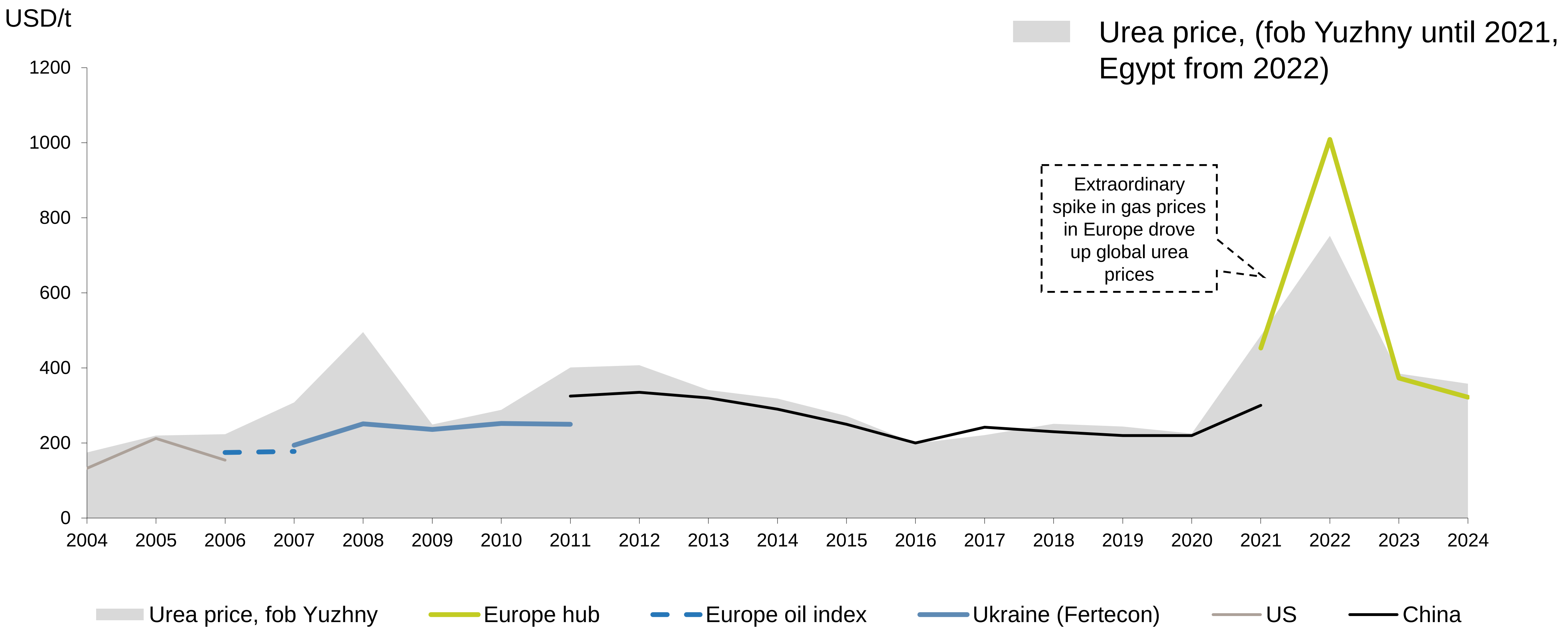
Source: Average of international publications

Grain prices important for fertilizer demand and pricing



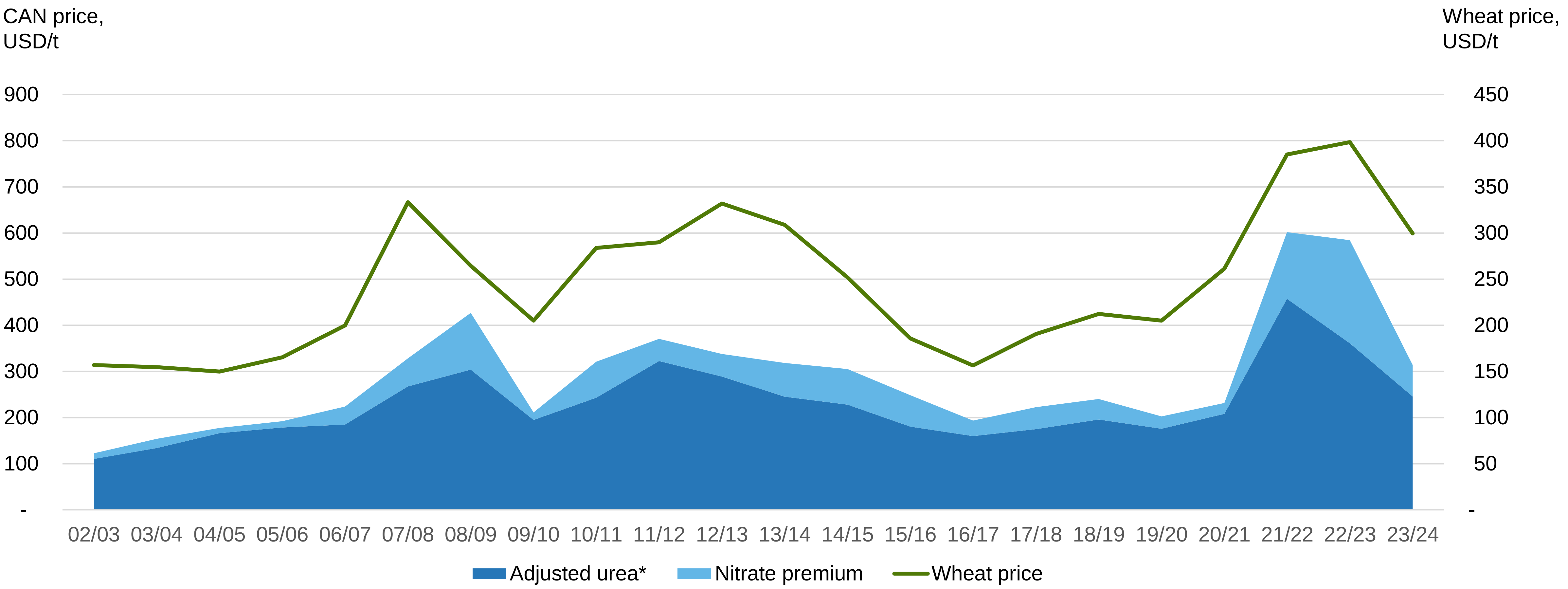
Source: World Bank, Fertilizer publications

The urea market has been increasingly demand-driven since 2020



Source: Fertecon (Ukraine), Yara estimates. The cost lines are drawn for illustration purposes only and not intended as exact cost estimates.

Nitrate premium is mainly a function of crop prices

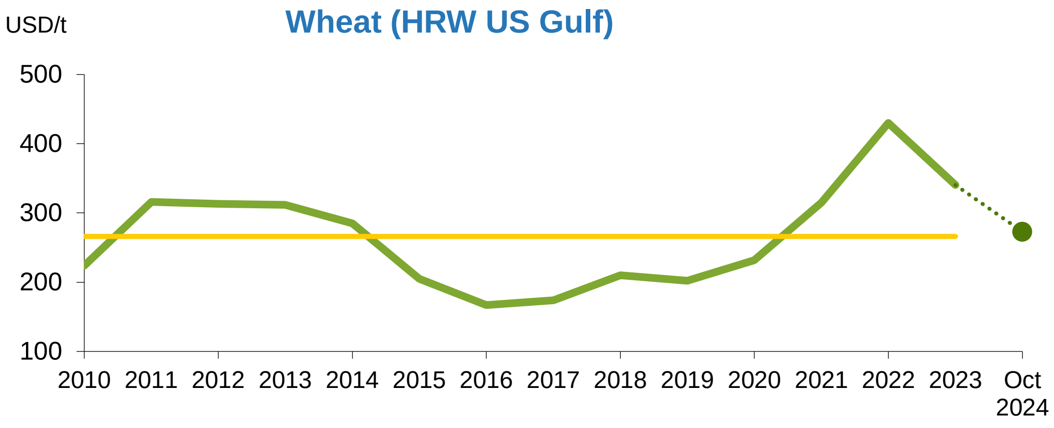


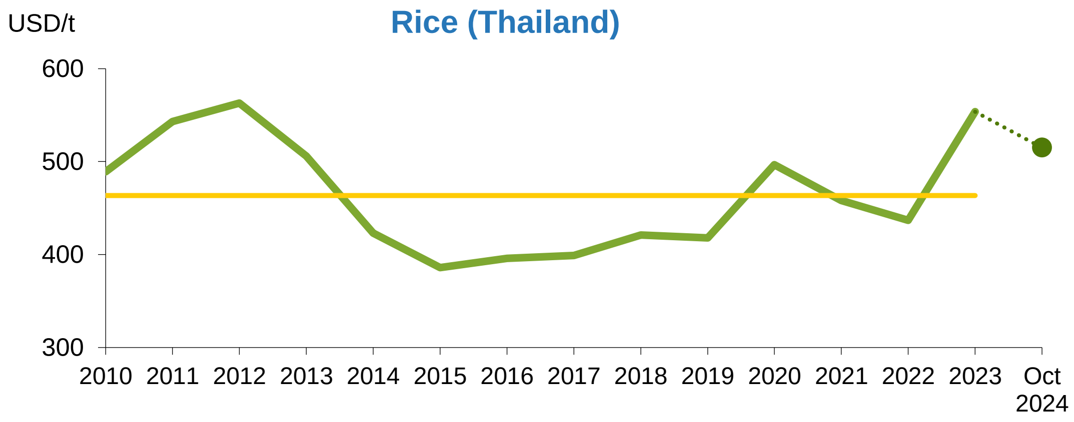
* Urea fob Egypt sea adjusted for transport costs into Europe and nitrogen content similar to CAN

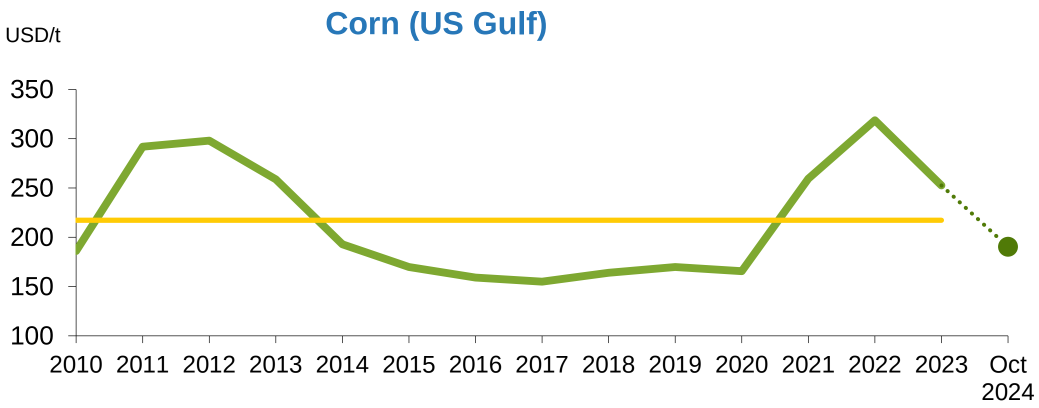
Source: World Bank, Fertilizer publications

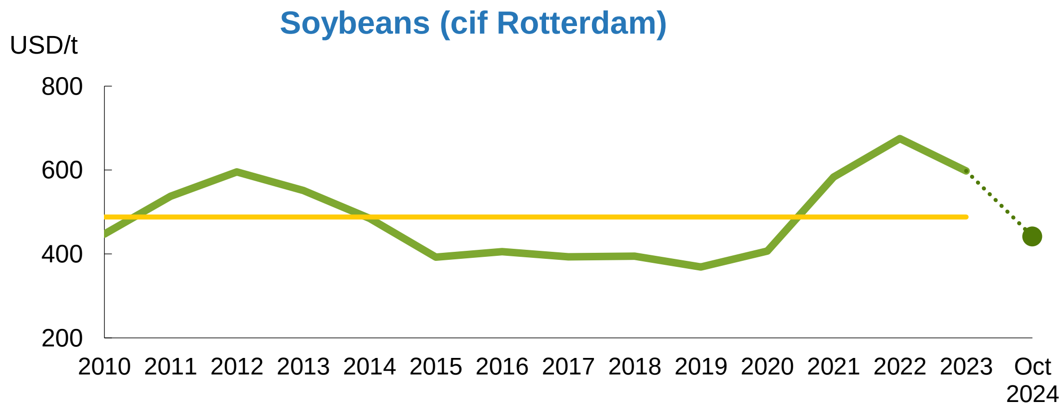
Main agricultural commodity prices – yearly averages

Average prices 2010- 2023





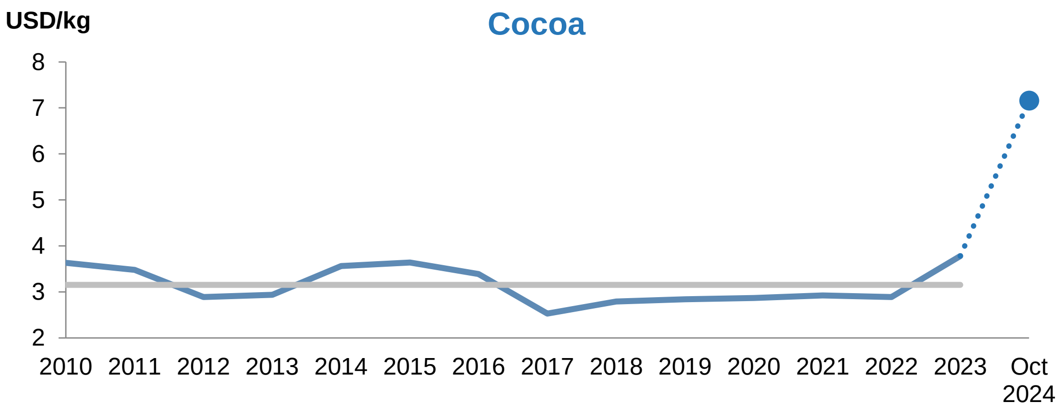


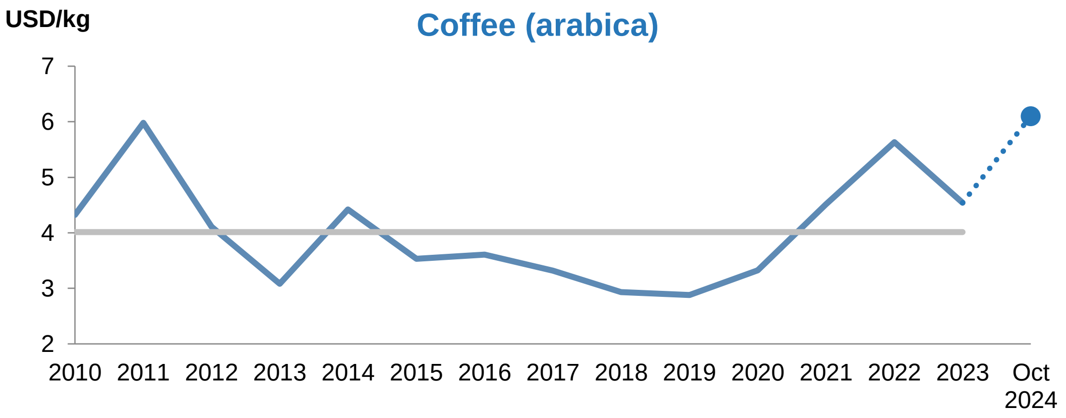


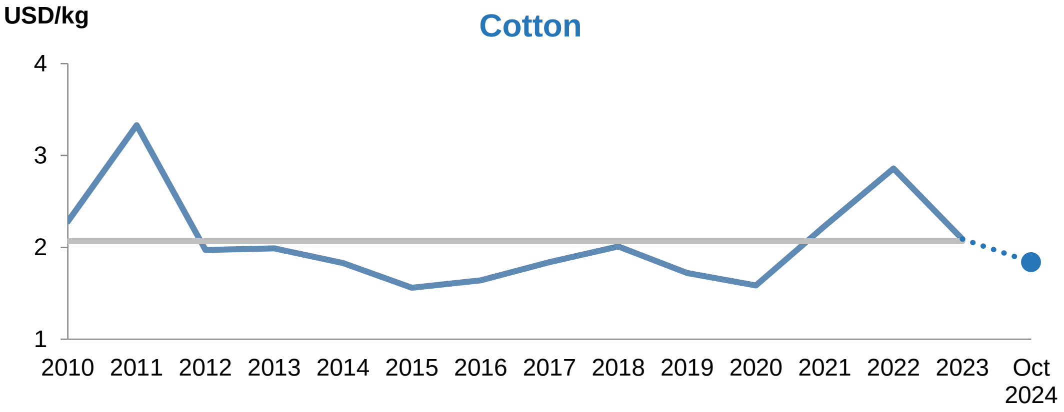
Source: World Bank

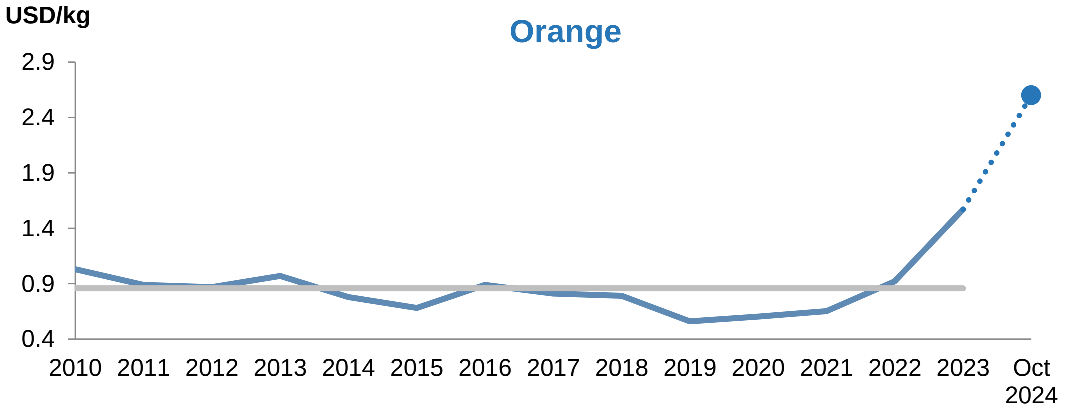
Cash crop prices – yearly averages

Average prices 2010 - 2023



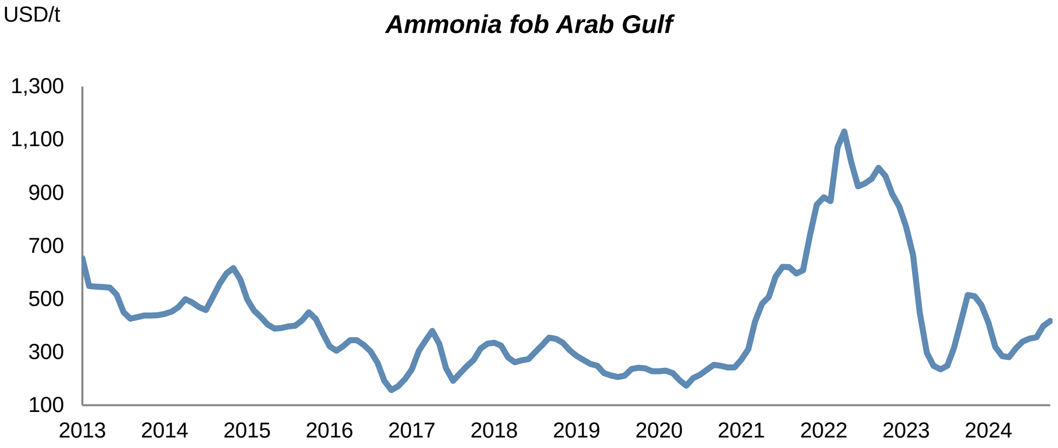


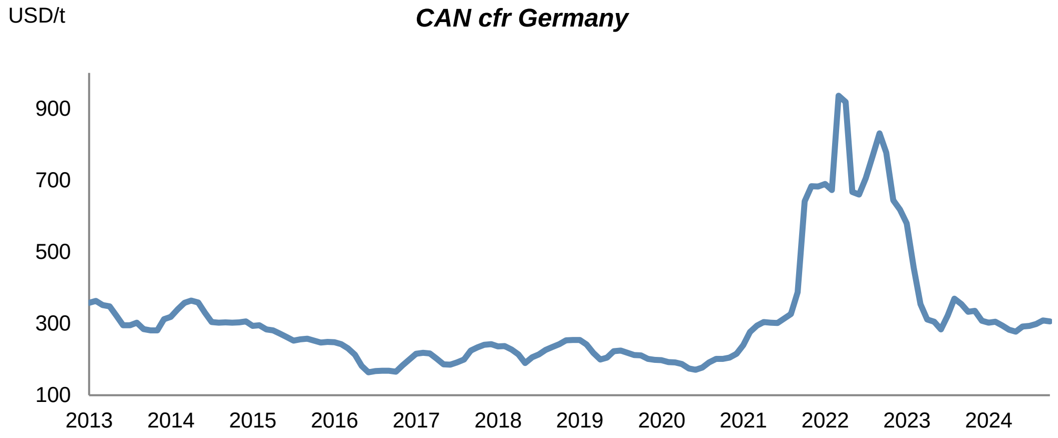


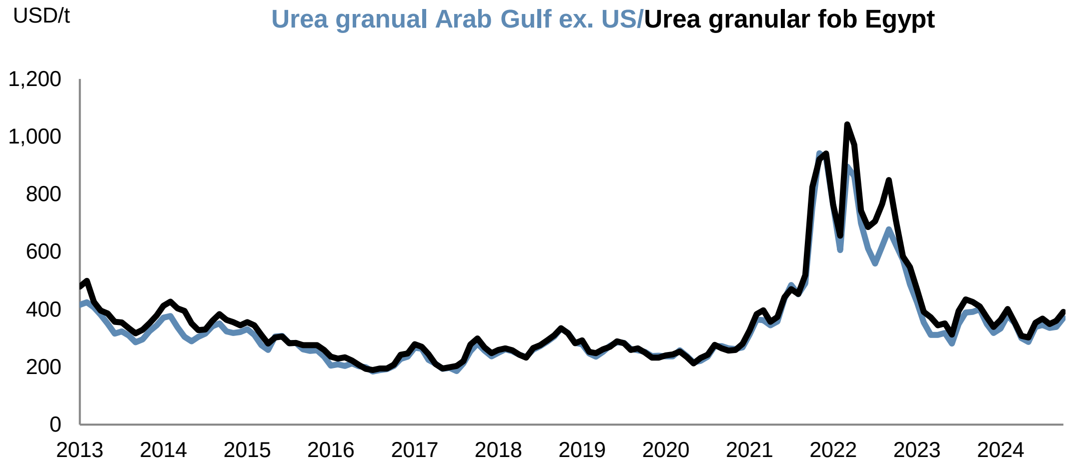


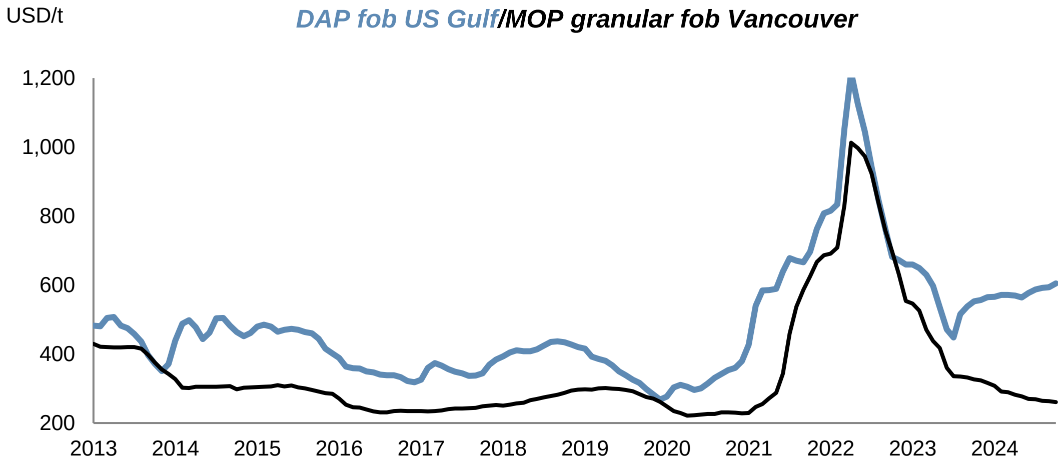
Source: World Bank

10-year fertilizer prices – monthly averages





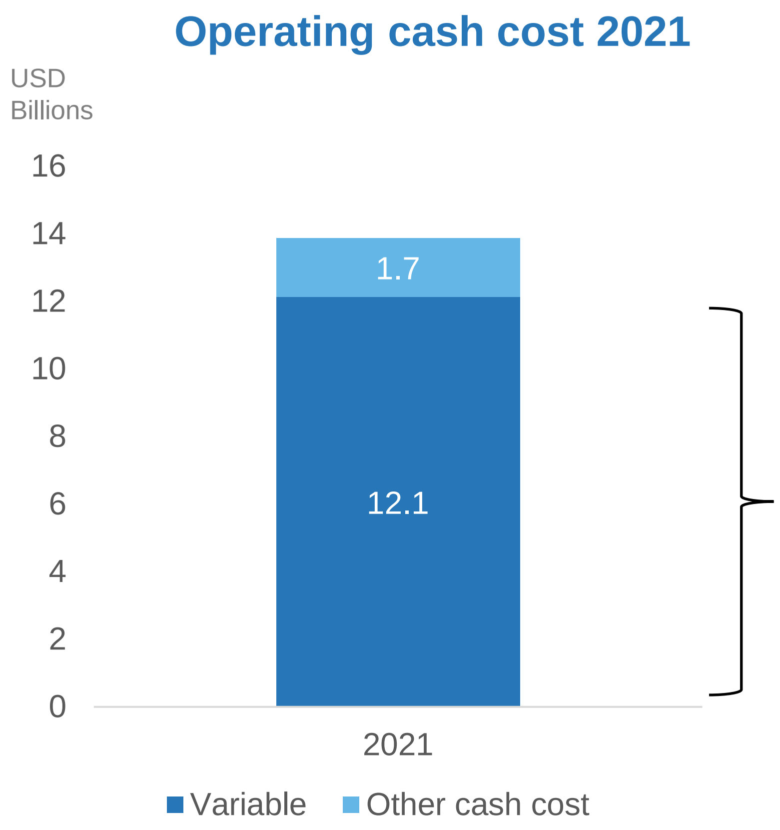




Source: Average of international publications

Production economics

Yara's operating cash costs are mainly variable



Other cash cost (12%)

Variable costs (88%)
- Dry raw materials
- Energy
- Freight
- 3rd party finished fertilizer

- Temporary plant closures can be carried out with limited stop/start costs
- Example for ammonia/urea plants:
  - Typically, half a week to stop and up to a week to start
  - Cost of stopping is 2 days energy consumption
  - Cost of starting is 3 days energy consumption

Ammonia cash cost build-up – example

	Gas price:	7	USD/MMBtu
x	Gas consumption:	36	MMBtu/mt NH_3
=	Gas cost:	252	USD/mt NH_3
+	Other prod. cost*:	39	USD/mt NH_3
=	Total cash cost:	291	USD/mt NH_3

Emissions[1]:	1.8-2.4	mtCO_2/mt NH_3

36 MMBtu natural gas/tonne ammonia

Ammonia (NH_3)
(82% N)

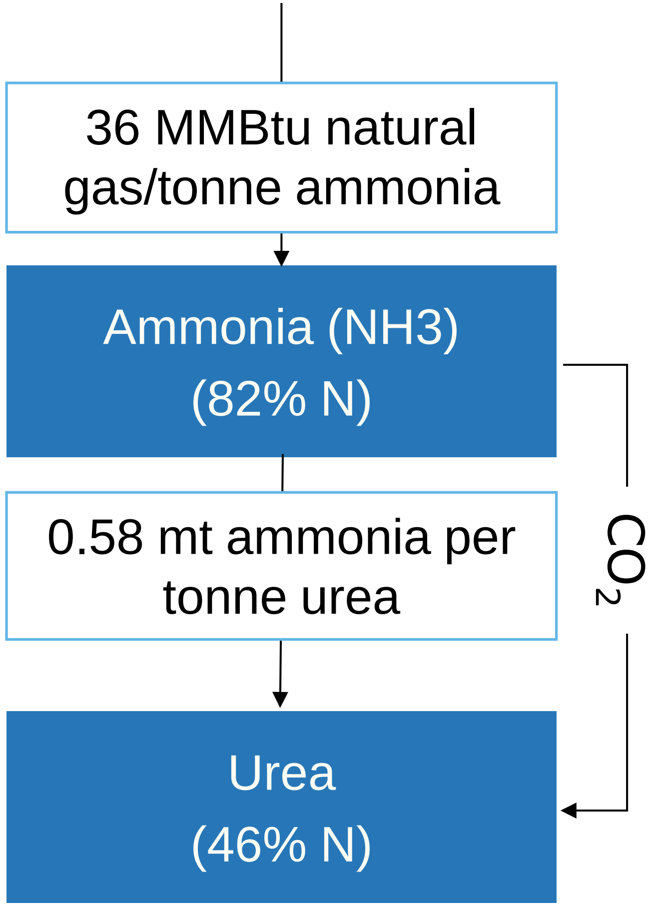
Typical natural gas consumption for ammonia production

1) *European ammonia production is exposed to a carbon/EU ETS cost. Currently each producer receives free allowances based on the current ammonia product benchmark of 1.57 mtCO_2/mtNH_3 adjusted for historical activity level, cross sectoral correction factor and exchangeability of fuel and electricity.*

* Source: other production cost is based on Fertecon (2022) for 2021, estimates for US Gulf

Urea cash cost build-up – example

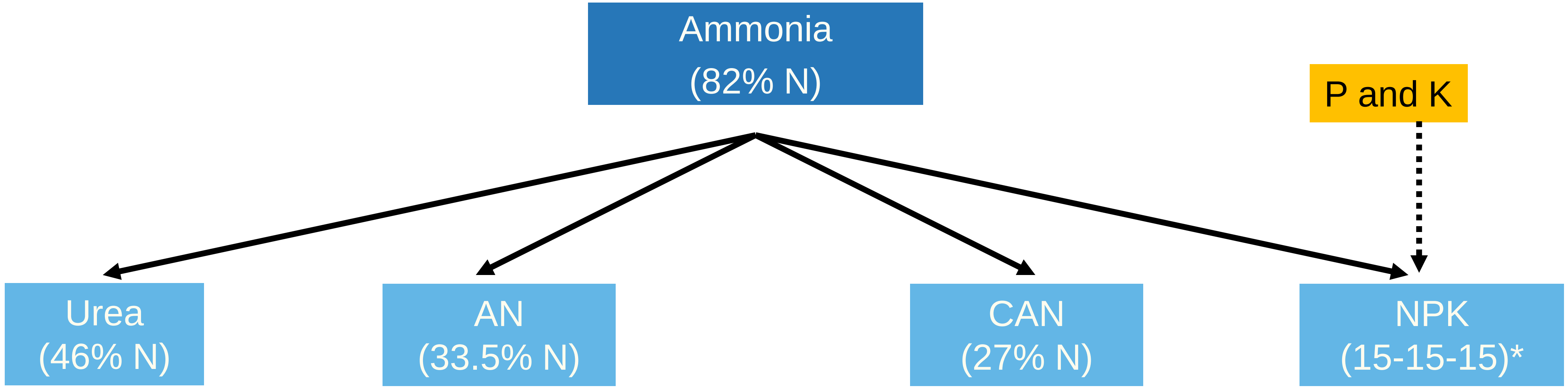
	Ammonia cost:	291	USD/mt NH_3
x	Ammonia use:	0.58	NH_3/mt urea
=	Ammonia cost:	169	USD/mt urea
+	Process gas cost*:	36	USD/mt urea
+	Other prod. cost**:	46	USD/mt urea
=	Total cash cost:	251	USD/mt urea



* Process gas cost is linked to natural gas price, 5.2 MMBtu gas per 1 mt urea
** Excl. freight & loading cost (~8 USD/t)

* Source: other production cost is based on Fertecon (2022) for 2021, estimates for US Gulf

Theoretical consumption factors

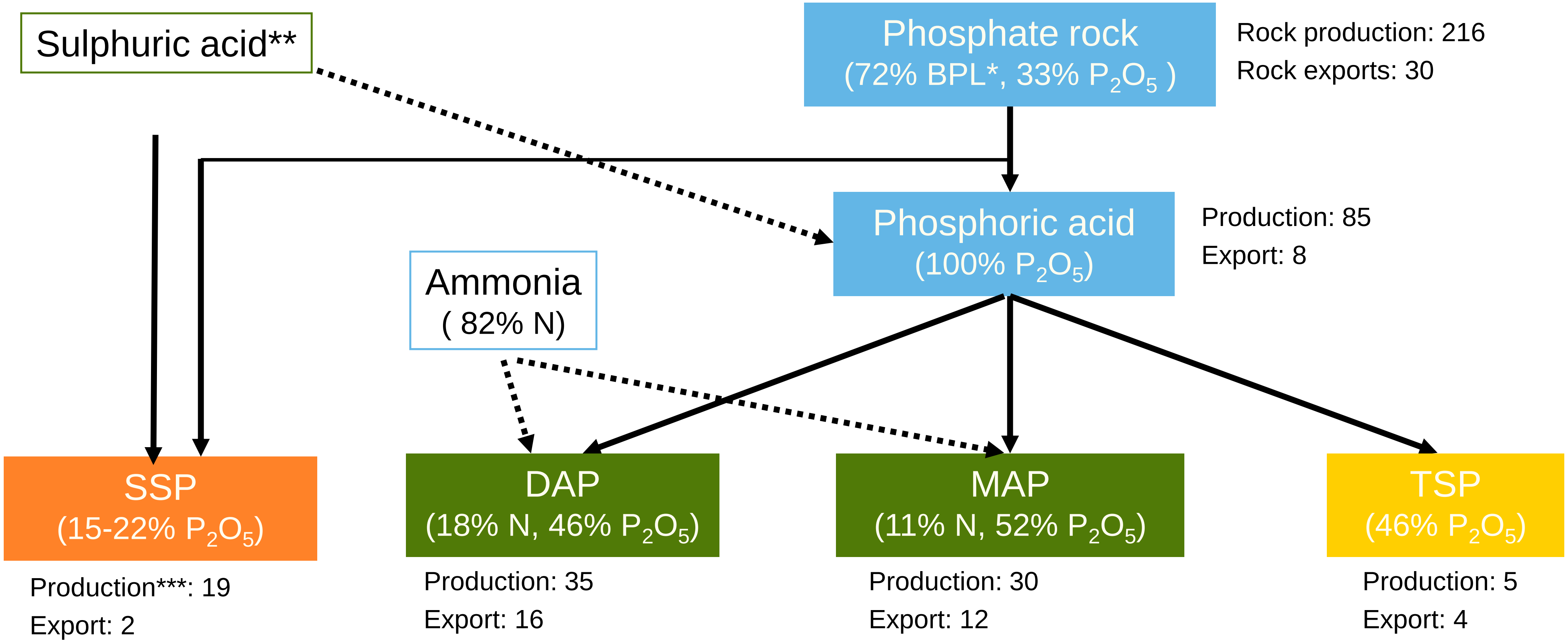


- Price comparisons should always be based on nutrient tons, not product tons

* There are many NPK formulas; 15-15-15 is one example

Main phosphate processing routes

2023 production and exports, million tons product

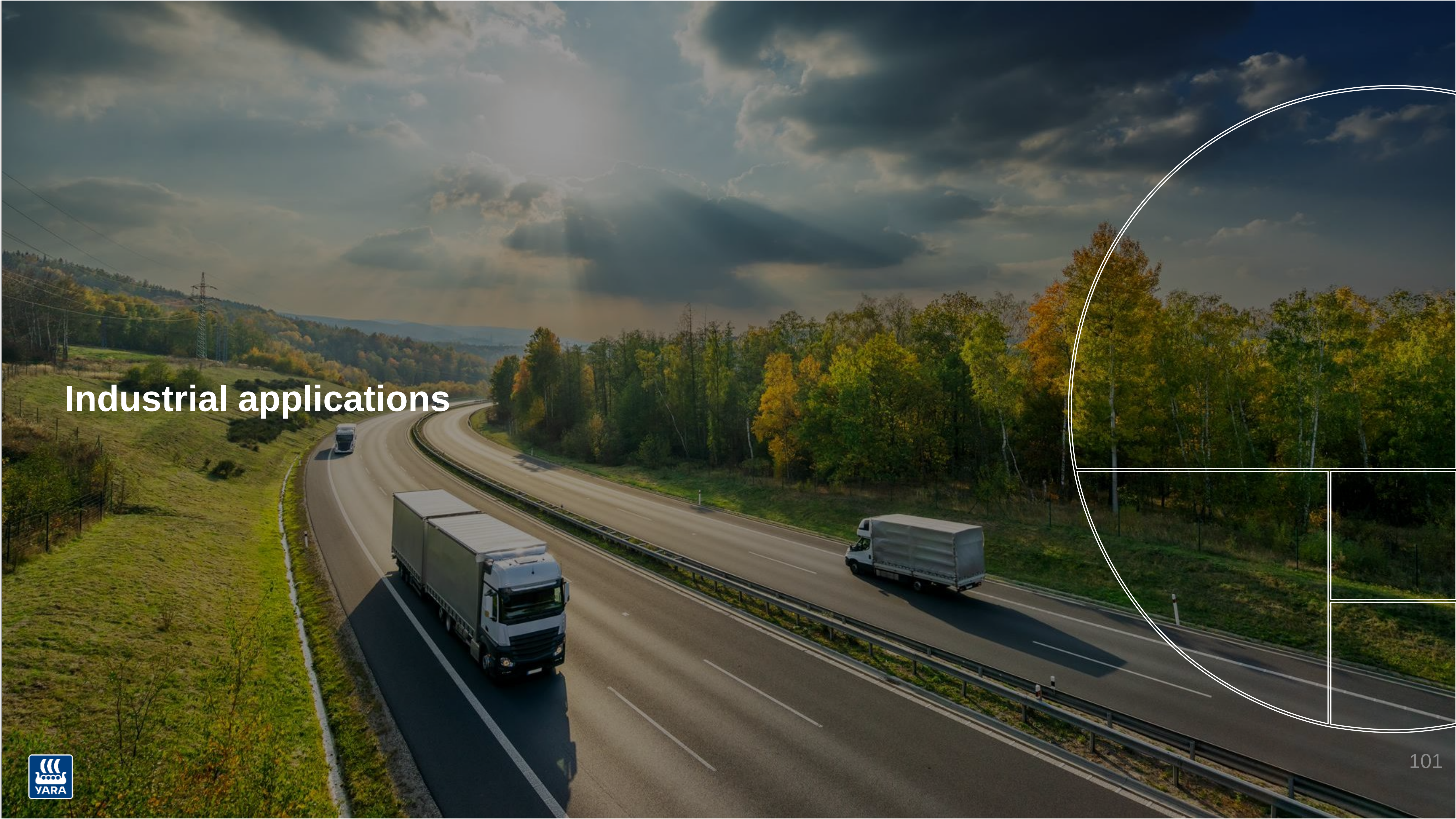


* P2O5 content of phosphate rock varies. This is an example.

** 1 ton of phosphoric acid requires 1 ton of sulphur.

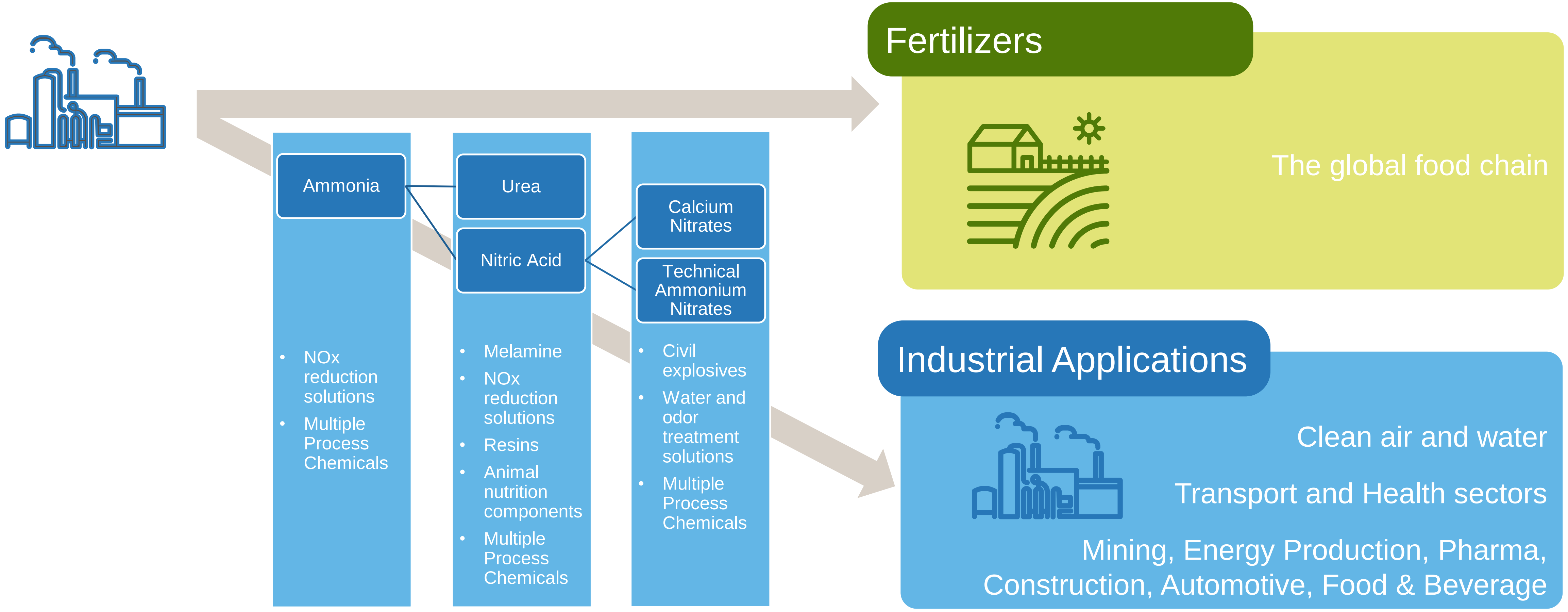
***2020 figures

Source: IFA

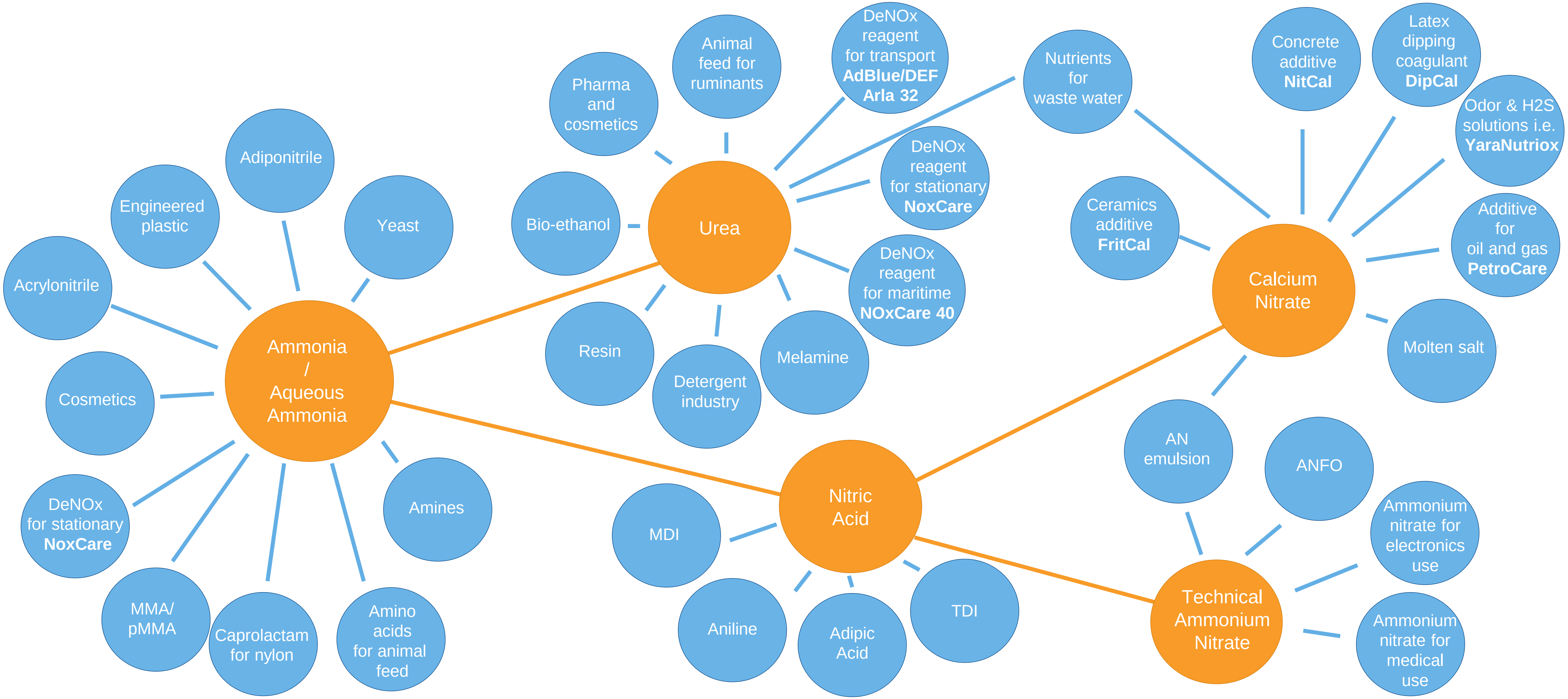


Industrial applications

Nitrogen is key for food production and indispensable in numerous industrial applications in addition to fertilizer

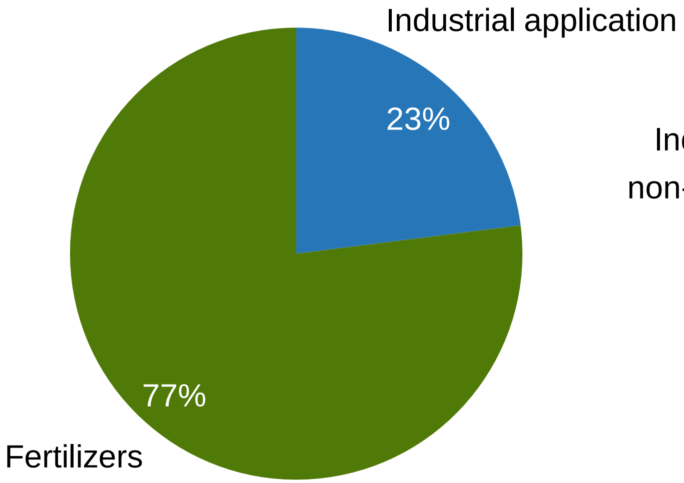


Nitrogen has many industrial applications



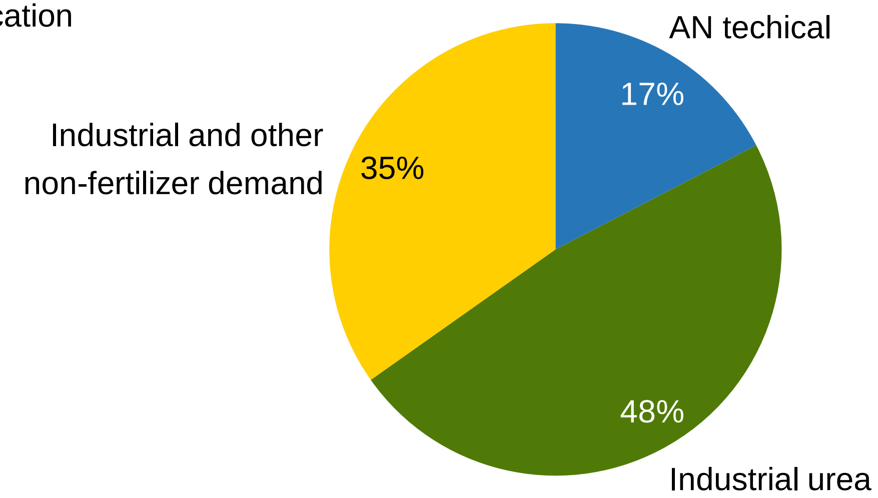
Industrial use accounts for ~23% of global nitrogen consumption

Global ammonia consumption



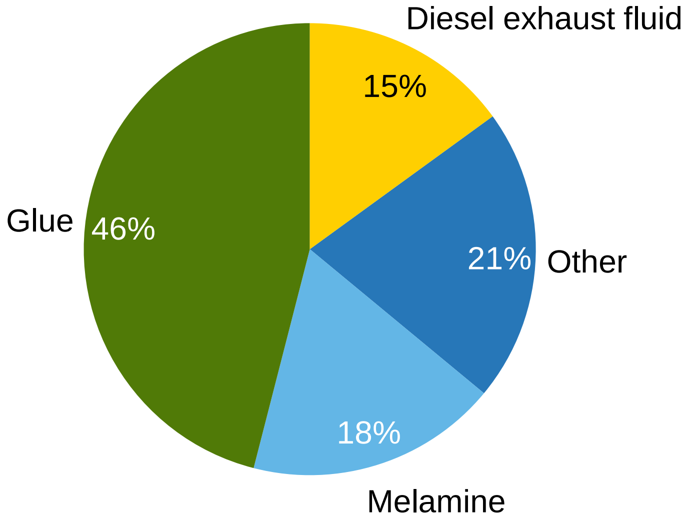
~ 197 mt ammonia

Industrial ammonia consumption



~45 mt ammonia

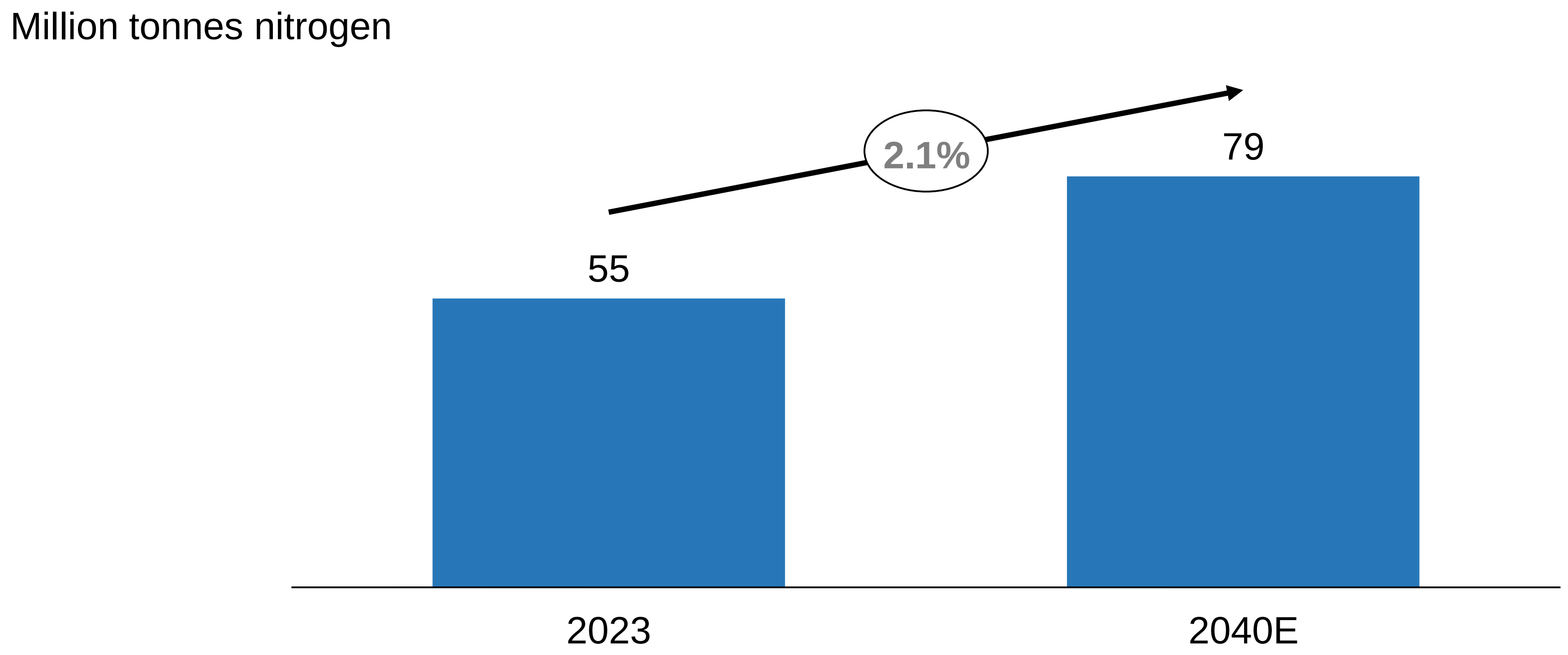
Technical grade urea consumption



~35 mt urea

* Sources: Fertecon, data for 2023

Global demand development for industrial nitrogen applications is strong



Demand growth for Industrial applications is estimated to ~2.1 % annually

Source: Fertecon

Reagents, technology and services to improve air quality

Nitrogen oxides (NOx) are a major air quality issue causing serious problems mostly in urban centers related to both the environment and human health. Legislation around the world drives the business growth.

- **Air 1™ AdBlue/DEF** is a generic name for urea-based solution (32.5% liquid urea) Air 1 is Yaras brand name for AdBlue that is used with the selective catalytic reduction system (SCR) to reduce emissions of oxides of nitrogen from the exhaust of diesel vehicles such as trucks, passenger cars and off-road vehicles

- **NOxcare™** As a world leader in reagents like urea and ammonia in combination with our experience in abatement systems like SNCR and SCR technology Yara offers its clients one of the most comprehensive and effective solutions to reduce NO_x emissions in industrial power plants and utilities.

Calcium nitrate applications in wastewater treatment, concrete manufacturing, oil fields and latex industries

- **Nutriox™** provides H2S prevention for Corrosion, Odor and Toxicity control of municipal and industrial wastewater systems
- **Nitcal™** is a multifunctional concrete admixture serving concrete admixtures companies around the world
- **PetroCare™** prevents well souring and supports drilling in oilfields around the world, for both the oil majors and the service companies that serve them
- **Dipcal™** is the premier dipping coagulant for the latex industry
- Other important applications are in the ceramics, bio-gas and solar CSP industries

YARA

Technical Nitrates for Civil Explosives

- Various grades of Ammonium Nitrate and Calcium Nitrate for use in the civil explosives and mining industries

- Largest customer segments are civil explosives companies, open-pit coal and iron mining sectors

Animal Feed industry with several nutritional products based on core chemicals

- **Feed Phosphates**

  Macro-minerals such as phosphorus and calcium are essential elements to sustain healthy and productive animal growth

- **Feed Acidifiers**

  Antimicrobial effect and lowering pH, replace AGP (antibiotic growth promoter) and effective against salmonella and moulds

- **Feed Urea**

  Source of NPN (non-protein nitrogen) used by rumen micro-organisms forming proteins, replacing part of vegetable protein

- **Ammonia for fermentation**

  Amino acids like lysine, methionine, and threonine are essential to add to lower the total use of protein

Market Data Sources

Sources of market information

Fertilizer market information

Argus	www.argusmedia.com
IHS Markit/S&P Global (Fertecon)	www.spglobal.com/commodityinsights/en/ci/products/agribusiness-fertilizers.html
Fertilizer Week	www.crugroup.com
Profercy	www.profercy.com
ICIS/The Market	www.icis.com
Green Markets (USA)	www.fertilizerpricing.com
China Fertilizer Market Week	www.fertmarket.com

Fertilizer industry associations

International Fertilizer Industry Association (IFA)	www.fertilizer.org
Fertilizers Europe (EFMA)	www.fertilizerseurope.com

Food and grain market information

Food and Agriculture Organization of the UN	www.fao.org
International Grain Council	www.igc.org.uk
Chicago Board of Trade	www.cmegroup.com
World Bank commodity prices	www.worldbank.org
US Department of Agriculture (USDA)	www.usda.gov

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Knowledge grows