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What is fertilizer?
Fertilizers are plant nutrients, required for crops to grow

- Crops need energy (light) CO₂, water and minerals to grow
- The carbon in crops originates from CO₂ 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
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 a balanced nutrition of all plant nutrients
Why mineral fertilizer?
Mineral fertilizers replace nutrients removed with the harvest

Supply of crop residues and organic fertilizer

Crop residues are decomposed to minerals

Mineralisation

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

Mineral fertilizers are necessary to replace those nutrients that have been removed from the field
# Mineral fertilizer characteristics compared to organic fertilizer

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Mineral fertilizer</th>
<th>Organic fertilizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutrient source</td>
<td>Nitrogen from the air, Phosphate and Potassium from deposits / mines</td>
<td>Crop residues and animal manures</td>
</tr>
<tr>
<td>Nutrient concentration</td>
<td>High nutrient concentration, Low logistical cost</td>
<td>Low nutrient concentration, Large volumes to transport and store</td>
</tr>
<tr>
<td>Nutrient availability</td>
<td>Immediately available for the crop</td>
<td>Variable, organic material needs to be decomposed to release nutrients</td>
</tr>
<tr>
<td>Quality</td>
<td>Traceable and consistent</td>
<td>Often inconsistent, Dependent on source</td>
</tr>
</tbody>
</table>
Nitrogen – the most important nutrient

Nutrient characteristics

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Primary benefit</th>
<th>Application</th>
<th>Industry structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium (K)</td>
<td>• Improve crop quality</td>
<td>• Application can be varied</td>
<td>• Fewer suppliers, production discipline</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>• Increase crop size</td>
<td>• Annual application critical</td>
<td>• Fragmented Industry, under consolidation</td>
</tr>
<tr>
<td>Nitrogen (N)</td>
<td>• Most important and commonly lacking nutrient</td>
<td></td>
<td>• More dynamic prices, but stable volume</td>
</tr>
</tbody>
</table>

Total 186 million tons nutrients

Source: IFA 2016/2017 season (June 2017 estimates)
Environmental impact of fertilizer
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 competitor average

Application
- Higher efficiency with nitrates
- Precision farming tools
The right nitrogen fertilizer rate is key to avoid nitrate leaching

- Leaching of nitrate into groundwater affects water quality and contributes to eutrophication
- Oversupply of organic and mineral nitrogen fertilizer represents the main driver for nitrate leaching
- Nitrogen fertilizer application according to crop demand does not increase nitrate leaching

![Graph showing the relationship between nitrogen fertilizer supply and grain yield and nitrate in soil after harvest.](image)
Choosing the right nitrogen fertilizer to avoid ammonia volatilization losses

- Volatilization of ammonia gas contributes to pollution, affects air quality and induces soil acidification
- The use of organic or urea-based nitrogen fertilizer represents the main driver for ammonia losses
- Nitrate-based N fertilizer or immediate incorporation of urea into the soil avoids volatilization losses

Ammonia volatilization in % NH3-N per unit N applied

<table>
<thead>
<tr>
<th>N fertilizer</th>
<th>Ammonia volatilization in % NH3-N per unit N applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>CN</td>
<td>0.7</td>
</tr>
<tr>
<td>CAN</td>
<td>1.8</td>
</tr>
<tr>
<td>AN</td>
<td>3</td>
</tr>
<tr>
<td>UAN</td>
<td>10.8</td>
</tr>
<tr>
<td>Urea</td>
<td>19.9</td>
</tr>
</tbody>
</table>

Reference: EMEP/EEA emission inventory guidebook 2013
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
- Sub-optimal crop nutrition tends to drive over-consumption of water
- Optimized crop nutrition improves water use efficiency

![Water requirement graph](image)

Water requirement (liter per kg of wheat grain)

- No fertilizer: 600
- Low: 510
- Medium: 450
- Right: 380

Supply of fertilizer to the crop

Source: Yara research
Carbon footprint of urea production differs by region

kg CO₂ equivalents per kg urea nitrogen

Source: Fertilizers Europe (2016) for production in 2014
Carbon footprint of ammonium nitrate production by region

kg CO₂ equivalents per kg AN nitrogen

Source: Fertilizers Europe (2016) for production of granulated AN in 2014
The fertilizer industry
Consumption trend per nutrient

Source: IFA, June 2017

* CAGR avg. 2014-2016 to 2021
Key global fertilizer products

Source: IFA 2016 (nutrient totals) and 2015 (product split)  * Does not include industrial nitrogen applications
Nutrient application by crop

By tonnes nutrient

Source: IFA (2014/15)
Fertilizer consumption by region – 5 key markets

Million tons nutrient consumption

Source: IFA 2015
Nitrogen consumption in key regions

Million tonnes nitrogen

Source: IFA, June 2017

* CAGR avg. 2014-2016 to 2021
Despite a consolidation trend, the industry is still higher fragmented

Top 3 producers account for only ~15% of world capacity

More concentrated than N-industry

Top 3 producers account for ~24% of capacity

Highly concentrated industry

Top 3 producers account for ~49% of capacity

Source: IFA

1) Nitrogen: 2013 figures
Nitrogen fertilizer application by region and product

Source: IFA 2015
Nitrogen fertilizer application by region and crop

Source: IFA 2014/15
Yara – the leading nitrogen fertilizer company

2017 production capacity, excl. Chinese producers¹ (mill. tonnes)

<table>
<thead>
<tr>
<th></th>
<th>CF</th>
<th>Yara</th>
<th>Nutrien</th>
<th>OCI</th>
<th>Oschrem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global no 2 in ammonia</td>
<td>9.9</td>
<td>9.1²</td>
<td>7.2</td>
<td>5.6</td>
<td>3.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Yara</th>
<th>Eurochem</th>
<th>Oschrem</th>
<th>Uralchem</th>
<th>Amon</th>
<th>Borealis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global no 1 in nitrates</td>
<td>7.7</td>
<td>4.2</td>
<td>3.0</td>
<td>2.9</td>
<td>2.4</td>
<td>2.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Yara</th>
<th>Coronandel</th>
<th>Gresik</th>
<th>IFCO</th>
<th>Amon</th>
<th>Proagro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global no 1 in NPK</td>
<td>6.2</td>
<td>3.3</td>
<td>2.7</td>
<td>2.7</td>
<td>2.2</td>
<td>2.2</td>
</tr>
</tbody>
</table>

¹ Incl. companies’ shares of JVs
² As of Jan 2018

* Incl. TAN and CN

* Compound NPK, excl. blends

Source: Yara estimates, company info
Yara – the European cost leader

Production cost index: 100 = European industry average excl. Yara

Source: Fertilizer Europe
Ammonia
Global ammonia production

2006-2016 trend growth rate = 1.9%/year

Source: IFA
Most of global ammonia production is upgraded to urea and other finished fertilizer.

### Ammonia trade - seaborne

- **World trade**
- **Yara trade**

### Ammonia use (2016)

- **Fertilizer**
  - Urea: 139
  - Nitrates
  - DAP/MAP
  - NPK
  - Other N: 37

- **Industrial use**

Sources:
- Yara, IFA
- Fertecon
Global ammonia trade

10 largest exporters (2016)

<table>
<thead>
<tr>
<th>Country</th>
<th>Million tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trinidad</td>
<td>4.6</td>
</tr>
<tr>
<td>Russia</td>
<td>3.7</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>1.4</td>
</tr>
<tr>
<td>Algeria</td>
<td>1.3</td>
</tr>
<tr>
<td>Canada</td>
<td>1.3</td>
</tr>
<tr>
<td>Indonesia</td>
<td>1.1</td>
</tr>
<tr>
<td>Qatar</td>
<td>0.8</td>
</tr>
<tr>
<td>Iran</td>
<td>0.7</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.4</td>
</tr>
<tr>
<td>Australia</td>
<td>0.4</td>
</tr>
</tbody>
</table>

10 largest importers (2016)

<table>
<thead>
<tr>
<th>Country</th>
<th>Million tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>4.8</td>
</tr>
<tr>
<td>India</td>
<td>2.7</td>
</tr>
<tr>
<td>Morocco</td>
<td>1.1</td>
</tr>
<tr>
<td>Korea</td>
<td>1.0</td>
</tr>
<tr>
<td>Belgium</td>
<td>0.9</td>
</tr>
<tr>
<td>Germany</td>
<td>0.7</td>
</tr>
<tr>
<td>Taiwan</td>
<td>0.6</td>
</tr>
<tr>
<td>France</td>
<td>0.6</td>
</tr>
<tr>
<td>China</td>
<td>0.5</td>
</tr>
<tr>
<td>Turkey</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Source: IFA
Main ammonia flows 2016

Million tonnes

Source: IFA 2016, 85% of trade shown
Urea
Global urea production

2006-2016 trend growth rate = 2.8% p.a.

Source: IFA
Global urea trade

10 largest exporters (2016)

- China: 8.9 M tonnes
- Russia: 6.0 M tonnes
- Qatar: 5.4 M tonnes
- Oman: 4.2 M tonnes
- Iran: 3.4 M tonnes
- Egypt: 2.9 M tonnes
- Algeria: 2.8 M tonnes
- UAE: 2.1 M tonnes
- Ukraine: 1.8 M tonnes
- Others: 1.4 M tonnes

10 largest importers (2016)

- India: 7.2 M tonnes
- USA: 7.2 M tonnes
- Brazil: 5.0 M tonnes
- Australia: 2.4 M tonnes
- Turkey: 2.3 M tonnes
- Thailand: 2.3 M tonnes
- Mexico: 1.8 M tonnes
- France: 1.1 M tonnes
- Philippines: 1.1 M tonnes
- Bangladesh: 1.0 M tonnes

Source: IFA
Main urea flows 2016

Million tonnes

Source: IFA 2016, 86% of total trade shown
Global pricing at times below the Chinese floor, due to limited need for Chinese urea in the global market

Source: China Fertilizer Market Week, International publications
Nitrate production

10 largest producers (2016)

<table>
<thead>
<tr>
<th>Country</th>
<th>Domestic consumption</th>
<th>Exports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russia</td>
<td>1.5</td>
<td>0.1</td>
</tr>
<tr>
<td>USA</td>
<td>2.4</td>
<td>0.1</td>
</tr>
<tr>
<td>China</td>
<td>0.1</td>
<td>1.8</td>
</tr>
<tr>
<td>France</td>
<td>0.1</td>
<td>1.2</td>
</tr>
<tr>
<td>Poland</td>
<td>0.2</td>
<td>0.7</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.7</td>
<td>0.6</td>
</tr>
<tr>
<td>Australia</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Ukraine</td>
<td>0.4</td>
<td>0.1</td>
</tr>
<tr>
<td>Uzbekistan</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Belgium</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

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

10 largest producers by company (2016)

<table>
<thead>
<tr>
<th>Company</th>
<th>AN/CAN/CN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yara</td>
<td>7.4</td>
</tr>
<tr>
<td>Eurochem</td>
<td>4.5</td>
</tr>
<tr>
<td>Ostchem</td>
<td>3.2</td>
</tr>
<tr>
<td>Uralchem</td>
<td>2.7</td>
</tr>
<tr>
<td>Borealis</td>
<td>2.3</td>
</tr>
<tr>
<td>Grupa Azoty</td>
<td>2.2</td>
</tr>
<tr>
<td>CF</td>
<td>1.9</td>
</tr>
<tr>
<td>Acron</td>
<td>1.8</td>
</tr>
<tr>
<td>Fertiberia</td>
<td>1.8</td>
</tr>
<tr>
<td>Agrofert</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Source: Yara estimates, company info
Nitrates are products with a nitrate content of 50 % or more

<table>
<thead>
<tr>
<th>N fertilizer</th>
<th>N content</th>
<th>Nitrate (% of total N)</th>
<th>Other nutrients</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN (calcium ammonium nitrate)</td>
<td>27%</td>
<td>50%</td>
<td>4% MgO</td>
</tr>
<tr>
<td>AN (ammonium nitrate)</td>
<td>33.5%</td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td>NPK</td>
<td>various</td>
<td>about 50%</td>
<td>P &amp; K</td>
</tr>
<tr>
<td>CN (calcium nitrate)</td>
<td>15.5%</td>
<td>93%</td>
<td>19% Ca</td>
</tr>
<tr>
<td>Urea</td>
<td>46%</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>UAN (liquid urea ammonium nitrate)</td>
<td>28%</td>
<td>25%</td>
<td></td>
</tr>
<tr>
<td>ASN (ammonium sulfate nitrate)</td>
<td>26%</td>
<td>25%</td>
<td>13% S</td>
</tr>
<tr>
<td>AS (ammonium sulfate)</td>
<td>21%</td>
<td>0%</td>
<td>24% S</td>
</tr>
</tbody>
</table>
Nitrates vs. urea

Nitrate is the most important fertilizer in Europe

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

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

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.
Urea and UAN underperformance compared with ammonium nitrate

Trial results for arable crops (cereals, UK)

Extra N required for same yield
%  
AN: 100  
UAN: 118  
Urea: 114

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

Protein content at identical N rate
%  
AN: 12.6  
UAN: 12.1  
Urea: 12.3

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

Yield at identical N rate
%  
AN: 8.6  
UAN: 8.3  
Urea: 8.3

Yield was also significantly lower with urea and UAN than with ammonium nitrate.

Source: DEFRA
Yield advantage of nitrates in tropical climate
Brazil, main season corn

- Research shows that the benefits of nitrates are even more pronounced in the tropics than in colder climates
- YaraBela nitrate provides direct and efficient uptake of nitrate-N
- Consistently lower NH$_3$ volatilization losses
- Reduced acidification in the root zone, supporting root growth and nutrient uptake

Source: Fundation Bahia (2013)
Nitrates’ agronomic advantage has higher value for cash crops than for commodity crops

**Crop value with nitrates**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Value (€/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat/UK</td>
<td>1,553</td>
</tr>
<tr>
<td>Oranges/Brazil</td>
<td>3,192</td>
</tr>
</tbody>
</table>

**Increase in crop production value using nitrates instead of urea**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Increase in Value (Index)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat/UK</td>
<td>100 (160 kg N/ha)</td>
</tr>
<tr>
<td>Oranges/Brazil</td>
<td>1,016 (180 kg N/ha)</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Urea + DAP + MOP</th>
<th>Compound NPK</th>
</tr>
</thead>
</table>

- **N – P$_2$O$_5$ – K$_2$O analysis in a pile of poor quality blend**
- **N – P$_2$O$_5$ – K$_2$O 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

- 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

Potato yield, tonne per ha

Source: Yara field trials
Compound NPK capacities

10 largest countries by capacity

<table>
<thead>
<tr>
<th>Country</th>
<th>Capacity (Million tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>47.1</td>
</tr>
<tr>
<td>Russia</td>
<td>6.8</td>
</tr>
<tr>
<td>Indonesia</td>
<td>6.2</td>
</tr>
<tr>
<td>Vietnam</td>
<td>4.2</td>
</tr>
<tr>
<td>India</td>
<td>3.7</td>
</tr>
<tr>
<td>Turkey</td>
<td>2.6</td>
</tr>
<tr>
<td>Japan</td>
<td>2.6</td>
</tr>
<tr>
<td>Norway</td>
<td>2.5</td>
</tr>
<tr>
<td>France</td>
<td>2.5</td>
</tr>
<tr>
<td>Malaysia</td>
<td>2.2</td>
</tr>
</tbody>
</table>

Source: IFA 2013/2014

10 largest producers by company (ex. China)

<table>
<thead>
<tr>
<th>Company</th>
<th>Capacity (Million tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yara</td>
<td>5.3</td>
</tr>
<tr>
<td>Coronandel</td>
<td>3.3</td>
</tr>
<tr>
<td>Greik</td>
<td>2.7</td>
</tr>
<tr>
<td>Iffco</td>
<td>2.7</td>
</tr>
<tr>
<td>Phosagro</td>
<td>1.9</td>
</tr>
<tr>
<td>Acrion</td>
<td>1.8</td>
</tr>
<tr>
<td>Eurochem</td>
<td>1.8</td>
</tr>
<tr>
<td>Roullier</td>
<td>1.5</td>
</tr>
<tr>
<td>Grupa Azoty</td>
<td>1.5</td>
</tr>
<tr>
<td>Rososh</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Source: Yara estimates, company info
Industry value drivers
Key value drivers

Ammonia fob Black Sea (USD/t)

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>525</td>
<td>240</td>
<td>357</td>
<td>516</td>
<td>545</td>
<td>477</td>
<td>496</td>
<td>387</td>
<td>236</td>
<td>267</td>
</tr>
</tbody>
</table>

Urea prilled fob Black Sea (USD/t)

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>499</td>
<td>249</td>
<td>289</td>
<td>423</td>
<td>407</td>
<td>341</td>
<td>318</td>
<td>272</td>
<td>198</td>
<td>221</td>
</tr>
</tbody>
</table>

Henry Hub (USD/MMBtu)

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>8.9</td>
<td>4.4</td>
<td>4.1</td>
<td>2.8</td>
<td>3.7</td>
<td>4.7</td>
<td>2.6</td>
<td>2.5</td>
<td>3.0</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Oil Brent blend spot (USD/bbl)

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Value</td>
<td>97</td>
<td>80</td>
<td>104</td>
<td>105</td>
<td>104</td>
<td>96</td>
<td>51</td>
<td>43</td>
<td>54</td>
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</tr>
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</table>

CAN cif Germany (USD/t)

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</thead>
<tbody>
<tr>
<td>Value</td>
<td>466</td>
<td>240</td>
<td>261</td>
<td>379</td>
<td>337</td>
<td>316</td>
<td>329</td>
<td>268</td>
<td>195</td>
<td>219</td>
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</tbody>
</table>

NOK/USD exchange rate

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<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Value</td>
<td>5.6</td>
<td>6.3</td>
<td>6.0</td>
<td>5.9</td>
<td>6.3</td>
<td>5.9</td>
<td>6.3</td>
<td>8.1</td>
<td>8.4</td>
<td>8.3</td>
</tr>
</tbody>
</table>

Source: Fertilizer market publications, World Bank, Norges Bank

Average 2008 – 2017
## Nitrogen fertilizer value drivers

<table>
<thead>
<tr>
<th>Drivers</th>
<th>Effect on</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chinese coal prices</td>
<td>Supply-driven price for urea</td>
</tr>
<tr>
<td>Grain inventories/prices</td>
<td>Urea demand</td>
</tr>
<tr>
<td>New urea capacity vs. closures</td>
<td>Urea supply</td>
</tr>
<tr>
<td>Global urea demand vs. supply</td>
<td>Urea price (above floor)</td>
</tr>
<tr>
<td>Urea price</td>
<td>Most other nitrogen fertilizer prices</td>
</tr>
<tr>
<td>Cash crop prices</td>
<td>Value-added fertilizer premiums</td>
</tr>
</tbody>
</table>

### Revenue drivers

<table>
<thead>
<tr>
<th>Drivers</th>
<th>Effect on</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil product prices and LNG capacity expansion</td>
<td>Gas cost in Europe</td>
</tr>
<tr>
<td>Manning and maintenance</td>
<td>Fixed cost</td>
</tr>
<tr>
<td>Productivity and economies of scale</td>
<td>Unit cost</td>
</tr>
</tbody>
</table>
Drivers of demand
Drivers of fertilizer consumption growth

• Food demand drives fertilizer consumption
  • Population growth of about 80 million each year
  • Economic growth change diets
    • Higher meat consumption in developing countries
    • More protein-rich diets
    • More fruit and vegetables
    • Reduce hunger
  • Biofuels

• Industrial consumption
  • Economic growth
  • Environmental limits (e.g. reduction of NOx emissions)
Key crops by producing by region

Maize-global production 1,031 mt
- United States: 37%
- China: 21%
- Other: 25%
- Ukraine: 3%
- EU-28: 6%
- Brazil: 8%

Wheat-global production 745 mt
- Other: 33%
- EU-28: 19%
- China: 17%
- Russia: 17%
- India: 12%
- US: 9%

Rice-global production 484 mt
- Other: 27%
- China: 30%
- Vietnam: 15%
- Bangladesh: 7%
- Indonesia: 8%
- India: 22%

Soybeans-global production 336 mt
- USA: 35%
- Brazil: 30%
- Argentina: 17%
- Other: 11%
- China: 3%
- India: 4%

Source: USDA, 2016/17 season
Growing meat consumption increases demand for cereals

China example

The example of China illustrates that changing diets towards higher meat consumption increases overall demand for cereals.

Higher meat consumption requires more feed grain.

Source: McKinsey
Steady growth in grain consumption, while production growth is more volatile due to weather variations

**Grain consumption and production**

- Consumption
- Production

**Days of consumption in stocks**

Source: USDA October 2018
China drives recent years’ increases in global grain stocks

Grain stocks – China versus the rest

Days of consumption in stocks

Source: USDA October 2018
Profitability of investment in mineral fertilizers

- The investment in nitrogen fertilizer is highly profitable for growers
- Fertilizer investment: 175 USD/ha
- Net return: 1,214 USD/ha
- Net return ~ 7 x investment

Source: Winter wheat yield data: Long term trial, Broadbalk, Rothamsted (since 1856).
Breakdown of grain production costs

Example: 2017F average US corn production costs

Source: USDA (Cost-of-production forecasts November 2017)
Large variations in yields across regions

**Maize yields**
- **US**: 11.0
- **Argentina**: 7.4
- **China**: 5.9
- **Brazil**: 4.3
- **Mexico**: 3.7

**Rice yields**
- **China**: 6.9
- **Viet Nam**: 5.6
- **Indonesia**: 5.4
- **Bangladesh**: 4.6
- **India**: 3.7

**Wheat yields**
- **China**: 5.4
- **France**: 5.3
- **US**: 3.5
- **India**: 3.1
- **Russia**: 2.7

**Soybean yields**
- **US**: 3.5
- **Argentina**: 3.0
- **Brazil**: 2.9
- **China**: 1.8
- **India**: 1.2

Source: FAOSTAT 2016
## Seasonality in fertilizer consumption

<table>
<thead>
<tr>
<th>Country/Product</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
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<tbody>
<tr>
<td><strong>Corn</strong></td>
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<td>Brazil, first crop</td>
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<td><strong>Wheat</strong></td>
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<td>China (winter wheat)</td>
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<td>China (spring wheat)</td>
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<td>India (Rabi)</td>
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<td>USA (winter wheat)</td>
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<td>Europe (winter wheat)</td>
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<td>FSU (winter wheat)</td>
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<td><strong>Rice</strong></td>
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<td>China (early double crop)</td>
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<td>China (late double crop)</td>
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<td>India (Kharif)</td>
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<td>India (Rabi)</td>
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</tbody>
</table>

### Source: USDA
N-fertilizer consumption from biofuels production

Million tonnes nitrogen

- US - maize for ethanol: 2.2
- Europe - rapeseed for biodiesel: 0.6
- Brazil - sugarcane for ethanol: 0.3
- Others: 0.4

Source: Yara estimates 2017
Organic farming represents a marginal share of total cultivated land

- The principles of crop nutrition are also valid for organic farms
- Organic farms use manure and crop residues to deliver minerals to their crops
- Organic farming is a niche market, mainly for consumers in the developed world

Source: Organic-world.net
Drivers of supply
Nitrogen value chain

Raw material
- Natural gas

Intermediate products
- Ammonia
- Nitric acid

Finished products
- H, Ar, CO etc
- CO₂
- Ammonia
- Urea
- Nitric acid
- Nitrates
- Calcium Nitrate

Industrial products
- Industrial gases
- Environmental products
- Industrial nitrogen chemicals
Fertilizer production routes

- Ammonia plant
  - Natural gas (coal, oil)
  - Air
  - Ammonia
  - CO₂

- Nitric acid plant
  - Air
  - Nitric acid

- Phosphoric acid plant
  - Rock (P)
  - Sulphur (S)
  - H₃PO₄

- Sulphuric acid plant
  - H₃PO₄

- Finished fertilizer products
  - Ammonia
  - Urea
  - Ammonium Nitrate (AN)
  - Calcium Ammonium Nitrate (CAN)
  - Triple Super Phosphate (TSP)
  - Single Super Phosphate (SSP)
  - DAP / MAP
NPK production routes

1. Igneous and calcined sedimentary

- **Natural gas** (coal, oil)
  - Ammonia plant
    - Nitric acid plant
      - Nitrophosphate plant
        - Phosphoric acid plant
          - Sulphuric acid plant

- Phosphate rock
  - Nitrophosphate plant
    - Phosphoric acid plant
      - Sulphuric acid plant
        - Sulphur
          - MOP/SOP

- Air
  - Ammonia
    - Nitric acid
      - Nitrophosphate plant
        - Phosphoric acid plant
          - Sulphuric acid plant

- **Urea**
  - AN/CAN
    - MAP/DAP
      - SSP/TSP
        - MOP/SOP

1. Nitrophosphate based NPK + Calcium Nitrate (CN)
2. Phosphoric acid based NPK + gypsum
3. Dry blend
4. Steam granulated NPK (also compound)
Nitrogen technology evolution

- Birkeland-Eyde electric arc method
- Cyanamid method
- Haber-Bosch synthesis
- Steam reforming natural gas
- Theoretical minimum
Projected nitrogen capacity additions outside China

Global urea capacity additions excl. China (mill. tonnes)

Source: CRU September 2018
30% of announced nitrogen projects realized on time

Likely and probable ammonia projects in pipeline 2002-2008; Million tons

- Projects in 02 pipeline: 22
- Added to pipeline from 02-08: 30
- Total projects in pipeline between 02-08: 52
- Due after 08: 17
- Due within 08: 35
- Cancelled: 22
- Delayed: 2
- Realized: 11

Note: Chinese projects are excluded from pipeline

5 year typical construction time for nitrogen fertilizer projects*

- Business development
  - Gas agreement
- Feasibility phase
- Concept selection phase
- Prepare for execution
- Construction
- Operation

4–6 years

12-24 months depending on complexity

30-36 months

6-12 months
- check cost assumptions by approaching market
- bidding for contracts and/or equipment

* Ammonia and urea plant example
Price relations
Upgrading margins from ammonia to urea

Source: Average of international publications
Grain prices important for fertilizer demand

Source: World Bank, Fertilizer publications
The urea market has been supply-driven since 2014

Source: Fertecon (Ukraine), Yara estimates
Nitrate premium is mainly a function of crop prices and marketing

Source: World Bank, Fertilizer publications

* Urea fob Black sea adjusted for import costs into Europe and nitrogen content similar to CAN
Grain/oilseed prices – yearly averages

Source: World Bank, December 2017
Cash crop prices – yearly averages

Source: World Bank, December 2017
10-year fertilizer prices – monthly averages

Source: Average of international publications
Production economics
Yara’s operating cash costs are mainly variable

Temporary plant closures can be carried out with limited stop/start costs

Example for ammonia/urea plants:
- Typically half a week to stop and a week to start
- Cost of stopping is 2 days energy consumption
- Cost of starting is 3 days energy consumption

### Operating cash cost 2017

- Variable costs (84%)
  - Dry raw materials
  - Energy
  - Freight
  - 3rd party finished fertilizer
  - Total: 70.3 billion NOK

- Other cash cost (16%)
  - Total: 13.3 billion NOK

Total operating cash cost: 83.6 billion NOK
## Ammonia cash cost build-up – example

<table>
<thead>
<tr>
<th>Component</th>
<th>Cost (USD/mt NH₃)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas price</td>
<td>4</td>
</tr>
<tr>
<td>× Gas consumption</td>
<td>36</td>
</tr>
<tr>
<td>= Gas cost</td>
<td>144</td>
</tr>
<tr>
<td>+ Other prod. cost</td>
<td>29</td>
</tr>
<tr>
<td>= Total cash cost</td>
<td>173</td>
</tr>
</tbody>
</table>

**Source:** Blue Johnson & Associates.

**Typical natural gas consumption for ammonia production**

36 MMBtu natural gas/tonne ammonia

Ammonia (NH₃) (82% N)
# Urea cash cost build-up – example

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia price</td>
<td>173 USD/mt NH₃</td>
</tr>
<tr>
<td>Ammonia use</td>
<td>0.58 NH₃/mt urea</td>
</tr>
<tr>
<td>Ammonia cost</td>
<td>100 USD/mt urea</td>
</tr>
<tr>
<td>Process gas cost</td>
<td>21 USD/mt urea</td>
</tr>
<tr>
<td>Other prod. cost**</td>
<td>25 USD/mt urea</td>
</tr>
<tr>
<td>Total cash cost</td>
<td>146 USD/mt urea</td>
</tr>
</tbody>
</table>

* Process gas cost is linked to natural gas price
** Including load-out

---

Source: Blue Johnson & Associates.
There are many NPK formulas; 15-15-15 is one example.

Theoretical consumption factors

- Ammonia (82% N)
- Urea (46% N)
- AN (33.5% N)
- CAN (27% N)
- NPK (15-15-15)*

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

2016 production and exports, million tons product

- Sulphuric acid**
  - Phosphate rock (72% BPL*, 33% P₂O₅)
  - Phosphoric acid (100% P₂O₅)
  - Ammonia (82% N)
  - SSP (15-22% P₂O₅)
    - Production: 25
    - Export: 2
  - DAP (18% N, 46% P₂O₅)
    - Production: 34
    - Export: 16
  - MAP (11% N, 52% P₂O₅)
    - Production: 29
    - Export: 10
  - TSP (46% P₂O₅)
    - Production: 6
    - Export: 3

Rock production: 200
Rock exports: 28

Production: 45
Export: 4

Production: 34
Export: 16

Production: 29
Export: 10

Production: 6
Export: 3

Source: IFA

* P₂O₅ content of phosphate rock varies. This is an example.
** 1 ton of phosphoric acid requires 1 ton of sulphur.
***2015 figures
Industrial applications
Nitrogen has many industrial applications

- Ammonia
- Nitric acid
- Technical nitric acid
- Concentrated nitric acid
- Acrylonitrile
- Urea
- Melamine
- Formates
- Aqueous ammonia
- Glue
- NO\textsubscript{x} abatement
- Industrial gases
- CO\textsubscript{2}
- Nitrogen
- Oxygen
- Argon
- Propane
- Dry ice
- AdBlue®/heavy-duty vehicles
- Vessels
- Stationary sources
- Applic. LIC
- LIC wholesale
- Nitrogen has many industrial applications
- H\textsubscript{2}S abatement in oil fields
- H\textsubscript{2}S abatement in sewage
- NITCAL®
- DIPCAL®
- ANFO
- Emulsions
- TAN
- N\textsubscript{2}O abatement
- NH\textsubscript{3}
- Ammonia
Industrial use accounts for 21% of global nitrogen consumption

~31.5 million tonnes N

- Chemicals: 75%
- Explosives: 19%
- Environmental and other: 6%

~21% of total nitrogen consumption

~10 million tonnes N as urea

- Glue: 57%
- Melamine: 20%
- Environmental: 11%
- Other: 12%

~13-14% of total urea consumption

Source: Yara estimates 2017, IFA, Fertecon, CRU, Integer
Global demand development of nitrogen chemicals for industrial applications is strong

Demand growth for Industrial applications is estimated to ~3 % annually

Source: Yara estimates, IFA, Fertecon, CRU, Integer
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 NOx emissions in industrial power plants and utilities.

- In the maritime segment Yara offers SCR and scrubber technologies to abate NOx and SOx (sulphuric oxide) emissions.
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 waste water 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
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, threonine are essential to add to lower total use of protein
Sources of market information

- **Fertilizer market information**
  - Argus
  - Fertecon
  - Fertilizer Week
  - Profercy
  - The Market
  - Green Markets (USA)
  - Beijing Orient Business (China)
  - China Fertilizer Market Week
  - www.argusmedia.com
  - www.fertecon.com
  - www.cruonline.crgroup.com
  - www.profercy.com
  - www.icispricing.com
  - www.fertilizerpricing.com
  - www.boabc.com
  - www.fertmarket.com

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

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