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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 fertilizer replace nutrients removed with the harvest

Supply of crop residues and organic fertilizer

Crop residues are decomposed to minerals

Organic material, humus

Mineralisation

N
P
K
S
Ca
Mg

NPK

• 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,</td>
<td>Crop residues and animal manures</td>
</tr>
<tr>
<td></td>
<td>Phosphate and Potassium from deposits / mines</td>
<td></td>
</tr>
<tr>
<td>Nutrient concentration</td>
<td>High nutrient concentration</td>
<td>Low nutrient concentration</td>
</tr>
<tr>
<td></td>
<td>Low logistical cost</td>
<td>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</td>
</tr>
<tr>
<td></td>
<td></td>
<td>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 181 million tons nutrients

Source: IFA 2015/2016 season (June 2016 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.
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 (%)</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
Water availability is the main constraint on agricultural production in many important growing areas.

Water scarcity is a clear issue

- Rio Grande: failed to reach Gulf of Mexico in 2001 for first time
- Lake Aral: only ~25% of original size
- Yellow River: dry on last 100km: 1972: 15 days, 1997: 226 days

Agricultural water use has to become more "intelligent"

- 17% of cropland is irrigated, it is twice as productive as other land and contributes 40% of world food production…
- …but it uses 70% of all freshwater…
- …thus, productivity growth from irrigation has to come from better use of water

The segment has seen strong growth historically

Expansion of Micro-irrigation

<table>
<thead>
<tr>
<th>Year</th>
<th>Mill. ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>0.4</td>
</tr>
<tr>
<td>1986</td>
<td>1.0</td>
</tr>
<tr>
<td>1991</td>
<td>1.8</td>
</tr>
<tr>
<td>2000</td>
<td>3.2</td>
</tr>
<tr>
<td>2006</td>
<td>6.2</td>
</tr>
<tr>
<td>2009</td>
<td>10.2</td>
</tr>
</tbody>
</table>

CAGR: 11.9%

Source: Center Pivot: carrot production in Brazil

Source: Kulakarni et.al., 2006; Gopalakrishnan, 2008; USDA, 2008; MOI, 2009
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 (liter per kg of wheat grain)**

<table>
<thead>
<tr>
<th>Supply of fertilizer to the crop</th>
<th>No fertilizer</th>
<th>low</th>
<th>medium</th>
<th>right</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water requirement</td>
<td>600</td>
<td>510</td>
<td>450</td>
<td>380</td>
</tr>
</tbody>
</table>

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

kg CO₂ equivalents per kg urea nitrogen

EU 27: 3.50
Russia: 3.99
US: 3.78
Africa: 3.61
China (coal-based): 6.53
China (gas-based): 4.14

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

kg CO\(_2\) equivalents per kg AN nitrogen

<table>
<thead>
<tr>
<th>Region</th>
<th>CO(_2) Footprint</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU 27</td>
<td>3.42</td>
</tr>
<tr>
<td>Russia</td>
<td>7.23</td>
</tr>
<tr>
<td>US</td>
<td>6.82</td>
</tr>
<tr>
<td>China (coal-based)</td>
<td>11.06</td>
</tr>
<tr>
<td>China (gas-based)</td>
<td>8.61</td>
</tr>
</tbody>
</table>

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

Source: IFA, June 2016

* CAGR avg. 2013-2015 to 2020
Key global fertilizer products

- **Potash K₂O**
  - 32 million tonnes
  - MOP/SOP 76%
  - NPK 21%
  - Other 3%

- **Nitrogen N**
  - Urea 58%
  - Ammonia 4%
  - DAP/MAP 7%
  - NPK 6%
  - AN/CAN 9%
  - UAN 5%
  - Other 11%
  - 108 million tonnes*

- **Phosphate P₂O₅**
  - 41 million tonnes
  - DAP/MAP 57%
  - SSP 9%
  - NPK 18%
  - TSP 6%
  - Other 10%

Source: IFA 2015 (nutrient totals) and 2014 (product split)  * Does not include industrial nitrogen applications
Nutrient application by crop

By tonnes nutrient

Source: IFA (2010/11)
Fertilizer consumption by region – 5 key markets

Million tons nutrient consumption

Source: IFA 2014
Nitrogen consumption in key regions

Million tonnes nitrogen

Source: IFA, June 2015

* CAGR 2015-2020
The N industry is fragmented, while the P and K industries are more concentrated

2015 figures¹, million tonnes nutrient

Nitrogen¹ (N)

Phosphate (P)

Potash (K)

¹ Nitrogen: 2013 figures

- 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 ~48% of capacity

Source: IFA
Nitrogen fertilizer application by region and product

China (32.9 mt)
- Urea: 70%
- Nitrates: 43%
- UAN: 12%
- NPK: 6%
- DAP/MAP: 9%
- ABC: 17%
- Other: 1%

West/central Europe (11.4 mt)
- Urea: 21%
- Nitrates: 43%
- UAN: 12%
- NPK: 7%
- DAP/MAP: 11%
- AS: 12%
- Other: 3%

USA (11.8 mt)
- Urea: 22%
- UAN: 28%
- Ammonia: 27%
- Nitrates: 2%
- NPK: 6%
- DAP/MAP: 7%
- Other: 7%

Brazil (3.9 mt)
- Urea: 55%
- Nitrates: 12%
- NPK: 1%
- DAP/MAP: 22%
- Other: 1%

India (16.8 mt)
- Urea: 84%
- Nitrates: 12%
- NPK: 3%
- DAP/MAP: 13%
- Other: 1%

Source: IFA 2014
Nitrogen fertilizer application by region and crop

Source: IFA 2010/11
Fertilizer company comparison

Revenues - USD billion

- **Yara**: 12.2 (L4Q), 13.4 (2015)
- **Agrium**: 13.9 (L4Q), 14.8 (2015)
- **Mosaic**: 7.5 (L4Q), 8.9 (2015)
- **PCS**: 5.3 (L4Q), 6.3 (2015)
- **K+S**: 3.9 (L4Q), 4.6 (2015)
- **ICL**: 5.5 (L4Q), 5.4 (2015)
- **CF**: 3.9 (L4Q), 4.3 (2015)

Source: Thomson Worldscope
Yara – the leading nitrogen fertilizer company

2016 production capacity, excl. Chinese producers\(^1\) (mill. tonnes)

<table>
<thead>
<tr>
<th></th>
<th>Global no 2 in ammonia</th>
<th>Global no 1 in nitrates</th>
<th>Global no 1 in NPK</th>
</tr>
</thead>
<tbody>
<tr>
<td>CF</td>
<td>9.9</td>
<td>7.4</td>
<td>5.3</td>
</tr>
<tr>
<td>Yara</td>
<td>8.4(^2)</td>
<td>4.5</td>
<td>3.3</td>
</tr>
<tr>
<td>PCS/Agrium</td>
<td>7.2</td>
<td>3.2</td>
<td>2.7</td>
</tr>
<tr>
<td>OCI</td>
<td>4.2</td>
<td>2.7</td>
<td>2.7</td>
</tr>
<tr>
<td>Osthem</td>
<td>4.1</td>
<td>2.3</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Source: Yara estimates, company info

1) Incl. companies’ shares of JVs
2) As of end 2016

* Incl. TAN and CN

* Compound NPK, excl. blends
Yara – the European cost leader

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

Source: Fertilizer Europe
Ammonia
Global ammonia production

**Total production**

- 2005-2015 trend growth rate = 2.2%/year

**10 largest producers (2015)**

- China: 66.6
- Russia: 15.2
- India: 13.8
- USA: 11.7
- Indonesia: 6.0
- Trinidad: 5.3
- Canada: 4.9
- Qatar: 3.7
- Pakistan: 3.7
- Saudi Arabia: 3.7

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

![Ammonia trade - seaborne](chart.png)

**World trade**

- 2005: 20 million tonnes
- 2006: 19 million tonnes
- 2007: 18 million tonnes
- 2008: 18 million tonnes
- 2009: 17 million tonnes
- 2010: 16 million tonnes
- 2011: 16 million tonnes
- 2012: 16 million tonnes
- 2013: 16 million tonnes
- 2014: 16 million tonnes
- 2015: 16 million tonnes

**Yara trade**

- 2005: 4 million tonnes
- 2006: 3 million tonnes
- 2007: 3 million tonnes
- 2008: 3 million tonnes
- 2009: 3 million tonnes
- 2010: 3 million tonnes
- 2011: 3 million tonnes
- 2012: 3 million tonnes
- 2013: 3 million tonnes
- 2014: 3 million tonnes
- 2015: 3 million tonnes

Source: Yara, IFA

![Ammonia use](chart.png)

- **Fertilizer**
  - Urea: 143 million tonnes
  - Nitrates: 10 million tonnes
  - DAP/MAP: 20 million tonnes
  - NPK: 30 million tonnes
  - Other N: 10 million tonnes

- **Industrial use**
  - 37 million tonnes

Source: Fertecon
Global ammonia trade

10 largest exporters (2015)

- Trinidad: 4.5
- Russia: 3.6
- Algeria: 1.2
- Canada: 1.2
- Indonesia: 1.1
- Saudi Arabia: 1.0
- Qatar: 0.8
- Iran: 0.7
- Ukraine: 0.7
- Netherlands: 0.4

10 largest importers (2015)

- USA: 5.4
- India: 2.3
- Korea: 1.0
- Belgium: 0.9
- Morocco: 0.9
- France: 0.8
- Germany: 0.7
- Taiwan: 0.6
- Turkey: 0.6
- Spain: 0.5

Source: IFA
Main ammonia trade flows (2015)

Million tonnes

Source: IFA 2015 trade statistics (covering 85% of total trade)
Urea
Global urea production


Source: IFA
Global urea trade

**10 largest exporters (2015)**

- China: 13.7
- Qatar: 5.4
- Russia: 5.0
- Saudi Arabia: 3.7
- Oman: 3.4
- Iran: 2.6
- UAE: 1.9
- Ukraine: 1.6
- Algeria: 1.5
- Malaysia: 1.0

**10 largest importers (2015)**

- India: 10.6
- USA: 7.9
- Brazil: 4.2
- Thailand: 2.1
- Australia: 1.8
- Turkey: 1.7
- Mexico: 1.2
- Bangladesh: 1.1
- France: 1.0
- Canada: 0.9

Source: IFA
Main urea trade flows (2015)

Million tonnes

Source: IFA 2015 trade statistics (covering 87% of total trade)
Chinese domestic urea price and export tax set the global floor price

Source: China Fertilizer Market Week, International publications
Nitrates
Nitrate production

10 largest producers (2015)

- Million tonnes nitrogen (AN/CAN)
- Source: IFA, AN/CAN including nitrate part of UAN, as are industrial grades

10 largest producers by company (2015)

- Million tonnes AN/CAN/CN
- 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>34%</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>
Nitrate is the most important fertilizer in Europe.

Nitrate ($\text{NO}_3^-$) and Ammonium ($\text{NH}_4^+$) are two forms of nitrogen used by plants. Ammonium is fixed onto clay minerals in the soil and therefore immobile. The plant roots have to grow actively towards the nutrient. Nitrate 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** ($\text{CON}_2\text{H}_4$) needs to be converted into ammonium-N before it is plant available.

**Nitrate** ($\text{NO}_3^-$) vs. **urea** ($\text{CON}_2\text{H}_4$):

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

**Diagram:***

- Urea ($\text{CON}_2\text{H}_4$)
- Ammonium ($\text{NH}_4^+$)
- Nitrate ($\text{NO}_3^-$)
Urea and UAN underperformance compared with ammonium nitrate

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 and UAN than from ammonium nitrate.

Protein content at identical N rate

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

Yield at identical N rate

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 NH₃ 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 Type</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 Type</th>
<th>Index (100 - 1,016)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat/UK</td>
<td>100</td>
</tr>
<tr>
<td>Oranges/Brazil</td>
<td>1,016</td>
</tr>
</tbody>
</table>
NPKs
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>

<table>
<thead>
<tr>
<th>N – P₂O₅ – K₂O analysis</th>
<th>N – P₂O₅ – K₂O analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>in a pile of poor quality blend</td>
<td>in a pile of compound NPK 15-15-15</td>
</tr>
</tbody>
</table>

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

- Compound NPKs 16+16+16
  - more particles and better distribution

- Bulk blend Urea-DAP-MOP
  - fewer particles, longer distance to roots

<table>
<thead>
<tr>
<th>Potato yield, tonne per ha</th>
<th>Bulk blend NPK</th>
<th>Compound NPK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source: Yara field trials</td>
<td>39</td>
<td>41</td>
</tr>
</tbody>
</table>
Compound NPK capacities

10 largest producers

<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>Coromandel</td>
<td>3.3</td>
</tr>
<tr>
<td>Gresik</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>Rossosh</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>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>245</td>
<td>264</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></td>
</tr>
</tbody>
</table>

### Urea prilled fob Black Sea (USD/t)

<table>
<thead>
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<tbody>
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<td>Price</td>
<td>223</td>
<td>308</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>
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### Henry Hub (USD/MMBtu)

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<tbody>
<tr>
<td>Price</td>
<td>6.7</td>
<td>7.0</td>
<td>4.0</td>
<td>4.4</td>
<td>4.1</td>
<td>2.8</td>
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<td>4.7</td>
<td>2.6</td>
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### Oil Brent blend spot (USD/bbl)

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<tbody>
<tr>
<td>Price</td>
<td>65</td>
<td>73</td>
<td>97</td>
<td>80</td>
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<td>96</td>
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</table>

### CAN cif Germany (USD/t)

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</thead>
<tbody>
<tr>
<td>Price</td>
<td>214</td>
<td>244</td>
<td>261</td>
<td>379</td>
<td>337</td>
<td>316</td>
<td>268</td>
<td>219</td>
<td>8.1</td>
<td>8.4</td>
<td></td>
</tr>
</tbody>
</table>

### NOK/USD exchange rate

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>6.4</td>
<td>5.9</td>
<td>5.6</td>
<td>6.3</td>
<td>6.0</td>
<td>5.7</td>
<td>5.9</td>
<td>6.3</td>
<td>8.1</td>
<td>8.4</td>
<td></td>
</tr>
</tbody>
</table>

Source: The Market, Fertecon, CERA, World Bank, Norges Bank

Average 2006 – 2016
## 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

- Chinese coal prices
- Grain inventories/prices
- New urea capacity vs. closures
- Global urea demand vs. supply
- Urea price
- Cash crop prices

### Cost drivers

- Oil product prices and LNG capacity expansion
- Manning and maintenance
- Productivity and economies of scale

### Drivers

- Oil product prices and LNG capacity expansion
- Manning and maintenance
- Productivity and economies of scale
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 975 mt
- United States: 36%
- China: 23%
- Brazil: 8%
- EU-27: 6%
- Ukraine: 2%
- Other: 25%

Wheat-global production 733 mt
- EU-27: 21%
- China: 18%
- India: 12%
- Russia: 8%
- US: 8%
- Other: 33%

Rice-global production 473 mt
- China: 31%
- India: 22%
- Indonesia: 8%
- Bangladesh: 7%
- Vietnam: 6%
- Other: 26%

Soybeans-global production 321 mt
- USA: 35%
- Brazil: 31%
- Argentina: 18%
- India: 12%
- Other: 11%

Source: USDA, 2015/16 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

Source: USDA December 2016
China drives recent years’ increases in global grain stocks

Grain stocks – China versus the rest

Days of consumption in stocks

Source: USDA December 2016
Profitability of investment in mineral fertilizers

- The investment in nitrogen fertilizer is highly profitable for growers
- Fertilizer investment: 126 USD/ha
- Net return: 973 USD/ha
- Net return > 8 x investment

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

Example: 2016F average US corn production costs

Source: USDA (Cost-of-production forecasts March 2016)
Large variations in yields across regions

Maize yields

<table>
<thead>
<tr>
<th>Country</th>
<th>Tonnes/Ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>10.7</td>
</tr>
<tr>
<td>Argentina</td>
<td>6.6</td>
</tr>
<tr>
<td>China</td>
<td>6.0</td>
</tr>
<tr>
<td>Brazil</td>
<td>5.2</td>
</tr>
<tr>
<td>Mexico</td>
<td>3.3</td>
</tr>
</tbody>
</table>

Wheat yields

<table>
<thead>
<tr>
<th>Country</th>
<th>Tonnes/Ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>7.4</td>
</tr>
<tr>
<td>China</td>
<td>5.0</td>
</tr>
<tr>
<td>India</td>
<td>3.0</td>
</tr>
<tr>
<td>US</td>
<td>2.9</td>
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<tr>
<td>Russia</td>
<td>2.5</td>
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</tbody>
</table>

Rice yields

<table>
<thead>
<tr>
<th>Country</th>
<th>Tonnes/Ha</th>
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<tbody>
<tr>
<td>China</td>
<td>6.7</td>
</tr>
<tr>
<td>Viet Nam</td>
<td>5.8</td>
</tr>
<tr>
<td>Indonesia</td>
<td>5.1</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>4.4</td>
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<tr>
<td>India</td>
<td>3.6</td>
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</tbody>
</table>

Soybean yields

<table>
<thead>
<tr>
<th>Country</th>
<th>Tonnes/Ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>3.2</td>
</tr>
<tr>
<td>Brazil</td>
<td>2.9</td>
</tr>
<tr>
<td>Argentina</td>
<td>2.8</td>
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<tr>
<td>China</td>
<td>1.8</td>
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<tr>
<td>India</td>
<td>1.0</td>
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</table>

Source: FAOSTAT 2014
# Seasonality in fertilizer consumption

<table>
<thead>
<tr>
<th>Crop</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>
<th>Jun</th>
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<tbody>
<tr>
<td><strong>Corn</strong></td>
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<td>Europe</td>
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<tr>
<td>Brazil (first crop)</td>
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<td>Brazil (second crop)</td>
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<td><strong>Wheat</strong></td>
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<tr>
<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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<tr>
<td>USA (winter wheat)</td>
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<td>USA (spring wheat)</td>
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<tr>
<td>Europe (winter wheat)</td>
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<td>FSU (winter wheat)</td>
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<tr>
<td><strong>Rice</strong></td>
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<tr>
<td>China (single crop)</td>
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<tr>
<td>China (early double crop)</td>
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<tr>
<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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</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: IFA 2013/2014
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
Fertilizer production routes

Natural gas (coal, oil) → Ammonia plant → Ammonia → Ammonia, CO₂ → Nitric acid plant → Nitric acid → Urea → Ammonium Nitrate (AN), Calcium Ammonium Nitrate (CAN)

Air → Ammonia plant → Ammonia → Ammonia, CO₂ → Nitric acid plant → Nitric acid → Urea → Ammonium Nitrate (AN), Calcium Ammonium Nitrate (CAN)

Rock (P) → Phosphoric acid plant → H₃PO₄ → Triple Super Phosphate (TSP) → Single Super Phosphate (SSP) → DAP / MAP

Sulphur (S) → Sulphuric acid plant → H₃PO₄ → Triple Super Phosphate (TSP) → Single Super Phosphate (SSP) → DAP / MAP
NPK production routes

1. Igneous and calcined sedimentary

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

GJ/tN

Year:
- 1910
- 1915
- 1930
- 1950
- 1960
- 1975
- 2000
Projected nitrogen capacity additions outside China

Capacity additions, excl. China (mill. tonnes urea¹)

<table>
<thead>
<tr>
<th>Year</th>
<th>Capacity Additions</th>
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<tbody>
<tr>
<td>2013</td>
<td>3.5</td>
</tr>
<tr>
<td>2014</td>
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<td>2015</td>
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<td>2016</td>
<td>3.6</td>
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<td>2017</td>
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<td>2018</td>
<td>5.3</td>
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<tr>
<td>2019</td>
<td>5.7</td>
</tr>
<tr>
<td>2020</td>
<td>3.8</td>
</tr>
<tr>
<td>2021</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Source: CRU, December 2016. Numbers include both additions and closures of capacity.

1) Using 50% operating rate in new plants’ first year of production.
30% of announced nitrogen projects realized on time

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

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**
  - 4–6 years
  - 6–12 months
  - 30–36 months
  - 12–24 months depending on complexity

- 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

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

Cash crop prices – yearly averages

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 2015

<table>
<thead>
<tr>
<th>NOK Billions</th>
<th>Operating cash cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Variable costs (87%)</td>
</tr>
<tr>
<td></td>
<td>Other cash cost (13%)</td>
</tr>
<tr>
<td>0</td>
<td>79.1</td>
</tr>
<tr>
<td>10</td>
<td>11.8</td>
</tr>
<tr>
<td>20</td>
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<td>30</td>
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<tr>
<td>90</td>
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<tr>
<td>100</td>
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</tr>
</tbody>
</table>

Variable costs (87%)
- Dry raw materials
- Energy
- Freight
- 3rd party finished fertilizer
Ammonia cash cost build-up – example

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas price:</td>
<td>4 USD/MMBtu</td>
</tr>
<tr>
<td>x Gas consumption:</td>
<td>36 MMBtu/mt NH₃</td>
</tr>
<tr>
<td>= Gas cost:</td>
<td>144 USD/mt NH₃</td>
</tr>
<tr>
<td>+ Other prod. cost:</td>
<td>29 USD/mt NH₃</td>
</tr>
<tr>
<td>= Total cash cost</td>
<td>173 USD/mt NH₃</td>
</tr>
</tbody>
</table>

36 MMBtu natural gas/tonne ammonia

Ammonia (NH₃) (82% N)

Typical natural gas consumption for ammonia production

Source: Blue Johnson & Associates.
Urea cash cost build-up – example

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ammonia price:</strong></td>
<td>173 USD/mt NH₃</td>
</tr>
<tr>
<td><strong>Ammonia use:</strong></td>
<td>0.58 NH₃/mt urea</td>
</tr>
<tr>
<td><strong>Ammonia cost</strong></td>
<td>100 USD/mt urea</td>
</tr>
<tr>
<td><strong>Process gas cost</strong></td>
<td>21 USD/mt urea</td>
</tr>
<tr>
<td><strong>Other prod. cost</strong></td>
<td>25 USD/mt urea</td>
</tr>
<tr>
<td><strong>Total cash cost</strong></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.
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

2015 production and exports, million tons product

- **Sulphuric acid**
  - Production: 26
  - Export: 2

- **Phosphate rock**
  - (72% BPL*, 33% P2O5)
  - Rock production: 201
  - Rock exports: 30

- **Phosphoric acid**
  - (100% P2O5)
  - Production: 44
  - Export: 4

- **Ammonia**
  - (82% N)

- **SSP**
  - (15-22% P2O5)
  - Production: 26
  - Export: 2

- **DAP**
  - (18% N, 46% P2O5)
  - Production: 36
  - Export: 17

- **MAP**
  - (11% N, 52% P2O5)
  - Production: 23
  - Export: 9

- **TSP**
  - (46% P2O5)
  - Production: 5
  - Export: 3

* P2O5 content of phosphate rock varies. This is an example.
** 1 ton of phosphoric acid requires 1 ton of sulphur.
***2013 figures

Source: IFA
Industrial applications
Nitrogen has many industrial applications

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

~30 million tonnes N

- Chemicals: 76%
- Explosives: 18%
- Environment: 6%

~21% of total nitrogen consumption

~9.5 million tonnes N as urea

- Glue: 58%
- Melamine: 21%
- Other: 11%
- Environment: 10%

~12-13% of total urea consumption

Source: Yara estimates 2015, IFA, Fertecon, CRU
Global demand development of nitrogen chemicals for industrial applications is strong

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

Source: Yara estimates 2015, IFA, Fertecon, CRU
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\textsubscript{x} 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 segment are civil explosives companies and 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**
  - FMB
  - Fertecon
  - Fertilizer Week
  - Profercy
  - The Market
  - Green Markets (USA)
  - Beijing Orient Business (China)
  - China Fertilizer Market Week
  - Fertilizer Week
  - www.cruonline.crugroup.com
  - Profercy
  - www.profercy.com
  - The Market
  - www.icispricing.com
  - Green Markets (USA)
  - www.greenmarkets.pf.com
  - Beijing Orient Business (China)
  - www.boabc.com
  - China Fertilizer Market Week

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

- **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.cbot.com
  - www.worldbank.org
  - www.usda.gov