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Yara Fertilizer Industry Handbook

This handbook describes the fertilizer industry and in particular the nitrogen part which is the most relevant for Yara International.

The document does not describe Yara or its strategies. For information on Yara-specific issues please see the Capital Markets Day presentations.

Fertilizers are essential plant nutrients that are applied to a crop to achieve optimal yield and quality. The following slides describe the value and characteristics of fertilizers in modern food production.
The law of minimum

The 'law of minimum' is often illustrated with a water barrel, with staves of different lengths. The barrel's capacity to hold water is determined by the shortest stave. Similarly, crop yields are frequently limited by shortages of nutrients or water. Once the limiting factor (constraint) has been corrected, yield will increase until the next limiting factor is encountered.

Nutrients are classified into three sub-groups based on plant growth needs. These are:

- **Macro or primary nutrients**: nitrogen (N), phosphorus (P), potassium (K)
- **Major or secondary nutrients**: calcium (Ca), magnesium (Mg) and sulphur (S)
- **Micro nutrients or trace elements**: chlorine (Cl), iron (Fe), manganese (Mn), boron (B), selenium (Se), zinc (Zn), copper (Cu), molybdenum (Mo) etc.

Yield responses to nitrogen are frequently observed, as nitrogen is often a limiting factor to crop production, but not the only factor. Balanced nutrition is used to obtain maximum yield and avoid shortages of nutrients.

Three main nutrients: Nitrogen, Phosphorus and Potassium

- Nitrogen (N), the main constituent of proteins, is essential for growth and development in plants. Supply of nitrogen determines a plant's growth, vigour, colour and yield.
- Phosphorus (P) is vital for adequate root development and helps the plant resist drought. Phosphorus is also important for plant growth and development, such as the ripening of seed and fruit.
- Potassium (K) is central to the translocation of photosynthesis within plants, and for high-yielding crops. Potassium helps improve crop resistance to lodging, disease and drought.

In addition to the three primary nutrients, the secondary nutrients sulphur, magnesium and calcium are required for optimum crop growth. Calcium is particularly important for the yield, quality and storage capacity of high-value crops such as fruit and vegetables.
Nutrients are depleted with the harvest

As crops take up nutrients from the soil, a substantial proportion of these nutrients are removed from the field when the crops are harvested. While some nutrients can be returned to the field through crop residues and other organic matter, this alone cannot provide optimum fertilization and crop yields over time.

Mineral fertilizers can provide an optimal nutrient balance, tailored to the demands of the specific crop, soil and climate conditions, maximising crop yield and quality whilst also minimizing environmental impacts.

Among the major plant nutrients, nitrogen is most important for higher crop yields

The fertilizer market is composed of three main nutrients – nitrogen, phosphorous and potassium. Nitrogen is by far the largest nutrient, accounting for 60% of total consumption, and Yara is the leading producer of this nutrient.

Phosphorus (phosphate) and potassium fertilizers are primarily applied to improve crop quality. Annual application is not always needed, as the soil absorbs and stores these two nutrients for a longer period than nitrogen. Nitrogen must be applied every year to maintain yield and biomass.

There are fewer large suppliers of phosphate and potash fertilizers, as phosphate rock and potash mineral deposits are only available in certain regions of the world. The potash industry is even more consolidated than the phosphate industry.

Nitrogen fertilizers are produced in many countries, reflecting the wide availability of key raw materials - natural gas and air, needed for its production on an industrial scale.

The global nitrogen market is therefore less consolidated, but some regions such as Europe and the US have seen significant restructuring of their nitrogen industries in the last decade.
Correct use of fertilizers can yield a 670% return on investment

Using 192 kg N/ha (winter wheat in Europe), it is possible to produce 9.3 tons of grain per hectare. The fertilizer cost at this application level using CAN (27% N) at EUR 290/t (0.82 USD/kg N) would be 192 kg x 0.82 USD = 157 USD/ha

Using a wheat price of 240 USD/t, the farmer gets the following alternative revenue scenarios:
• Optimal nitrogen level: 9.30 t grain/ha * 240 USD = 2,244 USD/ha
• No nitrogen fertilizer added: 2.07 t grain/ha * 240 USD = 500 USD/ha

The difference in revenues is 1,745 USD/ha resulting from an input cost of 261 USD/ha, i.e. a return on investment of close to 670%.

Fertilizer cost is small compared to total grain production cost

Fertilizer costs have decreased the last two years and represent around 22% of the total production cost of corn. For other major crops, the relative share is smaller varying from 6% for Soybeans up to 19% for wheat.
Nitrate is immediately and easily taken up by plants

Ammonia (NH₃) is the basis for all nitrogen fertilizers and it contains the highest amount of nitrogen (82%). Ammonia can be applied directly to the soil, but for several reasons, including environmental, it is common to further process ammonia into, e.g., urea or nitrates before application. If ammonia is applied directly to the soil, it must be converted to ammonium (NH₄⁺) and nitrate before plants can use it as a source of nitrogen. While ammonium and nitrate are readily available to plants, urea first needs to be transformed to ammonium and then to nitrate. The transformation process is dependent upon many environmental and biological factors. E.g., under low temperatures and low pH (as seen in Europe), urea transformation is slow and difficult to predict with resulting nitrogen and efficiency losses. Nitrates, in comparison, are readily absorbed by the plants with minimum losses. Therefore, nitrates are widely regarded as a quality nitrogen fertilizer for European agricultural conditions. This is reflected in their large market share.

Nitrate is a more efficient fertilizer than urea

Field trials confirm that nitrates give higher crop yields than urea and thus contribute to both higher farm revenue and better land use. Urea has a lower carbon footprint at the production stage of the fertilizer lifecycle than ammonium nitrate. This is mainly due to the fact that part of the CO₂ generated in ammonia production is captured in the urea. However, the CO₂ is released as soon as the urea is applied on the field. In addition, more N₂O is emitted from urea in the nitrification process. Urea also emits more ammonia to the atmosphere during farming than AN. The loss of ammonium from urea also requires higher dosage to compensate for higher losses. Overall, the life cycle carbon footprint of urea is higher than that of ammonium nitrate. Field trials confirm that nitrates give higher crop yields than urea and thus contribute to both higher farm revenue and better land use.
The more nitrate in fertilizer, the higher the yield

There are numerous examples of experiments that support the superior performance of nitrates in arable, fruit and vegetable crop production, both with regard to yield and quality.

For arable crops, nitrogen fertilizer containing 50% nitrate and 50% ammonium such as CAN or AN are likely to be the most financially rewarding option, due to the relatively low crop value.

For higher-value cash crops such as fruit and vegetables, fertilizer products containing a high amount of nitrate nitrogen are likely to be the optimum choice, especially for rapidly growing vegetables which need nitrogen readily available.

Field trials confirm the advantages of applying nitrates instead of a commodity nitrogen fertilizer

For wheat in UK trials concluded that yields improved by 3%, while for orange production in Brazil the yield improvement was a massive 17% using nitrates instead of urea.

**Winter wheat, UK**
- Average of 15 field trials between 1994 and 1998, both N forms tested at 160 kg N/ha
- Levington Research
- Yield with urea = 8.38 t/ha, CAN = 8.63 t/ha
- Grain price = 180 €/t (price at farm in NW-Germany, Nov 2011)

**Citrus, Brazil**
- Based on 1 field trial with oranges in Brazil, both N forms tested at 180 kg N/ha
- Cantarella, 2003
- Yield with urea = 37.1 t/ha = 909 boxes, AN = 43.3 t/ha = 1061 boxes
- Price per box = 4 $ = 3.01 € (industry price excluding harvest service, Nov 2011)
Organic fertilizer contains the same inorganic molecules as mineral fertilizer.

Crops can be fed with mineral or organic fertilizers (manure), and in both cases the crop will utilize the same inorganic molecules. A complete nutrient program must take into account soil reserves, use of manure or fertilizers, and an accurate supplement of mineral fertilizers.

Manures build up the organic content of soil and at the same time support beneficial micro flora (e.g. bacteria) to grow on plant roots. The efficiency of organic fertilizer is dependent on an appropriate bacteria content in the soil. The right bacteria break down the organic content in manures and supply them as nutrients for plant growth. But the quality and quantity of nutrient supplied to plants via this process is inconsistent and is very much dependent upon the vagaries of soil and climatic factors. Plant productivity achieved by supplying organic matter is low compared with mineral nutrients supplied in the form of fertilizers.

The separation of livestock and arable farming regions has lead to nutrient distribution inefficiency, with a surplus in the animal farming regions. The low nutrient content and bulky nature of manures makes transportation inconvenient and costly.

Organic farming represents only a marginal share of total cultivated land.

Organic farming accounts for less than 1% of cultivated land.

37 million hectares of agricultural land were managed organically in 2009, which represents a 6% increase from 2008.

Almost two-thirds of the agricultural land under organic management is grassland (22 million hectares) while the cropped area constitutes 8.2 million hectares.

With most of the area cultivated organically being grassland and low productivity, the impact of organic farming on fertilizer demand is limited.
Industrial production of fertilizers involves several chemical processes

The basis for producing nitrogen fertilizers is ammonia, which is produced on an industrial scale by combining nitrogen in the air with hydrogen in natural gas, under high temperature and pressure and in the presence of catalysts. This process for producing ammonia is called the ‘Haber-Bosch’ process.

Phosphorus is produced from phosphate rock by digesting the latter with a strong acid. It is then combined with ammonia to form Di-ammonium phosphate (DAP) or Mono-ammonium phosphate (MAP) through a process called ammonization.

Potassium is mined from salt deposits. Large potash deposits are found in Canada and Russia, which are the world’s major producers of this nutrient.

Phosphate and potash are sold separately or combined with, e.g. nitrogen, to form NPK fertilizers.

The side streams of the main production process (e.g. gases, nitrogen chemicals) can be utilized for industrial products.

The fertilizer industry

Due to the transportability of fertilizers, the industry is highly global meaning that the price of a standard fertilizer like urea is nearly the same everywhere adjusting for transportation costs. Consequently, it is important to focus on the global industry and supply-demand balance rather than regional ones.
Nitrogen is the largest nutrient with projected annual growth rate of 1.8%. Consumption of all three nutrients grew in 2010. After two years with negative consumption development for potash, consumption increased by more than 20% in 2010. The International Fertilizer Association (IFA) forecasts nitrogen fertilizer demand growth at 1.9% per year through 2015. A growth rate of 2.4% a year is estimated for phosphate and 3.7% for potassium.

For urea a higher growth rate is expected as this product is taking market share from other nitrogen products.

Asia is the largest fertilizer market, but Latin America has the highest growth rate. Asian share of global nitrogen consumption was 62% in 2010 with China representing more than half of that share. Demand in Latin America has been increasing quickly, but remains relatively small in absolute volume terms, it is still at a fairly low level. Asian and Latin American growth is expected to continue, while consumption in the mature markets of North America and Europe is forecast to grow at a slower pace.
The key nitrogen, phosphate and potash products are urea, DAP and MOP respectively. Urea, DAP and MOP are the key products for following price developments for nitrogen, phosphorus and potassium respectively. They have a large market share and are widely traded around the world.

Urea contains 46% nitrogen, and its share of nitrogen consumption is increasing. The majority of new and pipeline nitrogen capacity in the world is in the form of urea.

Diammonium phosphate (DAP) contains 46% phosphate (measured in P\textsubscript{2}O\textsubscript{5}) and 18% nitrogen. Monammonium phosphate (MAP) contains 46% phosphate and 11% nitrogen.

Potassium chloride (MOP) contains 60% potash, measured in K\textsubscript{2}O.

Geographical variances in nitrogen fertilizer products used
There are large variations in nitrogen fertilizer use in different regions/countries. Urea, the fastest growing nitrogen product, is popular in warmer climates. UAN is mainly used in North America, while nitrates are mainly used in Europe. In the US, ammonia is also used as a source of nitrogen in agriculture, especially for direct fall application.

In China, urea is dominant. China is also the only country that uses ammonium bicarbonate (ABC). Although ABC is gradually being phased out, it has still around 20% market share in China.

Brazil consumes substantial amounts of P&K due to a large soybean production.
The three large grain crops, wheat, rice and corn (maize), consume about half of all fertilizer used in agriculture.

The fertilizer market is not only a significant market in terms of size, but also an essential industry serving global food production. Grain production is the most important agricultural activity in the world, with global output at approximately 2.3 billion tons in the 2010/11 season.

It would not be possible to achieve this scale of production without intensive agriculture and use of mineral fertilizers. Therefore, grains are naturally the largest end-market for fertilizers followed by cash crops such as vegetables, fruit, flowers and vines. In order to gain a good understanding of the fertilizer market, it is necessary to understand both the grain market and the market for cash crops.

Geographical variances in nitrogen application

There are large regional differences when it comes to what crops nitrogen is being applied to.

Due to strong growth in bioethanol production in the US the last 6-7 years, corn has become by far the biggest nitrogen-consuming crop in the US. Wheat and other cereals like barley are dominating in Europe and Russia. In Asia, rice is a big nitrogen-consuming crop in addition to the fruits & vegetables segment in China.

These regional differences impact regional demand patterns as soft commodity prices develop differently and hence impact farmer economics and farmers’ incentives to apply fertilizer differently depending on what crops are dominating.

For Yara, with its strong European presence, wheat is the most important grain.
Yara and Agrium are the two largest fertilizer companies measured by revenues.

Yara is the global no. 1 producer of ammonia, nitrates and NPK. Yara’s position gives it unique opportunities to leverage economies of scale and spread best practice across a large network of plants, an important driver for Yara’s competitive returns.
Yara benefits from a favourable cost position in its European home market for nitrates and NPKs. The ammonia position reflects recent improvement, reflecting move away from traditional oil-linked natural gas contracts to more hub / spot gas exposure in contracts.

**Nitrate position**

Nitrate: stable cost position approximately 10-20% below European competitors. The 2008 nitrate position is explained by Tertre’s gas contract which was revised during 2008. Yara is also the low-cost leader on NPK producing 20% below European competitors, however the number of competitors is very limited.

**Fertilizer industry dynamics**

This section describes in more detail the competitive forces and product flows for the main nitrogen products.
The fertilizer industry is getting more consolidated and market-orientated in the past, the fertilizer industry has been affected by state funds driving investments from a food security point of view rather than from a business point of view, and by weak fertilizer companies that existed as part of government-owned enterprises or conglomerates. As state involvement is declining and conglomerates are cleaning up their portfolios, there is a trend towards consolidation and more financial discipline across the whole industry.

This development is strengthened by WTO and EU enlargement which creates more equal terms for all players in the industry.

In recent years there has been a significant spread between "low-cost gas regions" outside Europe and the US, creating a significant cost advantage for fertilizer plants located in the former. However, this spread has been reduced recently due to increased global LNG activity and higher pipeline capacity into Europe, improving liquidity. This development is expected to continue.

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**Ammonia**

Ammonia is the key intermediate product in the production of all nitrogen fertilizers. A strong ammonia position and understanding of the ammonia market is essential for a leading nitrogen fertilizer company.

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**Potential industry concerns and associated mitigants**

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<td>Terrorism, accidents, country, customer and currency risk</td>
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Ammonia

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China is the largest ammonia producer

Ammonia is the key intermediate for all nitrogen fertilizer products and large nitrogen-consuming countries are also large producers of ammonia. Ammonia is predominantly upgraded to other nitrogen products at its production site. Only 17.6 million tons or 12% of the ammonia produced globally in 2009 was traded. Ammonia production reached 157.5 million tons, an increase of 3.1% compared to 2009. The trend from 2001 to 2010 shows a growth rate of 2.5% per year.

Only 12% of ammonia production is traded

In 2010, world ammonia trade increased with 11% to 19.6 million tons implying that only 12% of world ammonia production was traded. Including the urea share from industrial consumption, urea consumes 54% of all ammonia production. This ammonia needs to be upgraded on site as urea production requires CO₂ which is a by-product of the ammonia production.

For the ammonia that is traded, there are four main categories of customers:
1. There is a substantial industrial market for traded ammonia
2. Producers of main phosphate fertilizers such as DAP and MAP (also some types of NPK) import ammonia as the regions with phosphate reserves often lack nitrogen capacity
3. Some of the nitrate capacity is also based on purchased ammonia.
4. Direct application on the field, only common in USA

Of the traded ammonia, Yara has a market share of around 20%. This leading position gives the company a good overview of the global supply / demand balance of ammonia and enables the company to make better business decisions.
Trinidad is the world’s largest ammonia exporter

The large ammonia exporters in the world have access to competitively priced natural gas, the key raw material for its production. Trinidad has large natural gas reserves and also lies in close proximity to the world’s largest importer of ammonia, the US. Trinidad has large stand-alone ammonia plants and excellent maritime facilities that cater for export markets. Yara owns two large ammonia production facilities in Trinidad.

The Middle East also has some of the world’s largest reserves of natural gas. The Qafco fertilizer complex in Qatar produces significant amounts (approximately 2 million tons) of ammonia, but most of the ammonia produced in Qafco is upgraded to urea. Therefore, Qafco is a major exporter of urea and there is a relatively small surplus of ammonia left for exports.

In the US, imported ammonia is used for DAP/MAP production, for various industrial applications and directly as a nitrogen fertilizer. India uses its imported ammonia mostly to produce DAP.

The majority of ammonia trade follows the routes shown in the map, mainly from countries with cheaper gas

The key centre for ammonia trade is Yuzhnyy in the Black Sea. This is the most liquid location, and where most spot trades take place. Russian and Ukrainian ammonia is sold wherever netbacks are the highest, and since they are key suppliers to USA, Europe and Mediterranean, relative pricing for the various locations West of Suez is very stable.

Asia is almost in a balanced situation. If there is a deficit, imports from the Black Sea are necessary, and fob prices in Asia increase. If there is a surplus, Asian exporters have to compete West of Suez, and Asian fob price levels suffer.
Urea

Urea is the largest finished nitrogen fertilizer product and is traded globally. Even though many markets prefer other nitrogen fertilizers for better agronomic properties, urea is the commodity reference product with an important influence on most other nitrogen fertilizer prices.

Urea production is estimated at 149.6 million tons in 2010, up 1.4% from 2009. During the years 2001-2010, urea production grew on average at 3.8% per year. The largest producers are also the largest consumers, namely China and India. China is self-sufficient on nitrogen fertilizer but India’s imports requirement is growing.

Most of the new nitrogen capacity in the world is urea, so it is natural that production/consumption growth rates are higher for urea than for ammonia/total nitrogen. Lately, the difference has been quite large, since urea has taken market share, particularly from ammonium bicarbonate in China. In addition, a major share of the capacity shutdowns in high energy cost regions have been stand-alone ammonia plants.

As urea has a high nitrogen content (46%), transport is relatively cheap. In addition, demand growth is to a large extent taking place in climates which favor urea use.
Natural gas-rich regions generally tend to be big exporters of urea

Urea is a global fertilizer and is more traded than ammonia. Trade increased by 17% in 2010 to 40 million tons, which is 27% of all urea produced. The main urea exporters are gas-rich countries/regions with small domestic markets. However, there are some exceptions. China has huge domestic capacity. Although the main purpose is to supply the domestic market, during periods with strong global demand China is needed to balance the market. North America, Latin America and South and East Asia are the main importing regions.

Black Sea and Arab Gulf are main urea export hubs

There are two main hubs to follow in the urea trade market, Black Sea and Arab Gulf. These flows determine the global prices. Black Sea exports supply Europe and Latin America, while Arab Gulf exports supply North America and Asia/Oceania. All the other flows, of more regional nature, like Venezuela to USA, Indonesia to other Asian countries etc, are only interesting to the extent they affect the need for Black Sea/Arab Gulf material. As an example, if China reduces its export, the Arab Gulf is not able to supply Asia on its own. Black Sea urea will flow to Asia, and an upward price movement will tend to take place.

The relative pricing between Black Sea and Arab Gulf depends on where they compete on the marginal volume. If the main drive is from Latin America/Europe/Africa, Black Sea will lead. If it is Asia/North America, Arab Gulf will lead.
China's export tax regime

China is a major swing exporter in the global urea market. As China is a net importer of energy, it does not make sense for China to export large amounts of energy in the form of urea and China is therefore not expected to be a large exporter of urea on the long run.

The export out of China is heavily dependant on both the global urea price and the export tax imposed on Chinese producers exporting product. In order to secure a stable price environment and enough product locally, Chinese authorities have implemented a system with export taxes.

Chinese authorities recently announced the export taxes for 2012, revealing that the window with low export taxes will be 4 months as in 2011 (2 months shorter than in 2010 and earlier years) and that the base price of 2,100 RMB triggering an escalating taxation during the low tax period is kept at the same level as in 2011.

Chinese urea production

The growth in Chinese urea production has slowed, with 2010 production down on 2009. China has signaled a policy in the direction of increased focus on efficient production and improvement in nutrient use efficiency, rather than further growth in production.
Increased anthracite coal prices
Most of the Chinese urea capacity uses anthracite coal as feed-stock. The sustained increase in the price of the anthracite coal in China has therefore lifted the break-even costs of Chinese producers. Domestic urea prices are above costs, indicating that despite significant investments in new capacity the last decade, the Chinese market is not oversupplied.

Industry value drivers
This section describes how the economic mechanisms of the fertilizer industry work and what determines fertilizer prices and company profits.
Fertilizer cyclicality is similar to oil

Fertilizer prices are cyclical just like any other commodity. The cyclicality is primarily caused by the "lumpiness" in supply additions resulting in periods of overcapacity and undercapacity. Comparing the 10-year price history of nitrogen fertilizer products in the top row with oil in the bottom row, one can see that the cyclicality is similar and to some extent correlated. This is not surprising as the main cost involved in producing ammonia and nitrogen fertilizer is feedstock in the form of oil and gas.

Drivers of supply and demand

In general, when demand is low, there tends to be a "supply-driven" fertilizer market in which the established "price floor" indirectly determines fertilizer prices. This price floor is set by the producing region with the highest natural gas prices. Historically the highest gas prices have been in the US and in Western Europe, while in 2009 and 2010 it is the Ukrainian and other Eastern European producers that have had the highest gas costs together with coal based producers in China.

When fertilizer demand is high, there is typically a "demand-driven" market with fertilizer prices above floor prices for swing (highest cost) regions. The fertilizer market balance and capacity utilization are other key factors that impact prices for urea and other N-fertilizers.

Yara’s gas consumption in its fully-owned plants is approximately 205 million MMBtu (of which 165 is in Europe). Adding Yara’s share of joint venture companies (including Burrup), the total consumption of natural gas is approximately 310 million MMBtu.
Drivers of demand

The main demand driver for fertilizer is food demand which translates into demand for grains and other farm products.

Nitrogen consumption growth is expected to be higher than global population growth

Population growth and economic growth are the main drivers for increased fertilizer consumption. Industrial consumption of nitrogen is mainly driven by economic growth and environmental legislation.
Global grain consumption growing steadily
Over the last 5 decades, grain consumption has increased by 2% a year on average while population has grown by 1.6% per year.
Dips in grains consumption have only been seen on three occasions, and these were related to supply issues rather than demand issues.

Global per capita consumption of meat main contributor in food and nutrient consumption
Diet change has together with increased calorie intake been the main factors explaining growth in grain consumption the last decade.
Global per capita consumption of meat is increasing
Pork and poultry are gaining popularity on a global basis, and meat consumption requires feed. To produce 1 tonne of poultry meat, feed corresponding to 2 tons of grain is needed. The multipliers are 4 for pork and 7 for beef.
Nitrogen required for meat production is estimated at 20-30% of total nitrogen fertilizer consumption.

Per capita arable land available for cultivation is decreasing, while demand for food keeps growing
The Food and Agriculture Organization of the United Nations (FAO) confirms that a key challenge for agriculture is to increase productivity. Key ways of achieving this are by replacing nutrients removed with the harvest, improving resource management, breeding new crop varieties and expanding agricultural knowledge.
Strong development in grain prices reflect the productivity challenge the world is faced with. Strong agricultural prices and farmer margins are a pre-requisite for increased agricultural productivity. Many parts of the world still suffer from sub-optimal growing practices, and continued strong incentives are needed to boost global grain production.

Higher productivity key challenge
The average per capita cereal production increased gradually from the 60's up until the mid 80s, but trended lower the next 15-20 years before rising grain prices as shown on the previous page provided the necessary incentives to turn the negative trend.
Robust food demand

On the back of a weak harvest in the 2010/11 season when production dropped by 2%, grain prices increased significantly providing farmers with strong incentives to maximize production. Therefore, the US Department of Agriculture currently estimates global grain production to increase 4% in the 2011/2012 season compared to 2010/11. However, this is only sufficient to meet expected consumption which continues to grow, leading to a situation where the stocks to use ratio is expected to decrease from an already low level.

Mineral fertilizer essential to sustain future yield increases

In the quest to maintain increases in agricultural productivity, mineral fertilizer has a key role. While the nutrient reserves in the soil do not increase and recycling of organic material is not sufficient for additional growth, increased production of mineral fertilizer can really make a difference. Since 1960 the use of mineral fertilizer is the major reason why global cereal yields have increased, and this trend is expected to continue.
Crop producing countries
The United States and China are large producers of agricultural products. While the US is the biggest producer of maize and soybeans, China is the biggest producer of wheat and rice.

Regional differences in fertilizer intensity
There are considerable differences in agricultural intensity (measured here in annual nitrogen applied per hectare) between the main agricultural regions of the world, with higher intensity in the northern hemisphere than in the southern hemisphere. For example, the same crops may have application rates 2-3 times higher in the US than in Brazil. This illustrates the significant remaining potential for improved agricultural productivity especially in India and Brazil. The existing differences in annual application rates are especially significant when taking into account that these regions have a much higher rate of double-cropping (2 harvests per year) than in the northern hemisphere.
Yield differences

There are large regional yield variations. These variations reflect among other things differences in agricultural practices including fertilization intensity as shown on the previous page. Weather and differences in soil quality imply that not all regions can achieve the same yields. However, the large differences observed today clearly indicate that by using the right techniques, including a correct fertilization, yields and grain production can be increased significantly.

Biofuel growth projected to continue

World biofuel output is projected to more than triple from 2005 to 2015, with the US continuing to be the dominant producer although a slower growth pace, closely followed by Latin America. The significant plans for biodiesel production in China, India, Indonesia and Malaysia are subject to some uncertainty with regard to scope and timing.
Biofuel crops boost fertilizer consumption
World N-fertilizer consumption due to biofuels production was estimated to be 3.0 million tons N in the 2008/09 growing season. This corresponds roughly to 3% of the global nitrogen consumption.
With around 1/3 of US corn production going to ethanol production, the US is by far the main contributor, accounting for close to 60% of all nitrogen being consumed for biofuels production.

Current GM traits have minor effect on fertilizer consumption
The global area planted to genetically modified crops amounted to 134 million hectares in 2009. This represents 9% of the world arable land area.
The main traits today are resistance against herbicide and insects, which have little impact on fertilizer consumption. Traits aiming at improving yields and yield stability will imply higher nutrient consumption and greater incentives for investing in inputs like fertilizer. An example of such a trait is drought tolerance (or other traits that increases the crops ability to adapt to unfavorable conditions). Drought tolerant maize varieties are anticipated to be commercially released in the US in 2012.
Improved nitrogen efficiency is a trait that potentially can have a negative impact on nutrient consumption. However, no major breakthroughs have been made on this recently and research on this trait is still at the “proof of concept” stage.
A life-cycle perspective on fertilizer is important

When new acreage is converted to cropland, above ground carbon is immediately removed and converted to CO₂, whereas carbon stored in the ground will leak out more gradually.

When the ambition is to minimize total carbon footprint from global biomass production, efficient use of land, based on modern agricultural practices, is therefore of great importance. Intensive farming with high yields is important to preserve forests - the real carbon sink tanks.

Organic farming with low yields would push for further deforestation and climate warming.

Fertilizer is a seasonal business

The seasonality is to a large extent linked to weather. Hence, there are large regional differences in when crops are planted and harvested and therefore when fertilizer is being applied.

Fertilizer is typically applied when seeds are planted, implying that the main application on the northern Hemisphere is during the first half of the calendar year while on the southern Hemisphere it is during the second half of the calendar year. Winter wheat is an exception, while planting typically is done in the second half of the year, fertilizer application is done in the spring.

In certain countries, certain crops are harvested twice a year, this applies especially to countries on the southern hemisphere like India and Brazil.
Drivers of supply

The main driver of supply is the cost of natural gas which is the main raw material in the production of nitrogen fertilizer.

Natural gas is the major nitrogen cost driver

Using a gas price of 6-8 USD per MMBtu, natural gas constitutes about 90% of ammonia cash production costs which is why almost all new nitrogen capacity (excluding China) is being built in low cost gas areas such as the Middle East and Northern Africa.

Ammonia is an intermediate product for all nitrogen fertilizer, while nitric acid is a second intermediate product for the production of, e.g. nitrates. Finished fertilizer products are urea, nitrates (CAN, AN), NPK and others. Industrial products range from high purity carbon dioxide and basic nitrogen chemicals to industrial applications of upgraded fertilizer products.
Reduced energy consumption in nitrogen manufacturing

The Haber-Bosch synthesis has not been challenged for almost 80 years. Technology development in the 20th century has reduced energy consumption down towards the practical and theoretical minimum. The energy base has changed, and technological advances have improved energy efficiency significantly. The graph illustrates that the industry is now more sensitive to energy price than developments in technology. Modern fertilizer plants utilize natural gas or other gases like propane or ethylene. In the most efficient plants, it takes approximately 0.66 kg of natural gas to make one kilogram of nitrogen as ammonia or ammonium nitrate and 0.75 kg to make urea. This is equivalent to 0.8 and 0.93 kg respectively of fuel oil.

West European ammonia producers are highly energy efficient

Ammonia producers in Western Europe have invested heavily in energy-efficient technology due to the historically high cost of energy in the region. According to EFMA, several ammonia plants in West Europe run on the lowest feasible energy consumption levels and emit the lowest possible amount of CO₂ per tonne of ammonia produced. The Western European ammonia industry is on average more energy efficient than ammonia producers in other parts of the world. This is also driven by EU environmental regulations for pollution control, which requires running plants at higher standards than elsewhere.
Expected urea capacity growth in line with historical consumption growth

Excluding China, the average gross nitrogen capacity growth per year during the period 2010-2014 is 2.1%, slightly above the 10-year historical consumption rate of 2.0% per annum. Taking closures into account, the net capacity growth is expected lower than the historical consumption growth.

Long lead-time on projects

Over the last years it has typically taken at least 5-6 years from a project for a new ammonia and urea plant to be initiated until the new plant is operational, even without unexpected delays.
Industry analysts expect utilization to drop due to China
Excluding China, capacity utilization is expected to decrease slightly from the record 2011 year. However, with capacity expansions in China, global utilization is expected to drop over the next couple of years.
China has enough export capacity to cap the urea price in the coming years, should they decide to continue with export.

Price relations
Based on the demand and supply drivers this section explores how prices in the end are determined.
China has taken over as the highest cost producer
Traditionally, US together with Western European producers have been the highest cost producers. Hence, gas costs in these regions have been setting the floor price for urea. However, in 2009 the Ukrainians took over as a swing producer paying an oil-linked gas price and carrying a logistical disadvantage compared to the Europeans also buying gas on oil linked contracts. With the sharp increase in Chinese anthracite prices in 2010, the Chinese producers have taken over the role as the highest cost producer setting the floor. In addition to higher feed stock costs, Chinese producers have also been facing a stricter tariff system in 2011 compared to earlier years.

Upgrading margin for converting ammonia into urea
While energy costs for the ammonia swing producers set a price floor for ammonia, the ammonia price sets a floor for the urea price. If the urea price drops below this floor, more ammonia will be offered for sale, less urea will be sold, and the relationship will be restored. In a tight supply/demand scenario for nitrogen where there is a demand driven urea margin, the correlation is lower. Such a scenario is often seen during periods with strong prices for agricultural soft commodities.
Correlation between long-term grain and fertilizer prices

Variations in grain price (corn or wheat) explain approximately 50% of the variations in the urea price, making grain prices one of the most important factors driving fertilizer prices. Some of the correlation may of course be spurious, like GDP growth, Chinese imports, strength of the USD etc. As

Average demand-driven margin of USD 75/t

The location of swing urea production has varied over the past decade, from the US Gulf, via Ukraine and now China. However, urea prices have only been supply-driven for shorter periods at a time, with the average demand-driven margin for the period 2004 – 2011 approximately USD 75 per ton.
Urea prices determine the price range for nitrates

There is a strong correlation between urea and nitrate prices, as they to some extent are substitutes. For agronomic reasons linked to the effectiveness of the nitrogen form, farmers are willing to pay a higher price per unit nitrogen from nitrates than from urea. The correlation is stronger in the medium to long term than within a season. However, crop prices are also an important factor that impacts the nitrate price and the nitrate premium. The higher the crop value is, the more willing the farmer is to pay a premium for a product that gives a higher yield and quality.
Production economics
This section describes the cash costs associated with production of standard nitrogen products which is useful to know in supply-driven situations with pricing determined by the marginal (swing) producers.
Production economics

90% of Yara’s operational cash costs are raw materials, energy and freight. A major part of these purchases can be terminated on short notice reducing the financial consequences of delivery slow-downs.

Yara’s plants can be stopped at short notice and at low cost as response to decline in deliveries or to take advantage of cheaper imported ammonia.

Natural gas costs the most important cost component

With a natural gas price of USD 8/MMBtu gas cost represents around 90% of the ammonia production cash costs. In this example, one dollar increase in gas cost gives USD 36 higher gas costs.

Most of the “other production costs” are fixed costs and therefore subject to scale advantages.

A new, highly efficient plant may use natural gas in the low thirties range to produce one tonne of ammonia; the corresponding figure for old, poorly maintained plants will be in the mid-forties.

mt = metric tonne

All cost estimates are fob plant cash costs excluding load-out, depreciation, corporate overhead and debt service for a US proxy plant located in Louisiana (ca. 1,300 metric tons per day capacity). In this example load-out barge is excluded.
Ammonia is the main input for urea production

Typically, it takes 0.58 tonne ammonia for each tonne urea. If we add the gas cost in ammonia (USD 182) and the additional process gas costs needed for the production of urea (5.2 MMBtu x USD 8/MMBtu = USD 41), natural gas represents around 90% of the total production cash cost.

All cost estimates are fob plant cash costs excluding depreciation, corporate overhead and debt service for a US proxy plant located in Louisiana (~1,300 mt per day capacity).

Consumption factors to compare price movements

As shown in the costing example for urea, the real ammonia consumption factor is above the theoretical consumption factor, which is based on N content. The difference varies between plants according to their energy efficiency. Using the theoretical consumption factors is easier when making calculations. If the N content for a product is known (46% N in urea), the ammonia consumption factor can easily be calculated by dividing the figure with the N content in ammonia (0.46/0.82 = 0.56).

Based on this illustration, it is possible to follow relative variation in the various nitrogen prices. As an example, if ammonia becomes USD10/mt more expensive, the production cost of urea increases by 10 * 0.56 (0.46/0.82) = 5.6USD/mt. Similarly, if the urea price increases by USD10/mt, a price increase of 10 * (0.27/0.46) = USD5.9/mt of CAN would keep the relative pricing at the same level.
Phosphate processing routes
The 3 main phosphate finished fertilizer products are diammonium phosphate (DAP), monammonium phosphate (MAP) and triple superphosphate (TSP), all of which are based on phosphate rock processed via intermediate production of phosphoric acid.

Nitrogen applications extend beyond fertilizer
The Industrial segment markets numerous industrial products, mainly originating from Yara’s Upstream and Downstream fertilizer operations, with certain products being intermediates in the production of fertilizers.
Main industrial products and applications
The ammonia nitrogen route provides opportunities in industrial processes where ammonia, urea or nitric acid can be used as traded raw materials. Examples are urea for the glue industry and ammonia for acrylonitrile producers (textile fibres). Other downstream applications are abatement of NOx gases from power plants, industry and vehicles.

Another branch of the Industrial tree is nitric acid, where derived products are technical grade ammonium nitrates for explosives, and calcium nitrate for a range of applications including odour control, waste water treatment, treatment of drilling fluids, and catalyst applications for the production of rubber gloves.

Yara Industrial's gas business includes argon extracted from our ammonia plants, as well as oxygen, and nitrogen gases. A derived product from Yara's nitrate plants is nitrous oxide (N2O or laughing gas) for the medical sector. Yara's ammonia plants produce the best food and beverage grade CO2 as a co-product. This has led to a unique position as the leading European supplier of liquid CO2. Yara Industrial's dry ice factories in France, England, Germany and Denmark have been developed as downstream vehicles to utilize our strong position towards the food and transportation industry.

Multiple products and applications
Chemicals is the largest segment where GDP growth in industrialized markets represents the key growth driver.

Environmental applications is the fastest growing segment, growth is driven by legislation and by the need to treat NOx emissions from heavy-duty trucks and in the power sector.

Technical ammonium nitrate (TAN) is the most global of all Industrial business units, where Yara already is the world's largest independent supplier of technical nitrates to the civil explosives industry. Asia and Australia are expected to drive growth in this business, with Europe and the US being more mature markets.

As industrial demand has a lower share of total urea demand than for nitrogen in total, the effect for the urea market is less. Industrial use of urea covers roughly 30% of total industrial nitrogen demand.
The pace of growth in nitrogen chemicals for industrial applications is significantly higher than global N-fertilizer growth (2% per annum).

Effective abatement of nitrogen oxides

NOx emissions producing smog are toxic. Most national governments have therefore given commitments and are now implementing legislation to reduce NOx emissions and improve the air quality.

Yara was at the forefront when we created a new product for an application linked to NOx abatement. This product is called AdBlue, which is packaged with the SCR technology for NOx abatement for heavy-duty trucks. Yara is today the world’s largest producer of AdBlue, and its Air1 brand is the only global brand. Similar technology, based on ammonia and/or urea, is used to reduce emissions of industrial installations such as power plants, cement factories, waste incinerators etc.

Europe is expected to progressively apply more stringent NOx emission limits. The marine market is currently driven by Sweden and Norway and many countries are expected to enact similar legislation soon. To fully serve the marine market, Yara established a joint venture with Wilhelmsen Maritime Services in 2007 under the name of Yarwil.
Technical AN: the main raw material for civil explosives

Technical ammonium nitrate is the main raw material for ANFO (Ammonium Nitrate Fuel Oil) which is the most used and most economical civil explosive currently on the market. The main civil explosive market segments are mining and infrastructure development.

ANFO was developed 40 years ago and has grown to be the most widely used industrial blasting agent in the world, due to its excellent manufacturing, handling and storage properties, low cost per energy unit, high safety levels and outstanding performance.

Calcium nitrate is used as a secondary nitrate in emulsion explosives. It extends the shelf life of the emulsion, increases the solubility of the ammonium nitrate and increases the total energy content of the emulsion.

CO₂ at every stage of food production and processing

The main applications of CO₂ are for use in the production of soft drinks and in the brewing sector, as well as for process cooling and freezing in the food sector. Carbon dioxide (CO₂) is used in the production, storage and transport of foods; from the planting of salads and tomatoes as seeds in the greenhouse, or from when salmon are introduced as fry in fish farms until they arrive on the dining table.

In greenhouses without a supply of CO₂, the level of this gas can drop to under half of what is normally found in air. When the correct amount of CO₂ added at the right time (during periods of light) some plant cultures can increase their yield by 30-50%.

CO₂ or nitrogen is used as a cooling agent for the freezing of foods, as atmospheres in the packing of foodstuffs to prolong the shelf-life of the products, and to maintain a controlled temperature during storage and transport. CO₂ gas enables low temperatures to be attained in a short time, preventing damage and minimizing thawing damage.
H₂S abatement for waste water

The presence of hydrogen sulphide (H₂S) in waste water and sludge is defined as a septic condition. By preventing septic conditions from arising, negative effects like odours, health hazards, corrosion and reduced efficiency of the treatment plant, can be eliminated or reduced.

Yara's calcium nitrate based septicity control process is a natural biological method of preventing septicity and removing H₂S by controlled dosage of nitrate. It can be used both for municipal sewer systems and industrial wastewater and sludge, and is non-toxic, non-corrosive, pH-neutral and safe-to-handle.

Nitrate-based products are also used to reduce H₂S toxic emissions in oil fields and pipelines.