PURE NUTRIENT *FACTS #1*

It's crops I want, not CO_2

THE CARBON FOOTPRINT OF FERTILIZERS

Agriculture plays an important role in the complex balance of factors determining climate change. Within this multifaceted scenario, fertilizers are an important element of leverage.

This information details the carbon footprint of Yara nitrogen fertilizers. Yara thus offers the transparency required by farmers and the general public to make decisions based on environmental considerations, minimizing the climate impact of farming.

YARA

Knowledge grows

Fertilizers and climate change

Does agriculture contribute to global warming? What is the carbon footprint of mineral fertilizers? How to feed a growing world population while preserving the climate? What are the best options for sustainable agriculture?

Farmers and the general public are searching for answers to some of the most serious issues of this century to date. With more than a hundred years' experience in plant nutrition, Yara is a knowledgeable partner in agriculture. We believe that it is our role to inform farmers about the carbon footprint of our nitrogen fertilizers.

WHAT IS CARBON FOOTPRINT?

Production, transportation and use of mineral fertilizers emit greenhouse gases (GHG), notably carbon dioxide (CO_2) and nitrous oxide (N_2O). These gases contribute to global warming. At the same time, fertilizers enhance agricultural productivity and stimulate CO_2 uptake by the crop. They increase yield and reduce the need to cultivate new land.

To understand the overall impact of fertilizers on climate, emissions and absorptions of GHG need to be evaluated throughout every stage of the "life" of a fertilizer. This is commonly referred to as life-cycle analysis, helping to determine the "carbon footprint" of a product and how to possibly reduce it.

ASSESSING THE CARBON FOOTPRINT OF AMMONIUM NITRATE

The illustration on the following pages explains the life-cycle of ammonium nitrate (AN), the most common source of nitrogen in European agriculture. It can be found in commercial products such as CAN, NPK, NP, NK etc.

GHG emissions and uptake are shown for each stage of the fertilizer life-cycle, including production in a typical Yara plant, transportation and application, growing of crops, their consumption as food, feed or bio-energy, and the protection of natural CO_2 sinks such as forests and wetlands.

Ⓐ FERTILIZER PRODUCTION

When operating ammonia and nitric acid plants with 'Best Available Technique' (BAT), the total carbon footprint of AN is 3.6 kg CO_2-eqv per kg N.

Ammonia production

Binding nitrogen from the air requires energy. Natural gas is the most efficient energy source. Yara plants are among the best performers in terms of energy efficiency worldwide.

- European average energy consumption: 35.2 GJ per ton ammonia
- EU BAT energy consumption: 31.8 GJ per ton ammonia (= 2.2 kg CO_2 per kg N in AN)

Nitric acid production

Nitric acid is used for making AN-based fertilizers. Its production releases N_2O. Catalytic cleansing developed by Yara reduces N_2O emissions below BAT level.

- N_2O emission without cleansing: 7.5 kg N_2O per ton nitric acid
- EU BAT emission with cleansing: 1.85 kg N_2O per ton nitric acid (= 1.3 kg CO_2-eqv per kg N in AN)

Solidification

AN solutions made from ammonia and nitric acid are granulated or prilled to form high-quality solid fertilizer. Solidification needs energy.

- European average energy consumption: 0.5 GJ per ton of product (= 0.1 kg CO_2 per kg N in AN)

MITIGATION POTENTIAL:

- Improve the energy efficiency of ammonia production and other production systems
- Install and further optimize catalytic cleansing of N_2O

Ⓑ TRANSPORTATION

Ammonium nitrate is transported by ship, barge, road or rail.

- European average: 0.1 kg CO_2 per kg N

MITIGATION POTENTIAL:

- Optimize logistics chain from production sites to farmers

Ⓒ FERTILIZER USE

Nitrogen, whether from organic or inorganic sources, is subject to natural microbial conversion in the soil. During this process N_2O can be lost to the air. In addition, CO_2 is also released by liming and farming machinery.

- Average footprint for AN: 5.6 kg CO_2-eqv per kg N

MITIGATION POTENTIAL:

- Assure balanced nutrition with all required nutrients
- Tailor N-application according to actual crop needs, avoid over-fertilization
- Use placement fertilization when appropriate
- Just-in-time (split) application to ensure rapid uptake
- Use of precision farming tools (N-Sensor™, N-Tester™, online applications)
- Maintain good soil structure (good draining, low packing)
- Select appropriate fertilizer (AN or CAN rather than UAN or urea)
- Efficient manure management
- Avoid volatilization losses, for example by incorporation into the soil

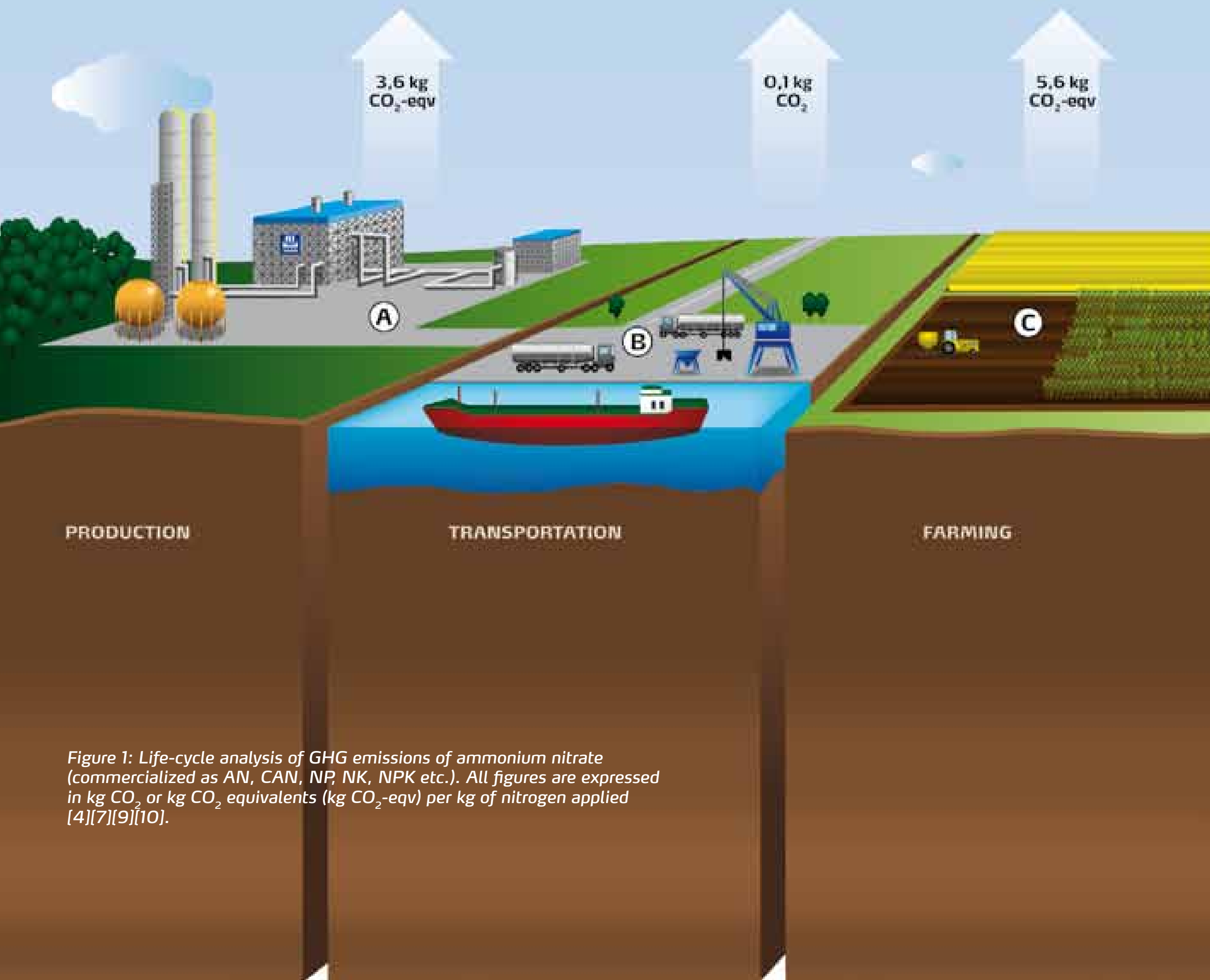


Figure 1: Life-cycle analysis of GHG emissions of ammonium nitrate (commercialized as AN, CAN, NP, NK, NPK etc.). All figures are expressed in kg CO_2 or kg CO_2 equivalents (kg CO_2-eqv) per kg of nitrogen applied [4][7][9][10].

Ⓓ BIOMASS PRODUCTION

Plants capture large amounts of CO_2 during growth. Optimum fertilization can increase biomass production, and thus CO_2 uptake by a factor of 4-5 compared to fields that remain long-term unfertilized.
For example, at a yield of 8 t / ha achieved with 170 kg N / ha, the grain fixes 12 800 kg / ha of CO_2. This corresponds to 75 kg of CO_2 fixed per kg of N applied.

- Example footprint: -75 kg CO_2-eqv per kg N

MITIGATION POTENTIAL:

- Ensure optimal fertilization to increase biomass production and CO_2 uptake per ha.
- Avoid changing land-use at one location to compensate for reduced efficiency at another
- Preserve and improve soil carbon stocks by increased inputs of organic material to the soil (e.g. residues) and conservation tillage techniques

Ⓔ BIOMASS CONSUMPTION

Most of the biomass produced is consumed as food or feed. CO_2 fixation is therefore only short term and cannot be considered a saving on a global scale.
The balance is different for bio-energy since it avoids the burning of fossil fuels. For example, using biomass instead of mineral oil for heating purposes reduces the CO_2 emission by as much as 70-80%.

MITIGATION POTENTIAL:

- Optimize efficiency of bio-energy production
- Increase productivity in food and feed production, allowing more acreage for bio-energy production

Ⓕ FOREST AND WETLANDS

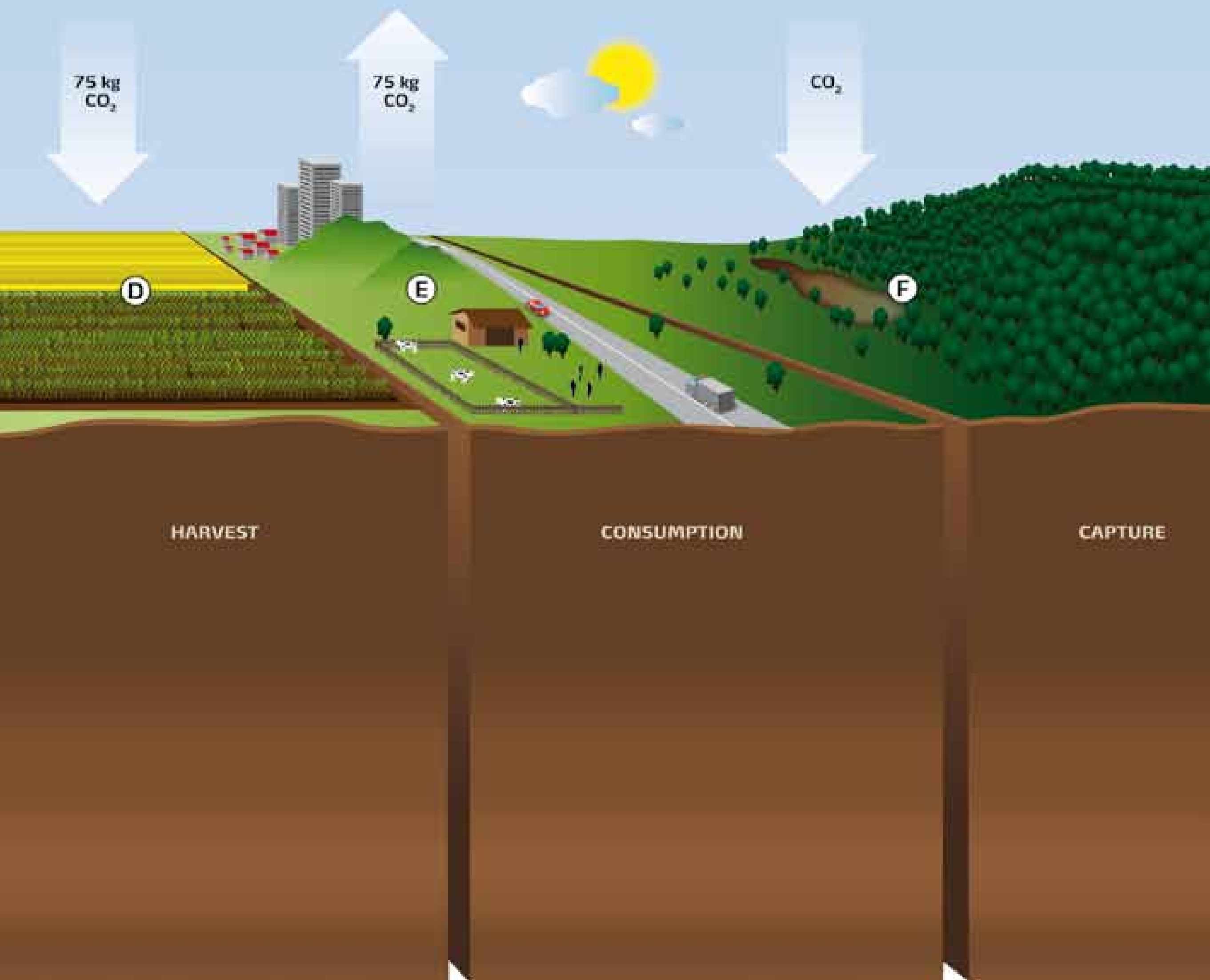
Forests and wetlands store 2-8 times more CO_2 than croplands. Land use change, mainly due to burning of tropical forests, is a large source of CO_2 emissions, accounting for approximately 12% of manmade CO_2 emissions. Preserving tropical and boreal forests is the most important contribution to mitigate climate change.

MITIGATION POTENTIAL:

- Protect tropical forests and wetlands
- Reforestation, restoration of wetlands
- Forest fertilization to increase long-term carbon capture
- Avoid further land-use change by increasing the productivity of existing agricultural land

CO_2 EQUIVALENTS

To make different GHGs comparable, they are converted into CO_2-equivalents (CO_2-eqv). For example 1 kg N_2O corresponds to 296 kg CO_2-eqv, as it has a 296 times stronger effect on the climate than CO_2. To further ease comparisons, all data presented in this illustration are expressed per kg of nitrogen applied.



Reducing our carbon footprint

European farming is already one of the most efficient worldwide. What can be done to further reduce the impact of agriculture in Europe on the climate? How can European agriculture contribute to preserving natural CO_2 sinks?

Improvements in production and application of fertilizers have made significant savings of GHG emissions. Making best use of arable resources where they are available reduces the pressure for land use change in remote regions of the world.

OPTIMIZING FERTILIZER PRODUCTION

Nitrate-based fertilizers, such as Ammonium Nitrate (AN), are the most common source of nitrogen in Europe. Production of AN releases N_2O and CO_2.

Use of catalysts reduces N_2O emissions from fertilizer production by as much as 90%. This technology was developed by Yara and since been shared with the rest of the industry. It is today part of the "best available techniques" (BAT) for fertilizer production as defined by the European Union. Yara plants apply BAT and are rated amongst the most energy efficient in the world.

A scientific study of the carbon footprint of wheat production has demonstrated a 35 - 40 % reduction of emissions by improved industrial processes (figure 2) [2][3][4][5].

OPTIMIZING FERTILIZER USE

The average emissions from application of AN fertilizer is 5.1 kg CO_2-eqv per kg applied N [7].They are mainly due to N_2O losses caused by denitrification and volatilization in the soil. Since N_2O has a strong impact on climate, N_2O losses are an important issue.

Best Farming Practice, for example, the use of precision farming tools such as the N-Sensor™, aims at applying the optimum form and amount of nitrogen with the right timing to reduce losses and enhance N uptake. A good soil structure further improves N-use efficiency. Optimizing N efficiency does not only reduce climate and other environmental impact, but it also improves yield and profitability (figure 2).

Yara's crop nutrition programs and precision farming tools such as the N-Sensor™ and the N-Tester™ as well as software applications such as the Internet based Megalab™ assist farmers in minimizing fertilizer application while optimizing yield.

PRESERVING NATURAL CO_2 SINKS

Pristine forests, savannahs and wetlands store more carbon than any other type of land. Land use change, i.e. clearing of pristine forest and wetlands, accounts for roughly 12 % of world GHG emissions. Stopping land use change and deforestation is a powerful lever in climate protection.

Arable land is a scarce resource. It needs to be used in the most appropriate way in order to ensure supply of food and bio-energy for a growing world population. Intensive, and therefore productive, arable production in Europe helps to save rainforests, grassland savannahs and wetlands from being converted into arable land in remote regions of the world. This fact needs to be kept in mind when evaluating the global carbon balance of fertilizers (figure 3) [8][9][10].

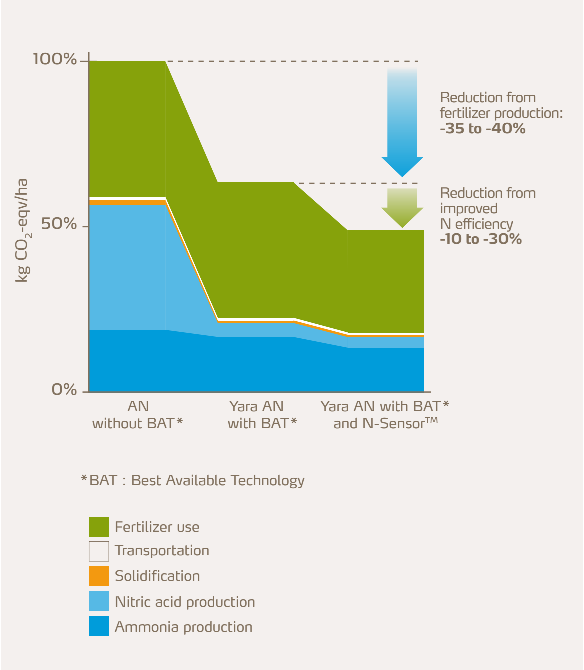


Figure 2: Yara has reduced the carbon footprint of nitrate fertilizer production by 35 - 40%. Enhancing N efficiency in fertilizer use can contribute by another 10-30% [6][7].

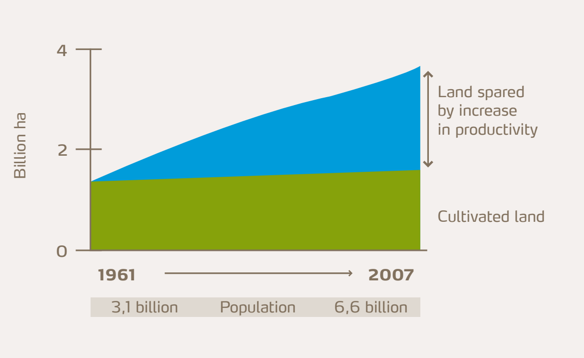


Figure 3: Global estimate of land required to produce sufficient food, if cereal yields had remained at the same level as in 1961 [1].

Optimizing yield, preserving the environment

Nitrate-based fertilizers – such as ammonium nitrate, calcium ammonium nitrate and nitrate-based NPK compounds – are pure nutrients offering the required precision, efficiency and reliability to meet the agronomic and environmental imperatives of sustainable agriculture. Yara nitrate-based fertilizers have a low carbon footprint and are the natural choice for farmers who want crops, not CO_2.

UREA OR AN?

During production, nitrate-based fertilizers emit more CO_2 than urea. However, during the application stage, the situation is inversed since urea releases the CO_2 stored in the molecule during production. In addition, more N_2O is emitted from urea by the nitrification process. The overall carbon footprint for nitrate-based fertilizers is thus lower than for urea. UAN, as a mix of urea and AN, has an intermediate carbon footprint. If volatilization losses are compensated by higher dosage (in general +10 % for UAN and +15 % for urea), the differences are even more marked (figure 4).

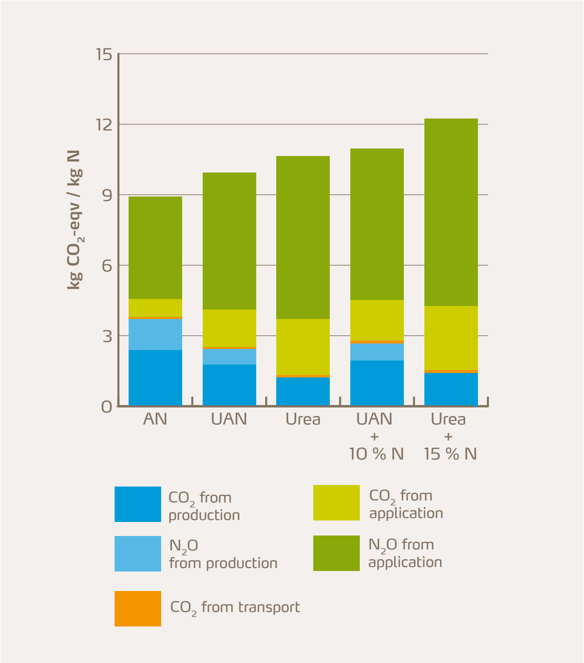


Figure 4: The life cycle carbon footprint for ammonium nitrate is lower than for urea and UAN. When conpensating the lower efficiency of urea and UAN by higher dosage, the difference is even more marked [11].

For scientific references and further information on nitrate fertilizers, get the complete nitrate fertilizer brochure from www.yara.com

ABOUT YARA

Yara International ASA is an international company headquartered in Oslo, Norway. As the world's largest supplier of mineral fertilizers for more than a century, we help to provide food and renewable energy for a growing world population.

Yara provides quality products, knowledge and advice to farmers in many countries around the world. Please do not hesitate to contact one of our local agronomists for further information.

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Yara International ASA
Bygdøy Allé 2,
P.O. Box 2464, Solli
N-0202 Oslo, Norway

Tel : + 47 24 15 70 00
Fax : + 47 24 15 70 01
www.yara.com