

# Harvesting energy

## with fertilizers

SUSTAINABLE  
AGRICULTURE  
IN EUROPE



The reason for agriculture's existence is to supply energy to mankind. Agriculture converts solar energy into biomass, which in turn supplies energy to human beings and animals in the form of food, feed or biofuels.

# Energy is a central issue in agriculture

As the Earth's non-renewable energy reserves decline, individuals, public bodies and industries including agriculture are under increasing pressure to reduce their consumption of fossil fuels.



Reducing fossil fuel consumption involves:

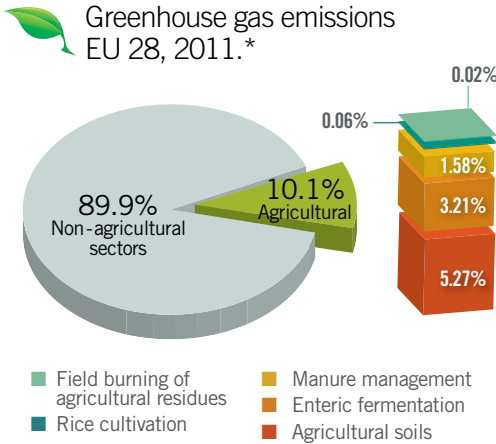
- Looking for advanced technological solutions that optimize the use of existing energy sources.
- Making the use of renewable energy sources a high priority.
- Finding energy sources which do not accelerate the greenhouse gas problem, and can even contribute to fixing or binding some CO<sub>2</sub>.

Agriculture produces energy in the form of biomass and also captures atmospheric CO<sub>2</sub>. Fertilizers greatly enhance this process.



# Fertilizers and energy

The energy efficiency of European agriculture is being improved from within the nitrogen fertilizer chain as well as on the farm.



\* Land Use, Land Use Change and Forestry (LULUCF) net removals are not included in total greenhouse gas emissions. Emissions from agricultural transport and energy use are not included in agriculture emissions, as these sectors are not defined as part of the agriculture sector by the current IPCC reporting guidelines.

Source: European Environment Agency

## Energy consumption in Europe

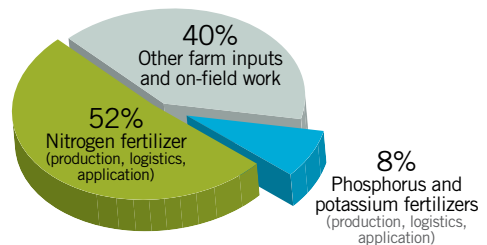
89.9% of energy in Europe is consumed by industry, traffic, private households and public services.

Agriculture accounts for 10.1% of energy consumption, including the energy used to produce mineral fertilizers.

## Energy consumption in European agriculture

For the production of wheat, approximately half the energy used is needed to produce, transport and apply the nitrogen fertilizer.

## Energy consumption in European agriculture\*



\* Source: IFA Statistics, UNEP, World Bank (World Resources 2000-2001)



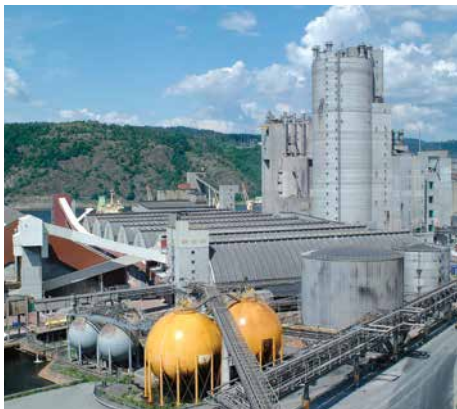


### N, P AND K FERTILIZERS: DELIVERING THE THREE PRIMARY PLANT NUTRIENTS

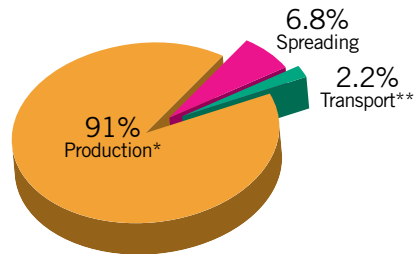
- ▶ N (nitrogen) is an important component of proteins and, as such, an essential nutrient for plants.
- ▶ P (phosphorus), a component of nucleic acids and lipids, is also key to energy transfers in plants.
- ▶ K (potassium) has an important role in plant metabolism: photosynthesis, activation of enzymes, osmoregulation, etc.

### Energy consumption in mineral fertilizer production

Within the nitrogen fertilizer chain, most of the energy used is required to produce mineral fertilizers. It is in this area, therefore, that technologies have been developed to ensure that the production processes are as efficient as possible.



### Energy consumption in the nitrogen fertilizer chain



**Total energy consumption:  
44 giga joule (GJ) per tonne of nitrogen**

\* including energy used for the extraction and transport of fossil fuels to the N fertilizer factory (average value for all N fertilizers).

\*\* transport of N fertilizer over a distance of 400 km by ship and truck (1 GJ = 25 litres oil)

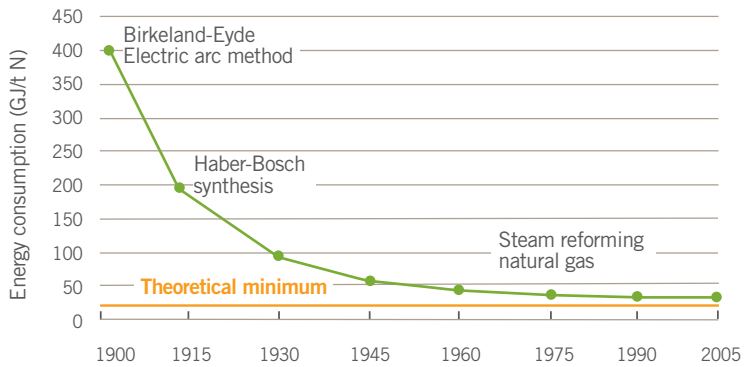


### Technical improvements in nitrogen fertilizer production

Energy efficiency in nitrogen fertilizer production has been significantly improved since the beginning of the 20th century. Modern fertilizer factories are now close to the theoretical minimum of energy consumption when producing ammonia - the first step in the production of N fertilizer.



### Evolution of ammonia production efficiency



Source: after Anundskas, 2000

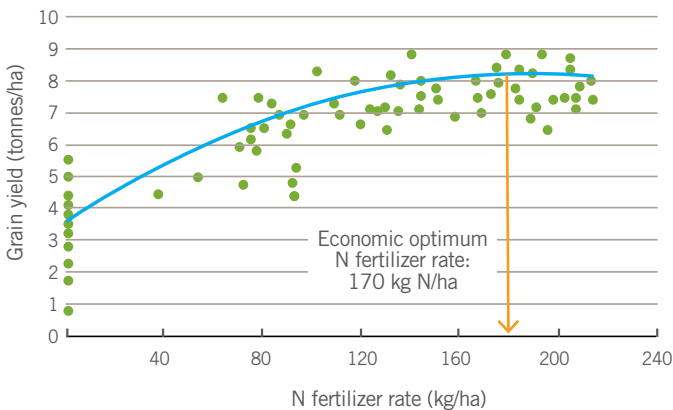


## Efficient energy use is a central issue on farms

Modern fertilizer application techniques can help to reduce the amount of energy used by adapting the quantity and number of applications to the crop's needs. Grain yield increases as more mineral nitrogen is applied. However, there is an economic optimum to the application rate of N fertilizer:



### Economic optimum of nitrogen fertilizer rate



Source: Küsters & Lammell, 1999

- The trials above show that the optimum N fertilizer application rate is about 170 kg N/ha, resulting in a yield of 8.2 tonnes per hectare.
- At this rate, the farmer's profit per hectare is the highest. This economic optimum is also known to have the best energy use/energy capture ratio.



# The energy balance

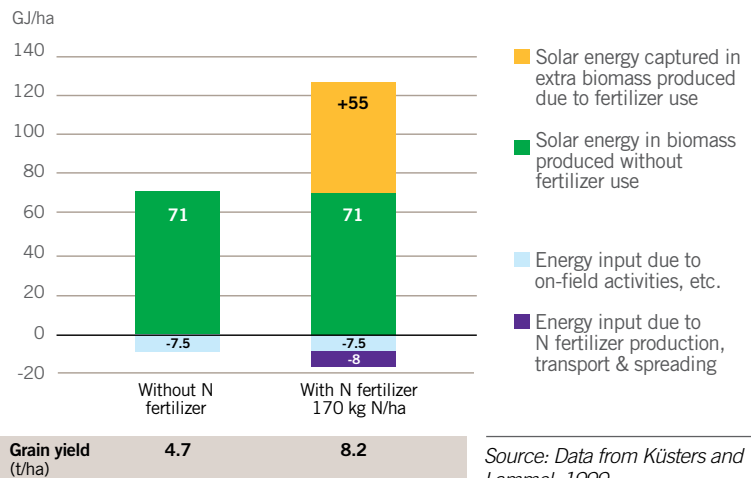
Nitrogen fertilizers greatly increase agriculture's positive energy balance, fixing solar energy and CO<sub>2</sub>.



The use of nitrogen fertilizer enables crops to grow more biomass by helping them to fix additional solar energy:

- ▶ When using 170 kg N fertilizer on a hectare of land, wheat yields are approximately 8.2 tonnes compared with 4.7 tonnes without N fertilizer.
- ▶ These 8.2 tonnes equate to 126 GJ (Giga Joule) of solar energy captured in the form of biomass when nitrogen is applied, compared with only 71 GJ without N fertilizer.
- ▶ The extra 55 GJ captured when using N fertilizers are more than 6 times the 8 GJ used to produce, transport and spread the same fertilizers.

 Energy produced from 1 hectare of wheat



Source: Data from Küsters and Lammel, 1999.




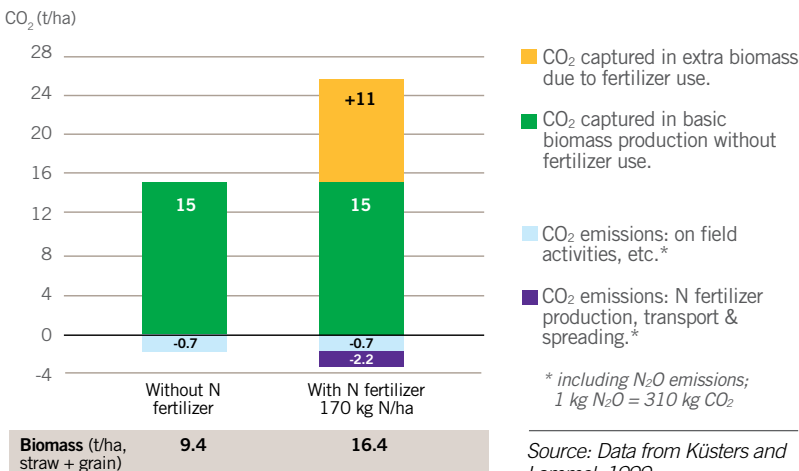
### The use of nitrogen fertilizer benefits the environment because it helps plants to fix extra CO<sub>2</sub>:

- When using solar energy to produce biomass, plants capture atmospheric CO<sub>2</sub> as their main source of carbon. Taking the same example of wheat production:
  - the higher yield obtained with N fertilizer means that more CO<sub>2</sub> is fixed: 26 tonnes compared with only 15 tonnes without N fertilizer
  - the extra 11 tonnes of CO<sub>2</sub> captured are more than 5 times the volume of CO<sub>2</sub> and other greenhouse gases (N oxides) emitted when producing, transporting and applying fertilizers.

- The CO<sub>2</sub> binding is not permanent, but short to medium term depending on the final use of the crop produced (food, feed, industry).
- The CO<sub>2</sub> binding is more permanent when part of the crop is ploughed in, increasing the soil's organic content.



 CO<sub>2</sub> fixed on 1 hectare of wheat



\* including N<sub>2</sub>O emissions;  
1 kg N<sub>2</sub>O = 310 kg CO<sub>2</sub>

Source: Data from Küsters and Lammel, 1999.

### Biomass as a direct energy source

Recycling crop wastes can have an added benefit since part of the biomass produced can be used as a direct energy source in the form of biofuels:

- When 15.5 GJ of fossil energy (which includes 8 GJ for fertilizers) are used to grow wheat, the total biomass produced is equivalent to 252 GJ.
- Half this biomass is straw. Used as a biofuel, these 8.2 tonnes of straw can replace 2.8 tonnes of oil, generating the same energy equivalent of 126 GJ.
- Unlike oil, straw is neutral in terms of greenhouse gas effect: the CO<sub>2</sub>

released when using straw as a biofuel is equal to the CO<sub>2</sub> captured to produce the same straw.

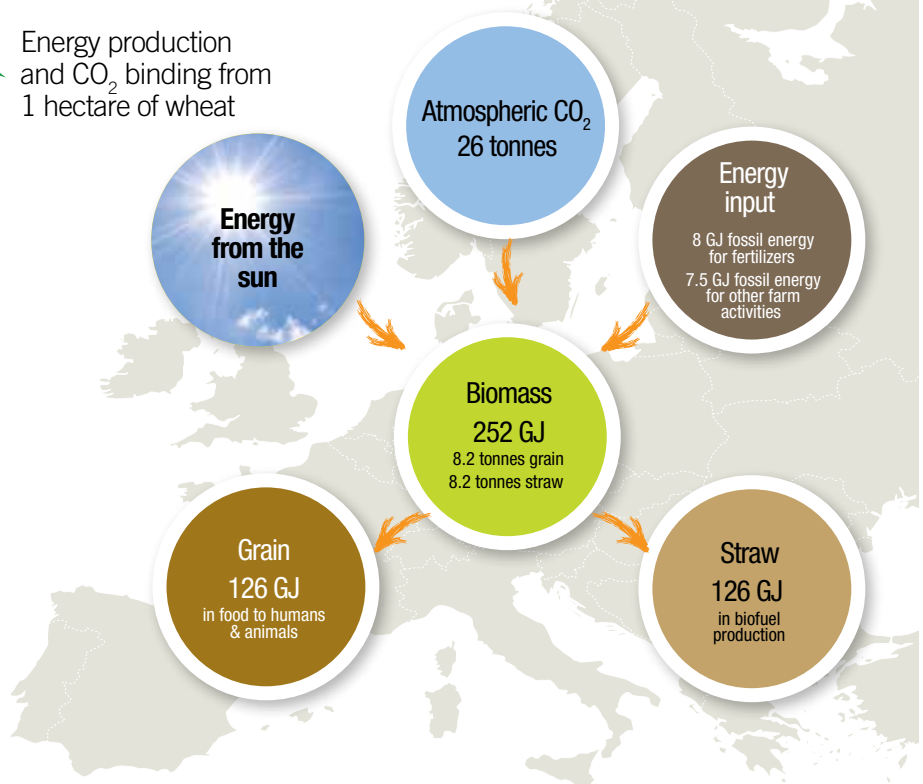
The potential impact is significant. Assuming that 50% of the straw produced on all (16.8 million) hectares of wheat in Western Europe is used as a biofuel, Europe will 'save' 3.5% of its total CO<sub>2</sub> emissions.

### Conclusions

With mineral fertilizers, crop production has an extremely positive energy balance and a positive effect on greenhouse gas levels, improving the sustainability of agriculture.



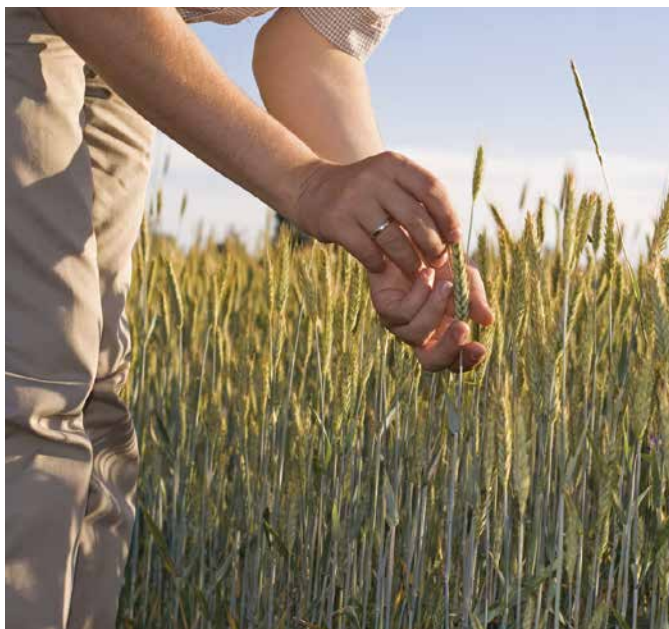
Energy production and CO<sub>2</sub> binding from 1 hectare of wheat



Sustainable agriculture will help feed the current world population, without compromising the ability of future generations to meet their own needs.

Mineral fertilizers are essential to sustainable agriculture by enhancing the production efficiency of food, feed and biofuels.





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