Harvesting Energy with Fertilizers

Agriculture produces energy and captures atmospheric CO_2. Fertilizers greatly increase this effect.

efma
European Fertilizer Manufacturers Association

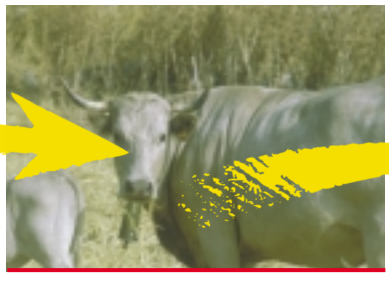
As the Earth's non-renewable energy reserves decline, individuals, public bodies and industries are coming under pressure to reduce their consumption of fossil fuels by :

- 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_2.

Agriculture produces energy

Agriculture converts solar energy into biomass, which in turn provides energy for human beings and animals :

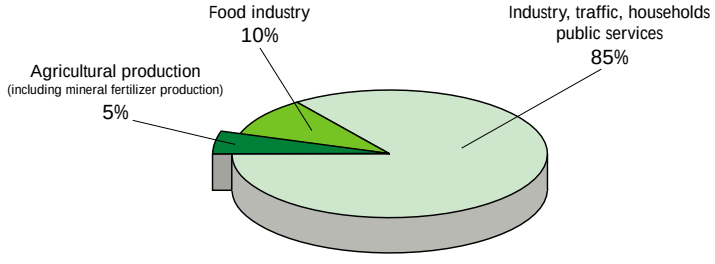
Energy is a central issue in agriculture.
The very reason for agriculture's existence is to supply energy to mankind. It does this by making use of solar power to convert energy into biomass, which in turn supplies energy to human beings and animals in the form of food and feed :



Energy efficiency is further increased in the nitrogen fertilizer chain

Energy consumption for different economic sectors in West Europe :

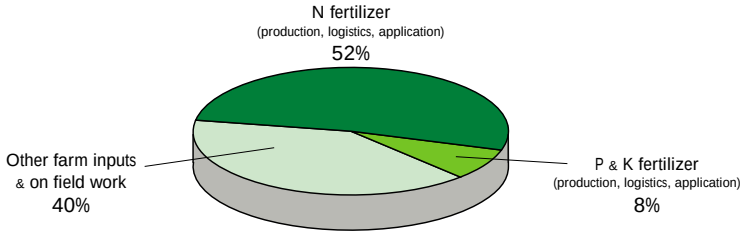
- 85% of total energy is consumed by industry, traffic, private households and public services.
- Food production accounts for 15% of this total energy consumption.
- Only 5% is used in agriculture, and this includes the energy used to produce mineral fertilizers.



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

Energy consumption in European agriculture :

Of all the energy used to produce wheat, approximately 50% is needed to produce, transport and apply nitrogen fertilizers.



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

N, P and K,
the three primary nutrients of plants :

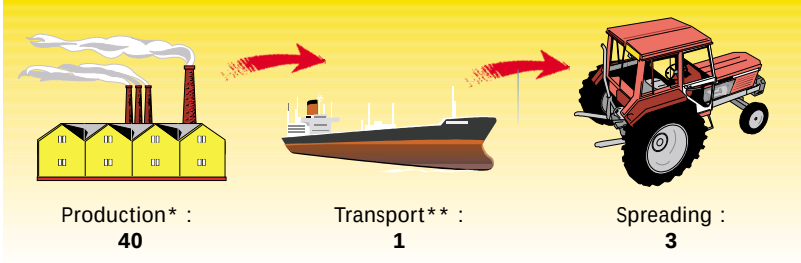
N (nitrogen) is an important component of proteins, and as such is an essential nutrient for plants.

P (phosphorus), 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, osmo-regulation, etc.

Energy consumption in the nitrogen fertilizer chain :

In this chain, most of the energy is required to produce mineral fertilizers, and it is therefore in this area that technologies have been developed to ensure that fertilizer manufacturing processes are as efficient as possible.



- values in Giga Joule (GJ) / tonne of N -

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

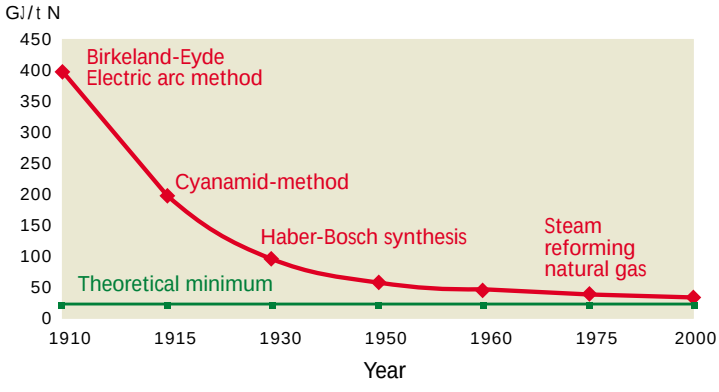
*** transport of N fertilizer over a distance of 400 km by ship and truck (1 GJ = 25 litres oil)*

Technical improvements in mineral nitrogen fertilizer production :

Energy efficiency in N fertilizer production has been significantly improved since the beginning of the 20th century.

Modern fertilizer factories are close to the theoretical minimum of energy consumption when producing ammonia, which is the first step in the production of N fertilizer.

Evolution of ammonia production efficiency

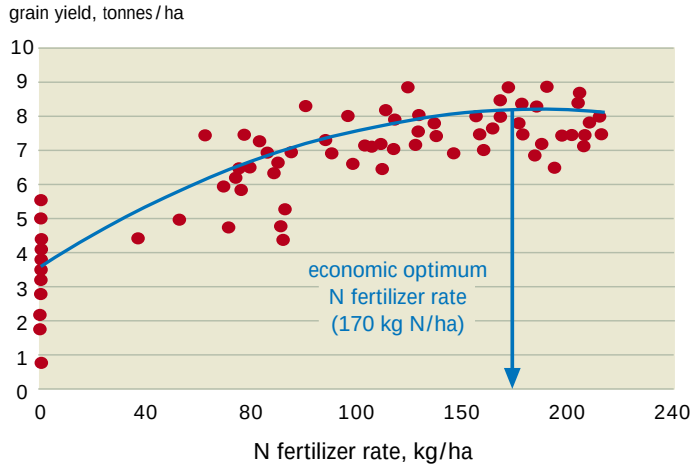


Source : Anundskas, 2000

Efficient energy use is also a central issue on farms :

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

Economic optimum of nitrogen fertilizer rate



Source : Küsters & Lammel, 1999

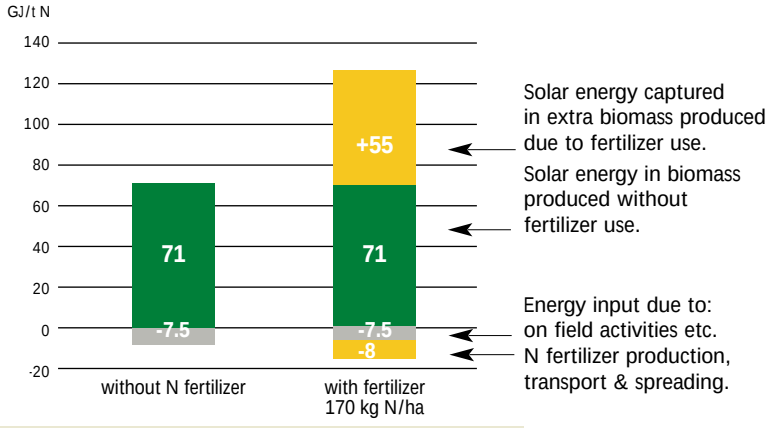
In these trials the optimum N fertilizer application rate is about 170 kg N/ha, resulting in a yield of 8.2 tonnes per hectare.
At this N rate the farmer's profit per hectare is the highest. This economic optimum is also known to have the best energy used /energy captured ratio.

Fertilizers greatly increase the positive energy balance of agriculture

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* 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 on 1 ha wheat



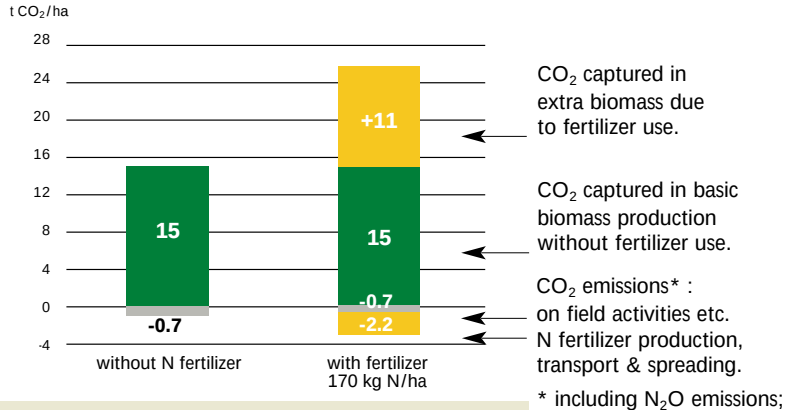
Grain yield (tonne/ha)	4.7	8.2

Source : Data taken from Küsters and Lammel, 1999.

The use of nitrogen fertilizer benefits the environment because it helps to fix extra CO_2 :

- When using solar energy to produce biomass, plants capture atmospheric CO_2 as their main source of carbon. Taking the same example of wheat production as above:
  - The higher yield obtained with N fertilizer means that more CO_2 is fixed: 26 tonnes compared with only 15 tonnes without N fertilizer.
  - The extra 11 tonnes of CO_2 captured are more than 5 times the volume of CO_2 and other greenhouse gases (N oxides) emitted when producing, transporting and applying fertilizers.

CO_2 fixed on 1 ha wheat



Biomass (t/ha, straw + grain)	9.4	16.4

Source : Data taken from Küsters and Lammel, 1999.

- The CO_2 binding is not permanent, but short to medium term, depending on the final use of the crop produced (food, feed, industry).
- The CO_2 binding is more permanent when part of the crop is ploughed in, increasing the soil organic content.

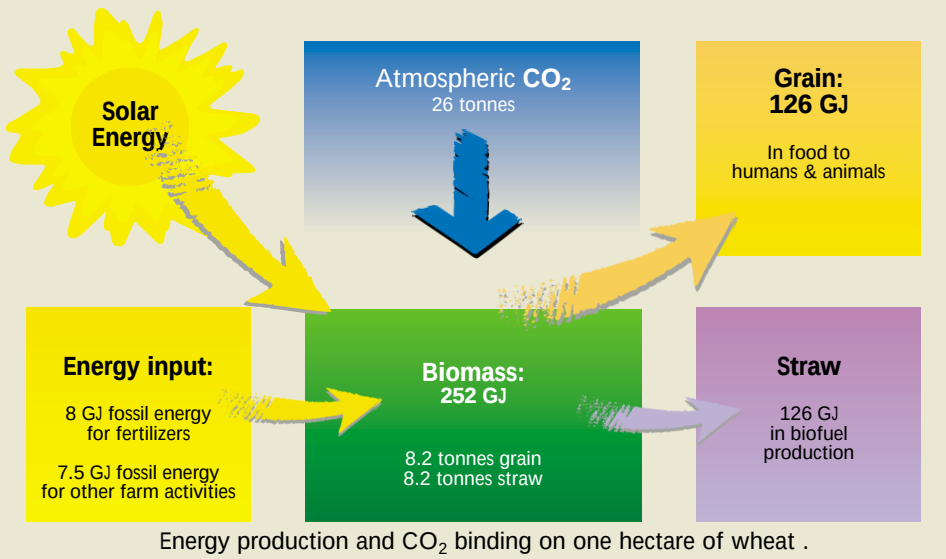
* GJ = Giga Joule

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_2 released when using straw as a biofuel is equal to the CO_2 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 West Europe is used as a biofuel, Europe will 'save' 3.5 % of its total CO_2 emission.



Energy production and CO_2 binding on one hectare of wheat .

In conclusion

- Energy balance in crop production is extremely positive.
- Crop production has a positive effect on greenhouse gas levels.

Mineral Fertilizers are essential for **Sustainable Agriculture**, which feeds the current world population without compromising the ability of future generations to meet their needs.

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