# Statistics

in focus

### ENVIRONMENT AND ENERGY

THEME 8 – 1/2003

#### ENVIRONMENT

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# Between 1990 and 2000, European agriculture has reduced its greenhouse gas emissions by 6.4 %

Koen Duchateau, Claude Vidal

. . . . .

In the EU-15, the contribution of the agricultural sector to total greenhouse gas emissions is almost 10%. In 2000, agriculture produced 390 Mt CO<sub>2</sub> equivalent, a reduction of 6.4% since 1990. The agricultural sector is doing better than the total greenhouse gas emission reduction of 3.5% over the same period. Greenhouse gas emissions from agriculture consist primarily of methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O), greenhouse gases which are many times more powerful than carbon dioxide (CO<sub>2</sub>). Over the period 1990-2000, methane emissions fell by 7% (with a reduction of methane emissions from enteric fermentation of almost 9%) and nitrous oxide emissions by 5.5%. Over the period 1990-2000, there was a significant reduction in methane emissions in Accession Countries and greenhouse gas emissions from agriculture fell by more than 6% in EFTA countries.

#### 10 % of the total greenhouse gas emissions originate from agriculture

Estimated EU-15 greenhouse gas emissions in 2000 totalled 4 058 million tonnes of carbon dioxide equivalent (Mt  $CO_2$  eq). This represents a decrease of 3.5% over the period 1990-2000, but an increase of 0.3% since 1999. The agricultural sector accounted for 390 Mt  $CO_2$  eq or 9.6% of total emissions in 2000 (Figure 1).

Among the greenhouse gases from agriculture, nitrous oxide is the most important (56%), followed by methane (43%). The share of carbon dioxide in greenhouse gas emissions from agriculture is only  $0.5\%^{1}$ .

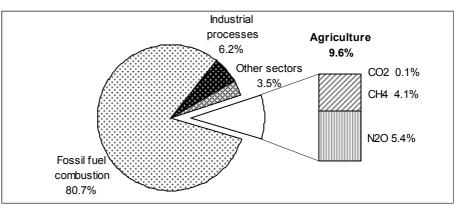


Figure 1 - Greenhouse gas emissions in EU-15 by source - 2000 (Source: UNFCCC / EEA)

<sup>&</sup>lt;sup>1</sup> These CO<sub>2</sub> emissions do not include emissions from fossil fuel combustion emerging from agriculture related transport, greenhouses and drying - see also methodological notes.

Emissions from agriculture were 0.8% lower in 2000 than in 1999 and 6.4% lower than in 1990 (Figure 2). This decrease was mainly realised from 1990 to 1993 and remained more or less stable after 1993. For the agricultural sector, methane emissions (168 Mt  $CO_2$  eq in 2000) have fallen by 7% and nitrous oxide emissions (219 Mt  $CO_2$  eq in 2000) by 5.5% since 1990.

Although agricultural emissions in the EU-15 fell by 6.4% on average between 1990 and 2000, the individual Member States show varying trends: Finland (-24%), Germany (-19%), Denmark (-17%) and Austria (-14%) are all performing significantly better than the EU-15 average, while Spain (+17%) and Ireland (+3%) show an increase, due to increased livestock populations (Figure 3). In absolute terms, the noted largest decrease is in Germany (16 Mt CO<sub>2</sub> eq).

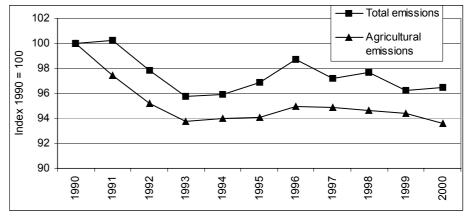
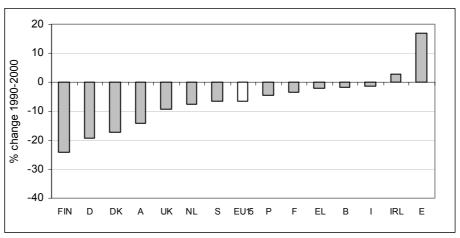


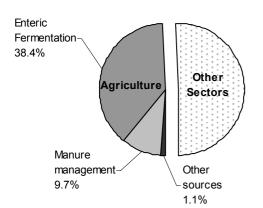
Figure 2 - Greenhouse gas emissions in the EU-15 - Trend 1990-2000 (Source: UNFCCC / EEA)



*Figure 3 - Change in emissions of greenhouse gases from agriculture in the Member States (Source: UNFCCC / EEA) Note: No data for Luxembourg* 

#### Agriculture: Major source of methane and nitrous oxide

Agriculture is the major source of methane and nitrous oxide emissions. The agricultural sector accounts for 49% of all methane emissions, followed by the waste (32%) and energy (18%) sectors (Figure 4).



For nitrous oxide, 65% comes from agriculture, followed by energy (16%) and industrial processes (14%) (Figure 5).

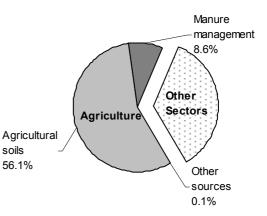


Figure 5 - Share of nitrous oxide sources in EU-15 in 2000 (Source: UNFCCC / EEA)

*Figure 4 - Share of methane sources in EU-15 in 2000* (Source: UNFCCC / EEA)

#### Livestock: Most important source of methane

Methane is produced in herbivores as a by-product of enteric fermentation, an anaerobic digestive process. Both ruminant animals (e.g. cattle, sheep) and some non-ruminant animals (e.g. pigs, horses) produce methane, although ruminants are the largest source since they are able to digest cellulose due to the presence of specific micro-organisms in their digestive tracts. The amount of methane that is released depends on the type, age, and weight of the animal, the quality and quantity of the feed, and the energy expenditure of the animal. Dairy cattle are the principal producer of methane emissions.

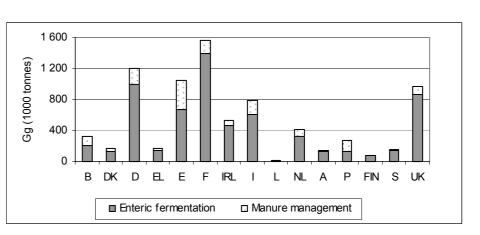
Livestock manure is the second most important source of methane. Methane is produced during the decomposition of manure under anaerobic conditions, while under aerobic conditions, carbon dioxide will be produced. These anaerobic conditions often occur when large numbers of animals are managed in a confined area (e.g. dairy farms, beef feedlots, and swine and poultry farms).

#### Share of enteric fermentation and manure management in methane emissions

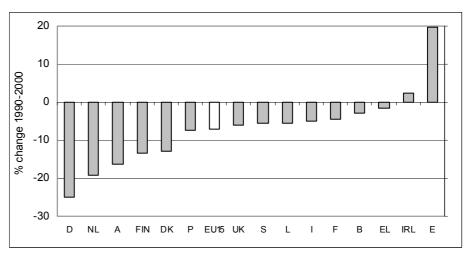
In 2000 agricultural activities in the EU-15 produced 8 Mt (168.3 Mt CO<sub>2</sub> eq) of methane: 6.3 Mt or 78% can be attributed to enteric fermentation and 1.6 Mt or 20% to manure management. The production of methane is thus closely related to livestock production. Other agricultural sources represent only 2% of the methane emissions: rice cultivation (1.4%), agricultural soils (0.8%) and field burning (0.09%).

The share of emissions caused by enteric fermentation or manure management varies between countries (Figure 6). There are many factors influencing this variation, such as temperature or livestock structure.

Between 1990 and 2000 methane emissions from agriculture decreased by almost 613 000 tonnes (12.9 Mt CO<sub>2</sub> eq) or 7.1% in EU-15 (Figure 7). In relative terms Germany, the Netherlands and Austria are ahead with decreases of more than 15%. In absolute terms Germany (-8.4 Mt CO<sub>2</sub> eq), the Netherlands (-2.0 Mt CO<sub>2</sub> eq) and France (-1.6 Mt CO<sub>2</sub> eq) show the largest decreases.



*Figure 6 – Methane emissions from enteric fermentation and manure management in the Member States, 2000 (Source: UNFCCC / EEA)* 



*Figure 7 - Change in methane emissions from agriculture in the Member States (Source: UNFCCC / EEA)* 



#### **Enteric fermentation**

Methane emissions from enteric fermentation decreased by almost 600 000 tonnes (12.6 Mt  $CO_2$  eq) or 9% between 1990 and 2000 in EU-15. In relative terms Germany, the Netherlands and Austria are ahead with decreases of more than 20%. In absolute terms Germany (-7.1 Mt  $CO_2$  eq), the Netherlands and France (both -1.7 Mt  $CO_2$  eq) show the largest decreases.

The amount of methane emitted by a population of animals is calculated by multiplying the emission rate per animal by the number of animals. To reflect the variation in emission rates among animal types, the population is divided into sub-groups, and an emission rate is estimated for each sub-group. Hence the reduction in methane emissions from enteric fermentation mainly reflects the decrease in dairy cattle population, which has the highest emission rate (-8.5% between 1994 and 1999 in the EU-15).

This calculation method does not take into account the effects of the exploitation system (intensive or extensive breeding,...) nor improvements in agricultural practices. In order to integrate these factors, more sophisticated calculation methods need to be developed.

Increasing rumen efficiency or production efficiency can reduce methane emissions from enteric fermentation. In the first case the amount of methane produced will decrease for a given feed intake. In the second case the amount of product (milk or meat) produced per unit of feed intake will increase. The increased efficiency will only have the desired result if the amount of produced milk or meat is kept constant, e.g. milk quota.

#### Manure management

Methane emissions from manure management remained stable between 1990 and 2000 for the EU-15. However, the trend varies between on the one hand countries with a much larger decrease than the EU-15 average, e.g. Germany (-22%), the Netherlands (-15%), Austria (-13%) and Portugal (-11%) and on the other hand Spain (+35%) and Sweden (+12%) with a significant increase. In absolute terms emissions fell most in Germany (-59 000 tonnes or 1.2 Mt  $CO_2$  eq) and Portugal (-17 000 tonnes or 0.4 Mt  $CO_2$  eq).

The main strategy for reducing methane emissions from manure is to influence the choice of manure management methods. These methods will determine whether the digestion process is predominantly aerobic or anaerobic and hence whether carbon dioxide or methane is evolved. Uncontrolled releases from anaerobic degradation can be avoided by ensuring aerobic digestion or recovering methane evolved from anaerobic degradation.

Covered manure management systems, for example, allow manure to be stored in anaerobic conditions and methane to be recovered as a bio-fuel. Burning methane turns it into carbon dioxide, which generates a much smaller greenhouse effect. By combining this with a heat recovery system, a double benefit can be realised: a reduction in greenhouse gas emissions and in use of conventional fossil fuel.

#### Soils and manure management: Sources of nitrous oxide

Emissions of nitrous oxide from agricultural soils are primarily due to the microbial processes of nitrification and denitrification in the soil. Nitrogen is put in the soil by the use of mineral fertilisers and livestock manure, through atmospheric deposition, biological nitrogen fixation and incorporation of crop residues. Also during the storage of manure, some manure nitrogen is converted to nitrous oxide. However, when manure is applied to the soil, much larger amounts of nitrous oxide are emitted

#### Share of agricultural soils and manure management in nitrous oxide emissions

In 2000, nitrous oxide emissions from agricultural soils (612 000 tonnes or 190 Mt  $CO_2$  eq) accounted for almost 5% of total greenhouse gas emissions in the EU-15. Agricultural soils are the largest source of nitrous oxide emissions in the EU-15 and within agriculture the soils account for almost 87% of the emissions. Manure management contributed 94 000 tonnes or 13% in 2000. The third agricultural source of nitrous oxide, field burning of agricultural residues, contributed only very little, 1 120 tonnes or 0.2% in 2000.



Nitrous oxide emissions vary greatly among the Member States (Figure 8). France, the leading agricultural producer of the EU-15, is the largest emitter, representing almost one guarter (24.4%) of the nitrous oxide emissions for 22% of the utilised agricultural area (UAA). The distribution of emissions between agricultural soils and manure management is fairly homogeneous among the EU Member States: 80% coming from agricultural soils, 20% from manure management. In Belgium and Germany, the share of manure management in the nitrous oxide emissions is higher however: 28% and 34% respectively.

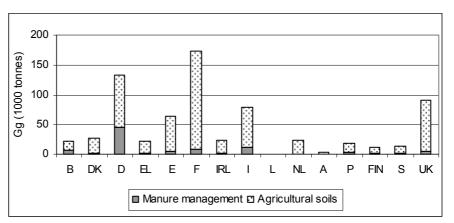
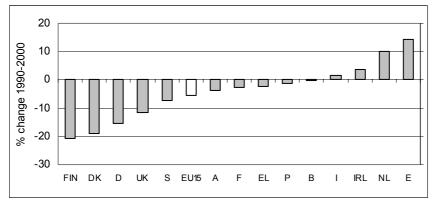


Figure 8 - Nitrous oxide emissions from agricultural soils and manure management in the Member States, 2000 (Source: UNFCCC / EEA) Note: No data for Luxembourg.



Nitrous oxide emissions fell by 41 000 tonnes (12.8 Mt  $CO_2$  eq) or 5.5% between 1990 and 2000 (Figure 9). The largest decreases are noted in Finland, Denmark and Germany (more than 15%), while in the Netherlands and Spain emissions increased by more than 10%. In absolute terms, Germany (-7.5 Mt  $CO_2$  eq) and UK (-3.7 Mt  $CO_2$  eq) show the largest reductions.

*Figure 9 - Change in nitrous oxide emissions from agriculture the Member States (Source: UNFCCC / EEA) Note : No data for Luxembourg.* 

#### Agricultural soils

In the EU-15, nitrous oxide emissions from agricultural soils fell by 6.9% between 1990 and 1993, and increased again later on. From 1997 onwards, the emissions fluctuated around 613 000 tonnes (190 Mt  $CO_2$  eq) per year. These variations could be explained partly by the set-aside policy of the Common Agricultural Policy (CAP): less agricultural land is cultivated and thus fewer nitrous oxide emissions are produced by agricultural soils. However, due to the large uncertainty in the emission estimates, it is not possible to derive any firm conclusions about the trend.

Trends in the Member States vary considerably, and should be interpreted with care, as there are methodological problems with estimating  $N_2O$  emissions from agricultural soils in a number of Member States. In relative terms, Finland, Denmark, the UK and Germany reduced emissions by more than 10% between 1990 and 2000, whereas Spain and the Netherlands had increases of more than 10%.

Improved agricultural management is the basis for a decrease in  $N_2O$  emissions from agricultural land: it has a major influence on nitrogen availability and environmental conditions, through, e.g. fertiliser applications, improved crop selection and breeding, livestock waste handling, residue management or operations affecting the structure, aeration and pH of soils. The introduction of appropriate management techniques, for example via the CAP and national policies, provides an important opportunity for  $N_2O$  mitigation in agriculture.



#### Manure management

Nitrous oxide emissions from manure management decreased in the EU-15 by 13% between 1990 and 2000. In the majority of the Member States these emissions fell significantly, but Belgium, Spain, Italy, Ireland and Portugal show an increase.

Nitrous oxide emissions from manure management can be reduced by improved manure storage systems and by decreasing the nitrogen in the animal manure. The latter can be achieved, for example, by improving the animal diet or by selecting livestock that is more nitrogen efficient.

#### Agriculture is a potential sink for carbon dioxide

As far as carbon dioxide is concerned, agriculture is a small emitter. Agricultural soils produce carbon dioxide when the organic carbon stored in the soils is released. In 2000 these emissions accounted for 2.0 Mt or 0.05% of the total greenhouse gas emissions in EU-15. Also the use of fossil fuels by the agricultural sector for agricultural machinery, transport, heating and drying leads to emissions of carbon dioxide. These energy related emissions are estimated at 53.6 Mt in 2000, representing 1.3% of the total greenhouse gas emissions in EU-15. In Figure 1 they are included under the category fossil fuel combustion. Since 1990, carbon dioxide emissions from fossil fuel use in agriculture increased by 4.8%.

Agriculture can also be a sink for carbon dioxide. By the conversion of agricultural land to forest or by the reversion of arable land to permanent grassland, carbon dioxide is absorbed from the atmosphere and stored as organic carbon in plants and soil. Other methods to increase the sink function of soils are associated with changes in the amount of soil organic carbon, for example by increased organic input in arable land (manure, compost, crop residues). However, carbon storage in soils is difficult to monitor. There is still considerable discussion on how to estimate the amount of carbon dioxide absorbed by agricultural activities. Currently a Good Practice guidance for the estimation of carbon sinks is being developed by IPCC and is expected to be available by the end of 2003.

#### Evolution in EFTA and Accession Countries

the EFTA and Accession In Countries<sup>2</sup>, nitrous oxide emissions make up the majority (55%) of all agricultural greenhouse gas emissions, but this varies from country to country (Figure 10). Ther potential for methane and nitrous oxide emissions have an equal share in the EFTA countries, while nitrous oxide has a much larger share in Republic, Bulgaria, the Czech Hungary and Poland.

Poland, the largest agricultural producer of the Accession Countries, is the largest emitter of greenhouse gases from agriculture. It accounts for around 30% of the methane emissions and of the nitrous oxide emissions of the Accession Countries presented here.

In the Accession Countries methane emissions fell significantly. Nitrous oxide emissions however should be interpreted with care. In some Accession Countries a major jump in values occurred in 1998-1999, when a change in methodology for nitrous oxide estimations was introduced. Not all countries have adopted the methodology for previous years. This is in particular the case for Hungary and the Czech Republic.

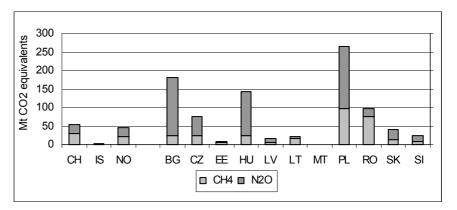
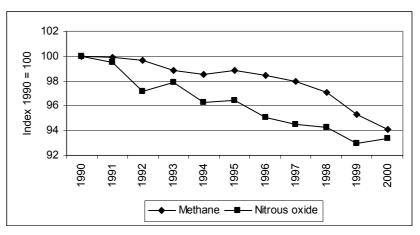


Figure 10 - Greenhouse gas emissions from agriculture in EFTA and Accession Countries, 2000 (Source: UNFCCC)



<sup>&</sup>lt;sup>2</sup> The following countries are not included because no data are currently available: Cyprus, Liechtenstein

Agricultural emissions in EFTA countries fell by more than 6% between 1990 and 2000: nitrous oxide emissions decreased by 6.6%, methane emissions by only 5.9% (Figure 11). Variations between countries are large: Switzerland shows the largest reduction, both in methane and nitrous oxide emissions (-10%). In Norway methane emissions remained on the same level. nitrous oxide emissions decreased by 3.5%. In Iceland methane emissions decreased by 9.2%, nitrous oxide emissions only by 1.4%.



*Figure 11 - Change in methane and nitrous oxide emissions from agriculture in EFTA countries* 

#### > ESSENTIAL INFORMATION - METHODOLOGICAL NOTES

For EU Member States, the data on agricultural greenhouse gas emissions are drawn from the "Annual European Community Greenhouse Gas Inventory" published annually by the European Environment Agency and based on the UNFCCC methodology, update 2002, years 1990-2000. For EFTA and Accession Countries, the data are based on information contained in the UNFCCC documents FCCC/SBI/2001/13 and FCCC/SBI/2001/13/Corr.1. Estimates on energy related CO<sub>2</sub> emissions from agriculture are extracted from Eurostat, New Cronos.

The data are submitted annually to UNFCCC and the EU Monitoring mechanism and are a combination of emission estimates based on volume of activities and emission factors. Recommended methodologies for emission data collection are compiled in the IPCC Guidelines for National Greenhouse Gas Inventories (1996).

Annual aggregated emissions of carbon dioxide  $(CO_2)$ , nitrous oxide  $(N_2O)$  and methane  $(CH_4)$  are weighted to their Global Warming Potential (GWP) coefficients over a 100 year time span (21 for  $CH_4$ , 310 for  $N_2O$ ). Data are expressed in Gg (=1000 tonnes) or Mt  $CO_2$  equivalents.

According to the UNFCCC, the following are sources of greenhouse gases from agriculture:

- enteric fermentation (CH<sub>4</sub>)
- manure management (CH<sub>4</sub>, N<sub>2</sub>O)
- rice cultivation (CH<sub>4</sub>)
- agricultural soil management (CO<sub>2</sub>, N<sub>2</sub>O, CH<sub>4</sub>)

• prescribed burning of savannahs (CH<sub>4</sub>, N<sub>2</sub>O)

• field burning of agricultural residues (CH<sub>4</sub>, N<sub>2</sub>O)

Carbon dioxide emissions do not include emissions from fossil fuel combustion emerging from agriculture transport, greenhouse heating and grain drying. This source is inventoried in IPCC under the section Energy, but the individual contribution of agriculture is not inventoried. Eurostat estimates these energy related emissions from agriculture. The calculations are made on the basis of annual energy data collected with joint Eurostat/IEA/UNECE questionnaires and the default IPCC  $CO_2$  conversion factors.

Methane estimates are reasonably reliable as they are based on a few well-known sources. The IPCC believes that the uncertainty in  $CH_4$  emissions, in Europe, is likely to be about 20%. The trend is likely to be more accurate than the individual annual values – the annual values are not independent from each other.

Nitrous oxide estimates are not very reliable, as major agricultural sources are not well quantified. The IPCC believes that the uncertainty in the N<sub>2</sub>O emission estimates, in Europe, is likely to be 50%, and as much as 100% in some sectors. The trend is likely to be more accurate than the individual absolute annual values as the annual values are not independent from each other. It is not yet clear if all countries backdate methodological changes to 1990, although this effect is expected to be large in the case of N<sub>2</sub>O.



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