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Towards a European levy on nitrogen

A new policy tool for reducing eutrophication, acidification and climate change

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Nitrogen input is the source of three major emissions from agriculture: nitrate causing eutrophication, ammonia causing both eutrophication and acidification, and nitrous oxide causing climate change. Reducing nitrogen input will, therefore, have a threefold environmental benefit. This report deals with a simple and effective way to reduce nitrogen input:a European levy on nitrogen. A levy of 100% would reduce emissions of N_2O by
3.7-20%, of NO_3 by 10-20% and of NH_3 by 10-20%. Several options for a levy and reimbursement, and their expected economic and environmental impacts, are discussed.

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Summary

1. The use of nitrogen in agriculture is the source of three emissions causing environmental problems: nitrate (NO_3) contributes to eutrophication, ammonia (NH_3) to both eutrophication and acidification and nitrous oxide (N_2O) to climate change. EU policy tools for reducing NO_3 and NH_3 are already in place or in preparation: the Nitrate Directive and the proposed ammonia threshold. Policy tools for reducing N_2O emissions are not yet available. This is a serious omission, since N_2O accounts for 8% of greenhouse gas emissions in the EU, 46% of which comes from agriculture. Under the Kyoto Protocol the EU has committed itself to reducing all greenhouse gas emissions by 8% compared with the baseline year 1990. This paper discusses a policy tool for reducing *all* nitrogen emissions, including N_2O: a European levy on nitrogen.
2. There is a risk that in seeking to reduce one nitrogen emission farmers will inadvertently increase other emissions. For example, raising the groundwater level to reduce NO_3 emission may lead to higher N_2O emissions. A levy on nitrogen would discourage such "solutions", while giving the farmer an incentive to reduce *all* nitrogen emissions simultaneously. It would make the Nitrate Directive and the ammonia threshold more effective.
3. The best points at which to raise the levy are the fertiliser and feedstuff industries and imports.
4. For a 10% reduction in the use of nitrogen fertiliser, a levy of 100% on fertiliser-N seems sufficient.
5. Such a levy would reduce emissions of N_2O from agriculture by 3.7–20%, and emissions of NO_3 and NH_3 by 10–20%. If we include emissions from outside agriculture, these figures become 1.7-9%, 5-10% and 9-18%, respectively. For the total of *all* greenhouse gas emissions, including CO_2 and NH_4, the reduction would be 0.3-0.9%. Precise figures cannot be given for the total of all emissions relevant to eutrophication and acidification, but these are no doubt higher.
6. A levy can have adverse effects: unjustified income loss among certain groups of farmers, concentration of agricultural activity on a smaller area, higher nitrate and ammonia emissions in productive regions, and land abandonment in other regions – including regions where agriculture is vital for maintaining rural communities, cultural landscapes and biodiversity. To prevent such effects, it is logical to redistribute the revenues from the levy to the farmers.
7. Reimbursement can be achieved in various ways. The simplest way is a flat rate area payment, which can be made dependent on environmental conditions (cross-compliance). A more targeted way is reimbursement through agri-environmental programmes.
8. A levy-and-reimbursement system largely complies with the Polluter Pays Principle (PPP), although less than a levy on the nitrogen surplus per hectare. Inevitably, some regions and some groups of farmers will gain, while others will lose income. Reimbursement per hectare is consistent with PPP, particularly if the payments are linked to environmental conditions (cross-compliance). Reimbursement through agri-environmental programmes may be less consistent with the PPP, but complies with the Steward is Paid Principle (SPP).

9. A levy on imported fertiliser and feedstuff complies with WTO rules, as long as it is applied in the same way to domestic products. Reimbursement will be less easily accepted. It can be argued, though, that a levy-and-reimbursement system on balance does not reduce competition within agriculture and among fertiliser industries.
10. There are at least two alternatives for a nitrogen levy: tradeable nitrogen permits and a levy on (or a maximum standard for) the nitrogen surplus on individual farms. The first option has more adverse social, economic and environmental side-effects than a levy. The second has various advantages, but requires a thorough and reliable farm bookkeeping system. Some EU countries meet this requirement, but it cannot be expected in the near future in many other countries, including pre-accession countries. Introducing a levy is much simpler and can be realised within a shorter period of time.
11. In the EU, tax issues are still subject to unanimous decision making. A unanimous decision in favour of a common nitrogen levy is perhaps not likely in the next few years. A more realistic option is for countries that have already started greening their tax system to take concerted action. The main countries are Germany, France, Denmark, Sweden, Belgium and the Netherlands.
12. Environmental NGOs can play a key role in putting a nitrogen levy (with reimbursement) onto the political agendas of the EU and its member states.

1 Introduction

Nitrogen use in agriculture is the source of various environmental problems. Nitrate (NO_3) contributes to eutrophication, ammonia (NH_3) to both eutrophication and acidification and nitrous oxide (N_2O) to global warming. Figure 1 shows the different pathways of nitrogen from fertiliser after application.

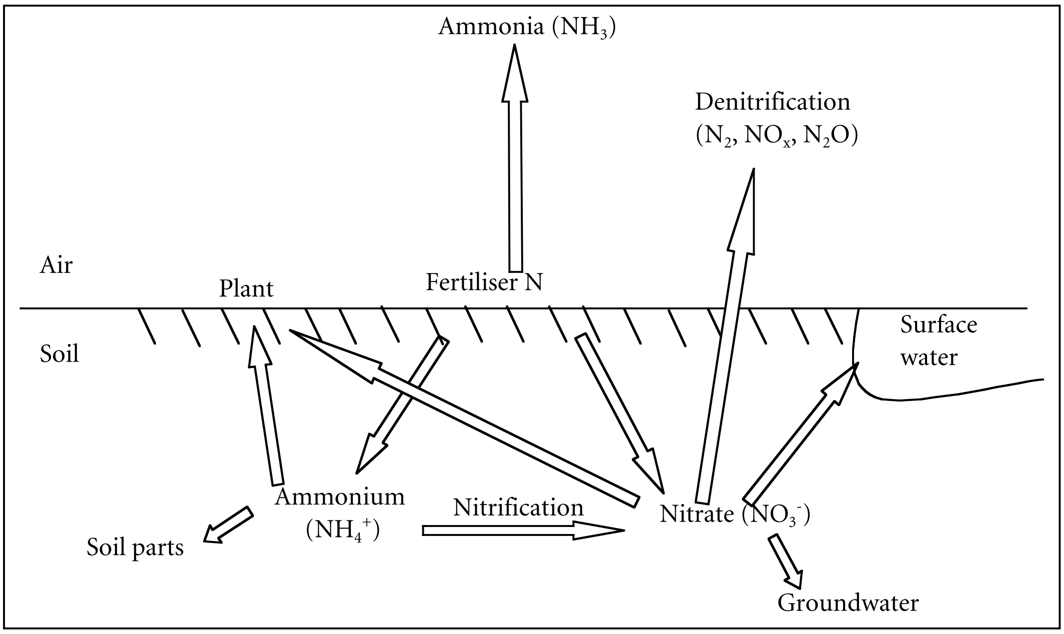

Figure 1. Pathways of N from fertiliser

Problems occur at all levels, from the field to the globe. Table 1 gives an overview (for details see Appendix 2).

Table 1. Nitrogen problems and regulation areas

Emission	Causing problem at the level of: field	farm	local area, region	(group of) countries	Europe / world
Nitrate (NO_3^-) to groundwater	●	●	●		
Nitrate (NO_3^-) to small surface waters			●		
Nitrate (NO_3^-) to large surface waters				●	
Ammonia (NH_3) to air		●	●	●	
Nitrous oxide (N_2O) to air					●

Thanks are due to Gerwin Verschuur and Eric Hees for comments and suggestions.

All of these emissions, except for nitrous oxide, are being addressed by the EU and its member states. This paper is a plea for a European levy on nitrogen. It is argued that such a levy can reduce emission of nitrous oxide, while simultaneously helping to reduce other nitrogen emissions and thereby eutrophication and acidification.
We first give more detailed arguments for a nitrogen levy, and then deal with the practical set-up, expected environmental and economic effects, possible support for the levy and alternative policy options.

2 Arguments for a European levy on nitrogen

Both the EU and member states have developed and introduced policies to reduce emissions of nitrate and ammonia. Key measures are the Nitrate Directive (1991) and more recently the proposed ammonia threshold. Why then a levy on nitrogen?
We give eight arguments for such a levy:

1. Although the EU has committed itself under the Kyoto Protocol to reduce all greenhouse gas emissions by 8% compared to the base year 1990, an effective policy tool is so far lacking. This is a serious omission, since nitrous oxide is held responsible for 8% of greenhouse gas emissions from the EU (AEA technology Environment, 1998).
2. Nitrous oxide emissions nor other nitrogen emissions can be measured on farm level. What can be calculated, however, is the total nitrogen surplus on the farm, which corresponds to the total of all nitrogen emissions. That can be done by subtracting all nitrogen outputs (through products like milk, meat and wheat) from total nitrogen input. This, however requires a good and reliable bookkeeping of all inputs and outputs. Although such bookkeeping has become common practice in some regions of European agriculture, it is lacking in many others and will continue to be so in the foreseeable future. Therefore a European nitrous oxide policy cannot be implemented on farm level. Clearly a more global policy tool is necessary. Two feasible options are: tradeable N-permits and a European levy on nitrogen, with or without a levy-free foot.
3. Policies to reduce single N-emissions have the risk of shifting the problem. For instance, measures to reduce ammonia emissions through an obligation to apply manure *in* rather than *on* the soil, may well enhance nitrate emissions. And raising the groundwater level to reduce NO_3 emission, may well enhance N_2O emission. This is another reason to address *total* N-emission rather than single emissions.
4. Nitrous oxide is a global problem. That also justifies a global policy instrument like a European levy on nitrogen or tradeable permits.
5. Both tradeable nitrogen permits and a nitrogen levy make nitrogen more expensive. This may have unintended social and environmental side-effects. For instance, production may tend to concentrate in the most favoured areas, followed by abandonment of so-called less favoured areas at the expense of rural communities, landscapes and biodiversity. Government can prevent or reduce such side-effects, e.g. by supplying hectarage payments. Such payments can easily be financed from the revenues of a levy, but not from tradeable permits. In that respect a levy clearly is to be preferred.
6. A levy can be introduced with or without a levy-free foot. Such a foot is justified since part of the nitrogen leaves the farm through the product, without harming the environment. But this system also requires detailed bookkeeping. A levy-and-reimbursement system is equivalent, but on farm level does not require bookkeeping of fertiliser and feedstuff, only of land. That is more realistic in larges areas in the EU.
7. One might argue that a nitrogen levy is not necessary for reducing nitrate and ammonia emissions, since specific policies, mainly the Nitrate Directive and the proposed ammonia threshold, are already in place or underway. However, these policies are only partly effective and are difficult to police since they conflict with the price signals the farmer gets. A nitrogen levy reduces the conflict and will render these regulations more effective and more easily to police. It is even possible

that farmers do not just comply with the standards set, but go further voluntarily for economic reasons.

8. It is thinkable that some regulations can be relaxed to some extent, giving more "freedom of choice" to farmers in the means they choose to comply with the standards set.

In the following pages, we will focus largely on the effect of a European nitrogen levy on emission of the greenhouse gas nitrous oxide.

3 Practical set-up

To make a N-levy system successful, we suggest the following set-up of the system.

Levy on industry
The level can be put on farm level, but it is much simpler to put in on the fertiliser industry and the feedstuff industry.

Levy passed on to the farmer
Some European countries did already introduce a N-levy in the past: Finland, Sweden, Norway and Austria. In 1986 a tax on fertiliser-N was introduced in Austria. During the first year the fertiliser industry and the distributors decided to carry the burden: they simply cut the 'before tax' prices for their product, so the farmers did not get an economic incentive to reduce N-use. Nevertheless the use of nitrogen fertiliser decreased by 17% in 1986, probably due to a signalling effect of the levy. Between 1987 and 1989 prices increased and demand decreased by a further 2.5%. After abolishment of the tax, N-use increased slightly again (Rougoor et al., 2001)
In case industries do not voluntarily pass the levy onto the farmer, in order to keep or enlarge their market share, it may be helpful to create a legal option to enforce the industry to do so.

Levy of 100%
The effect of the levy is highly dependent on its level. We assume that, to justify a new policy instrument, a reduction in nitrogen use of at least 10% is required. From Appendix 3.1 we can conclude that this reduction requires a levy of at least 100%.
In the EU the price of 1 kg N in fertiliser is roughly 1.54 EUR (see Appendix 1).
Thus the levy will be 1.54 EUR per kg N.
At first sight a 100% levy may seem high, but it is low compared to environmental levies currently put on items like energy and cigarettes in several European countries.

Reimbursement to farmers
Although many farmers are able to improve the efficiency of their nitrogen use, others would either face higher costs due to the levy, or lose income by cutting nitrogen input to the extent that yield declines. Government can neutralize this effect by reimbursing the tax revenues to the farmers. If we disregard transaction costs, the average farmer can even be 100% compensated.
Such reimbursement can have four advantages:

13. the system better complies with the Polluter Pays Principle, since it accounts for the fact that part of fertiliser and feedstuff input leaves the farm through the product, without harming the environment;
14. most farmers will suffer no net income loss and will be less reluctant to accept the levy;
15. adverse side-effects, like increased abandonment of rural areas, can be prevented;
16. the global competitiveness of the agricultural sector can be maintained.

There are several options for reimbursement. The most simple option is a flat rate area payment for all European farmers, comparable to those already given for farmers growing cereals, maize, starch potato and protein crops. Another option is a more targeted reimbursement through agri-environmmental programs.

Whatever option is chosen, it will inevitably overcompensate some groups of farmers while undercompensating others. For instance, a flat rate hectarage payment would overcompensate farmers in less productive areas, who per unit of output use much land, while undercompensating farmers in highly productive areas. Similarly, reimbursement through agri-enviromental programs by definition favours those farmers who qualify for payments under these programs. That is a matter of political choice. So long as there is (still) not enough support in the EU for a common levy, a limited number of member states may decide to introduce such a levy, as they did in some other green taxes. In that case reimbursement will also be given on a national basis. That would need specific approval from Brussels, because it is seen as income support. Conditions for approval are (Hees, 2000):

- it has to be temporary (not exceeding 5 years);
- it may only compensate for extra costs;
- there has to be no net advantage for the specific sector;
- conditions have to be transparant and not arbitrary.

Tax not on manure

Due to the higher price of fertiliser, the production costs of feedstuff and the costs of manure will increase. Therefore strictly speaking it is not necessary to put a levy on feedstuff and manure. In addition the market price for feedstuff and manure will increase and as a consequence its use will decrease and become more efficient. However, there is one reason to put a levy on feedstuff: it is necessary to justify a levy on imported feedstuff under the WTO regime.

Import tax on fertiliser and feedstuff

If the levy is put only on domestic fertiliser and feedstuff, that would evoke substitution by imported counterparts, thus distorting competition and reducing the environmental effect. Therefore imported fertiliser and feedstuff should equally be taxed.

4 Effects on emissions

What environmental effects can we expect from a European N-levy? To answer this question we first have to deal with the following questions:

- what is the expected effect on total N-use and on the N-surplus?
- how will the different N emission routes be affected?
- what is the (indirect) effect on CO_2-emissions from production of fertiliser and concentrates?

These questions are dealt with in Appendix 3. Here we give the most important results.

Effect on total N-use and on N-surplus

If a N-levy of 100% on fertiliser is introduced, a decline in use of fertiliser N by at least 10 % can be expected. The average utilisation of N is roughly 50%. It seems reasonable to assume that despite the decrease in use of N the production will not significantly decrease, i.e. the farmers will increase the efficiency of their use of fertiliser and manure. As a consequence the N-surplus will decrease by about 20%.

Effects on specific N-emissions

The reduction of N-surplus will affect emissions of nitrate, ammonia and nitrous oxide. Opinions differ on the effect of such a reduction on these single emissions. We give three different calculations.

Calculation 1: All emission routes face the same effect

The simplest estimate is that emissions of all three kinds will be reduced equally by 20%. If that is the case, what will be the effect on total greenhouse gas emissions in the EU?

Nitrous oxide emission is responsible for about 8% of the EU greenhouse gas emissions (expressed in CO_2-equivalents; see Appendix 2). Of this 8%, 46% is due to agriculture, equalling 3.7% of total emissions. Thus, 20% percent less nitrous oxide emission from agriculture results in 0.7 % less greenhouse gas emissions in the EU.

Calculation 2: Estimate based on the FAO statistics database

A different figure can be obtained using a report made by AEA Technology Environment (1998) for the FAO. The report states that between 1990 and 1994 a decrease in the use of inorganic nitrogenous fertiliser in the EU by 6% resulted in a reduction of the N_2O-emission from agriculture by 5%. Using this ratio, we can calculate that due to a reduction of fertiliser use by 10%, N_2O-emission from agriculture will decrease by 8%. This equals 0.3% less greenhouse gas emissions in the EU.

This figure is an underestimate, if we assume that a levy will also be imposed on N in imported feedstuff, resulting in an additional effect. In addition the ratio used is debatable. The emission reduction was empirically measured. But this reduction may well have been the result of more agricultural factors than just the reduced use of nitrogenous fertiliser.

Calculation 3: IPCC standard method

A third estimate can be based on the IPPC, the Intergovernmental Panel on Climate Change of the UN. According to their standard method each kg reduction in fertiliser reduces N-emissions by 0.0125 kg N_2O-N. Mosier et al. (1998) also use this figure. Total fertiliser use in the EU equals 9,216 kilotonnes (kt) (Appendix 1). In our case 10% reduction of 9,216 kt equals 922 kt less N-use from fertiliser.

This would result in 922 x 0.0125 = 11.5 kt N_2O-N. This equals 11.5 x [(2x14)+16]/(2x14)[1] = 18.1 kt N_2O. For comparison: total N_2O-emission from agriculture in the EU is 484 kt. Thus, this emission will be reduced by 3.7 % and total N_2O-emission by 1.7%. This equals 0.14% of total greenhouse gas emissions.
This figure, again, is an underestimate, if we assume that a levy will also be imposed on N in imported feedstuff, resulting in an additional effect.

Effect on CO_2

There is an additional indirect effect on greenhouse gas emissions. Less use of fertiliser and feedstuff will normally speaking be followed by less production of these materials, including concentrates. As a result, the associated CO_2-emission will also decline.
It can be calculated (Appendix 3) that greenhouse gas emissions will thus fall by an extra 0.15 %.

Table 2 gives an overview of the effects of a tax on N in fertiliser and feedstuff on all relevant emissions.

Table 2. Effects of a 100% tax on N in fertiliser and imported feedstuff on four emissions

Environmental aspect	Reduction (% of total in agriculture) (A)	% of total emission due to agriculture (B)	Reduction as % of total emission (A x B)	% of green-house gas emissons (CO_2-eq.) (C)[2)]	Reduction of total green-house gas Emissions (A x B) x C
Nitrate leaching	10 - 20%	24 – 81%[5)]	5 - 10%	n.r.[1)]	n.r.[1)]
Ammonia emission	10 - 20%	95%[3)]	9 - 18%	n.r.[1)]	n.r.[1)]
N_2O emission	3.7 - 20%	46%	1.7 - 9%	8%	0.1 – 0.7 %
CO_2 emission	?[4)]	1%[3)]	0.11%	80%	0.15 %
TOTAL	-	-	-	-	0.3 – 0.9 %

[1)] n.r. = not relevant
[2)] We have only included CO_2, N_2O en CH_4. Other sources (fluoride compounds) have not been taken into account.
[3)] These data are based on Europe's Environment (1995): this is the emission directly due to agriculture.
[4)] This figure cannot be given exactly, because the reduction applies to indirect energy use, not to direct energy use in agriculture.
[5)] This differs between countries, ranging from 24% in Finland to 81% in Denmark (Stanners & Bourdeau, 1995). The weighed average is 50%.

The effect of a levy on climate change emissions seems much lower than the effect on eutrophication and acidification. However, this comparison is not fair, since we have counted *all* greenhouse gas emissions, *not* all emissions contributing to eutrophication and acidification. Thus the difference is much smaller.

[1] Based on the atomic weights of N (14) and O (16).

Other considerations

Some factors mayreduce or rather reinforce the estimated effects:

- farmers will optimise the use of animal manure. That will result in further reduction of nitrogen emissions of all kinds and thus reinforces the effect of the levy;
- some farmers will substitute fertiliser N by biologically fixed N. They can do so by growing (more) legumes as a crop or as a cover crop. Like in the case of fertiliser, this N will partly leak into the environment in various forms. This will reduce the effect ofthe levy on fertiliser;
- other farmers will substitute concentrates from the feedstuff industry by feedstuff from other farmers. This will reduce the effect of the levy on concentrates;
- some farmers will grow (more) spring crops. These crops need less fertiliser, but show higher nitrate leaching (Hansen, 1991). This will reduce the effect of the levy. But the area involved will probably remain small due to market conditions;
- less nitrogen use may be followed by less use of other inputs, like phosphate, potassium and pesticides. That in turn may lead to less production of these materials and and less CO_2-emission. This effect will probably be small;
- if a levy on feedstuff is not just put on imported feedstuff, but - for reasons of trade policy - also on concentrates from domestic raw materials, the latter is in fact levied twice. That will increase the effect of the levy;
- water levels are increasing in the lower parts of Europe. Deltas are intensively used for agriculture. Rising water tabels will enhance denitrification. As a result, N_2O-emissions will increase and nitrate emissions decrease.Thus the effect of a levy on nitrate leaching will be lower, and the effect on greenhouse gas emissions be higher than assumed;
- various countries have introduced a levy on energy. This alone will increase the price of fertiliser and concentrates and thereby reduce their use. But this does not necessarily reduce the additional effect of a nitrogen levy;
- the BSE-crisis will have various effects on production and consumption. Firstly, meat and bone meal, which contains much protein and thereby nitrogen, is no longer allowed as animal feed. It will be substituted by feedstuff grown in the EU or imported from abroad. Thus more nitrogen wil be used and emitted. In addition energy use and CO_2-emission will increase. Secondly, the average consumer will eat less meat and more plant proteins. The net result will be less nitrogen use and emissions, less use of energy and less CO_2-emission. Probably the latter effect will prevail. If so, the additional effect of the levy will be lower.

Effect expressed in windmills

To get an idea of the scope of the effect on greenhouse gas emissions, it may be helpful to compare the effect with other options to reduce these emissions. For instance we can substitute fossil energy by durable sources like wind energy. In Appendix 3.4 we have calculated that to reach the same effect as a nitrogen levy of 100%, around 30,000 windmills of at least 80 m high would have to be built. In that case there will also be less use of fossil energy in power plants and thereby less NO_x-emission and thus somewhat less acidification. But no effect on eutrophication is to be expected.

5 Economic effects

We now turn to the economic effects of the levy, from farm level to the EU.

Farm level

A tax of 100% on N in fertiliser and concentrates without a refund would have a large effect on average farm income (see Appendix 3). However, if reimbursement is 100% andtransaction costs would be payed by the governement, there will be no effect on average farm income.

Especially farms with a high livestock density will face income loss. They pay many levies because they use many concentrates though not necessarily much fertiliser per unit of product, whereas under a flat rate hectarage payment they get back little money because they have little land per unit of product. To some extent they can escape, because they have relatively much scope to replace fertiliser by animal manure. Very extensive farms, in contrast, will profit, because they use little fertiliser and concentrates and much land per unit of product. Organic farms may benefit most. This is in accordance with the Polluter Pays Principle (PPP).

International level

In the EUR-15 the total consumption of fertiliser-N was about 9.2 million tonnes in 1990 (Appendix 1). Forecasts were by then that the nitrogen fertiliser consumption would decline by 6 % until 2000. Total N-use in 2000 would then have been 94% of 9216 kt = 8600 kt. A levy would give an additional reduction by 10%, resulting in 7800 kt. Assuming a levy of 1.54 EUR per kg N, total levy revenues would amount to 12 billion EUR. If this would be reimbursed on a flat rate hectarage basis, the payment would be 100 EUR per hectare.

Fairness

Is a levy-with-reimbursement a fair system? This would require in the first place that the system is in accordance with the Polluter Pays Principle (PPP) and with the Steward is Paid Principle (SPP). More specifically, do those farms having high a nitrogen surplus (and thereby the highest emissions) actually suffer most income loss? And are farmers with a better environmental performance actually rewarded? We also have to ask whether the system does account for natural circumstances relevant for the amount of levy farmers have to pay.

A levy is most consistent with the PPP if it is put on the nitrogen surplus - the difference between nitrogen input and output - per hectare on farm or even field level, since it is this surplus which causes the emissions. As we saw earlier, however, such a system is not realistic on a European scale. Nor is a levy with a levy-free foot. A levy-and-reimbursement system is more realistic. The only unfairness left is that a flat rate area payment does not account for differences in output level per hectare.

Knickel (1999) found that if a 200% tax on fertiliser N is introduced, farmers with a more balanced nutrient management are not always relatively better off. Some farms with a relatively balanced nutrient management suffer significant income loss, while other farms with a relatively high nutrient surplus do not face a significantly negative effect on income. However, if we consider the surplus per hectare, this may be in accordance with the PPP: a very intensive farmer can have a relatively balanced nutrient management but on a per hectare basis can still be a larger polluter than an extensive farmer with a less balanced nutrient management.

Reimbursement per hectare can be made even more consistent with PPP by linking the payments to environmental conditions (cross-compliance), as is already possible and more and more practised under the current CAP. Reimbursement through agri-environmental programmes is less consistent with PPP, but does comply with the SPP.
If farmers are reimbursed, the fertiliser and feedstuff industries will claim the same. This claim, however, is not fair if industries pass the levy onto the farmers, as is fore-seen in the system.
As regards the influence of 'natural circumstances', it is obvious that there are differ-ences between farms on different soil types. Some soils have a relative high natural N-supply, giving the farms a financial advantage. This advantage increases under a levy and will not be corrected by a flat rate reimbursement. However, this is not necessarily unfair, since such differences have always existed in the past and were already impor-tant 50 years ago when fertiliser prices were much higher than today.
We may conclude that by and large a N-levy with reimbursement is a fair system.
There is another element of fairness in the system. Many countries have introduced levies on energy, partly motivated by climate change. It seems neither fair nor effective to put the entire burden on CO_2, leaving other greenhouse gases like N_2O unaffected.

6 Actor-analysis: expected support for such a system

What are the political opportunities for a levy with reimbursement? Which actors are likely to support it, which resist?

Farmers

The farming community will not welcome a levy on nitrogen, since it increases their costs. But if 100% reimbursement is guaranteed, farmers will be less negative. Clearly some farmer groups will have to pay, whereas other groups will gain. But often the first group will speak out more loudly than the second group. If the levy would be linked to relaxation of some very stringent regulations, that would help getting the support of the farming community.

Industry

The fertiliser and feedstuff industries will pay part of the bill, since farmers will improve the efficiency of their nitrogen use, will substitute part of their fertiliser by manure and legumes and will substitute part of their concentrates by feedstuff purchased from other farmers. Sales of fertiliser and concentrates will inevitably decline, which in fact is one of the goals of the levy. In addition, a levy will draw public attention to the environmental effects of fertiliser and concentrates. On the other hand, the levy will help to reduce emissions and thereby to improve public image of fertiliser and concentrates.
Industry will certainly lobby against a levy and if they expect they cannot stop it, will lobby for financial compensation, for an equal levy on imported materials and for a tax refund on exported materials. The first claim does not seem justified if industries pass the levy onto the farmer. Reimbursement even may reduce the chance that they do so, making the levy less effective. An equal levy on imports, however, would make the levy more effective and would keep the industry competitive. The latter reason would also justify a tax refund on exports.

NGOs and water authorities

The system is likely to get support from many NGOs: environmental, conservation and perhaps consumers. In addition support can be expected from water and drinking water authorities.

Countries and regions

Since there are major differences in average N-use per unit of product between countries, it is inevitable that some countries will on balance benefit, whereas other countries pay a price, even under 100% reimbursement. So long as this is in accordance with the PPP, it is politically defendable. But the political reality is that the system can only be introduced if leading countries like Germany and France accept it. Tax issues are still subject to unanimous decision making. That reduces the chances of the levy on the short term. The only short term opportunity seems to be that a group of relatively “green” countries take the lead in a concerted action.

CEE countries
In view of the expected accession of Central and Eastern European countries, what will be the effects of the system for these countries?
These countries largely have extensive farming systems. Prices of products are low compared to the EU. As a consequence, fertiliser is relatively expensive and extensively used. After accession prices of products will rise to EU levels, creating an incentive to intensify the use of fertiliser and other inputs.
Thus the system is likely to have the following effects:

- farmers in the CEE countries would gain because per unit of product they use relatively little fertiliser and feedstuff and much land. Therefore they would pay relatively little levy and - at least in the case of reimbursement on hectarage basis - get much payment.
- the incentive to intensify N-use will be weakened because of the levy. While farmers can still raise production per hecare, they will continue to use nitrogen in an efficient way, to the benefit of the environment.
- income losses in areas with high pig and poultry densities would be substantial. This would justify temporary provisions to prevent a drastic fall in income.

WTO
The relationship between trade rules and environmental taxes is currently studied in the WTO (OECD, 1997). Border tax adjustment is a WTO legal mechanism to provide rebates for domestic taxes paid on exported goods and to levy a domestic tax on imported products at the border (Knickel, 1999).
WTO rules do not seem to prohibit environmental levies on imported products if these are equally applied to domestic products. Such levies are already common practice on energy. Thus a levy on imported nitrogen fertiliser and feedstuff, and rebates for exported fertiliser and feedstuff, would seem acceptable.
Reimbursement will be less easily accepted. It can be argued, however, that a levy-and-reimbursement system on balance distorts competition of neither agriculture nor the industry. Of course reimbursement will increase total payments to farmers, but it can be argued that the average farmer will not gain. In addition, reimbursement makes the levy more compatible with the PPP.
Not acceptable will be a levy on imported feedstuff if it is not equally put on domestic feedstuff. We saw earlier that environmentally speaking there is a good case for this differential approach, but it does not comply with WTO rules.

7 Alternative options

Tradeable permits

In Chapter 2 we mentioned an alternative option for reducing N-use and emissions: tradeable N-permits. What are its advantages and disadvantages compared to a levy and reimbursement system?
There are two advantages:

- the total amount of nitrogen use in the EU, which is particularly relevant for climate change, can be more directly regulated;
- tradeable permits fit better in policies based on "less taxes and more market", as is the case in the US.

However, there are at least five disadvantages:

- the system is much more complicated than a levy on industry level and transaction costs will be higher;
- production will concentrate on highly productive land and on profitable farms which can easily afford buying nitrogen quotas;
- nitrogen use in highly productive areas and on profitable farms may not decline or even increase. For the UK it has been stated that most of the permits, and hence nitrogen use, would be concentrated in areas such as East Anglia, where intensive cereal growing is profitable and mineral nitrogen use has already caused significant groundwater pollution (Clunies-Ross, 1993). Here we see a difference between greenhouse gas emissions and nitrate emissions: for the first geographical distribution is irrelevant, for the latter it is very important;
- marginal areas, including areas where farming is vital for the landscape and for biodiversity, may be abandoned;
- although more farmers will leave the business, after having sold their nitrogen permit, it becomes more expensive for young farmers to start a farm, because they have to buy permits.

Some effects depend on the way quotas are allocated. If they were allocated on a flat rate hectarage basis, this would financially benefit farms on marginal land and organic farms, who can sell (part of) their permits. They will be bought by profitable farms, especially on highly productive land, who thus will face higher costs. These farmers will heavily oppose introduction of such a system. They would welcome allocation on the basis of historic use, but this violates the PPP, since farmers who used to apply much nitrogen per unit of product would be rewarded.
As mentioned earlier, many of these disadvantages can be prevented by introducing payments, either on a flat rate or a more targeted basis. But without a levy such payments would, politically speaking, be much more difficult to finance or would go at the expense of current CAP budgets for farmers.
On balance, although a tradeable permit system has much in common with a levy-and-reimbursement system, the latter is to be preferred from the viewpoint of farm income, rural policy, environment and transaction costs.

Regulating nitrogen surplus on farm level

Perhaps the best available system for reducing all nitrogen emissions is introducing a nitrogen balance on every farm, i.e. bookkeeping of all nitrogen in- and outputs, followed by a levy or a standard to the nitrogen surplus (Van Zeijts, 1999).
Such a system, which is applied in the Netherlands:

- takes account of all nitrogen inputs, including animal manure;
- takes account of the fact that on highly productive land more nitrogen leaves the farm through the product, without harming the environment;
- is targeted on the environmentally most relevant parameter: the nitrogen surplus per hectare;
- in short is superior in terms of environment, economy and fairness.

An obvious disadvantage of the system is its complexity and high transaction costs.
In addition, as mentioned earlier, it requires a solid and reliable nitrogen bookkeeping system on farm level. That is not available on the majority of farms in the EU and in the pre-accession states. Introduction would would take decades. A levy system is more feasible in the short term, at least in a group of EU member states.

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Appendix 1 Nitrogen use in Europe

1.1 Nitrogen use

There is a high variety in nitrogen use across Europe. De Roest (1999) calculated that in Europe the average N-use per ha is 49 kg N per ha. He defined 20 regions. N-use per ha varied from 22 (Sicilia) to 366 kg (parts of The Netherlands and Belgium).
Mills (1992) stated that in the EUR-12 the total consumption of fertilisers was about 19 million tonnes in 1979 and has remained at virtually the same level till 1992. Forecasts were by then that the nitrogen fertiliser consumption would decline by 6 percent by 2000.

Use of fertilisers in The Netherlands in 1997/'98: 402,9 kt N. This equals 205 kg N per ha (Land- en tuinbouwcijfers 2000). Europe's Environment (1995) gives information on consumption of nitrogen fertilisers per ha of agricultural area in 1990. This gives a total estimated of 9,216 kt of N. This seems to be the best estimate we have (see Table A.1.1).

Table A.1.1 Fertiliser use in the 15 EU countries in 1990 (source: Europe's Environment, 1995)

Country	fertiliser N-use (in kg/ha)	Area for agriculture (km^2)	total fertiliser N-use (in kilo tonnes)
Austria	39	35,221	137
Belgium	125	13,428	168
Denmark	142	28,002	398
Finland	81	27,052	219
France	81	304,620	2,467
Germany	99	181,996	1,802
Greece	47	39,587	186
Ireland	66	57,183	377
Italy	52	177,759	924
Luxembourg	..	1,267	≈ 6
The Netherlands	194	20,093	390
Portugal	37	≈ 50,000	≈ 185
Spain	35	49,915	175
Sweden	62	32,874	204
United Kingdom	85	185,524	1,577
TOTAL		1,204,521	9,216

1.2 Price of fertiliser

Price of N in fertiliser in the Netherlands '98/'99: around NLG. 1,- per kg N (Eur 0.45) (Land- en tuinbouwcijfers 2000).
The average price across the 15 EU-countries for ammonia nitrate (25% N) was 44.38 ECU/100 kg, or 1.71 ECU/kg N. A compound fertiliser (17:17:17 NPK) cost on average 19.58 ECU per 100 kg, or 1.15 ECU/kg N. Given this, the average price of fertiliser-N was calculated to be 1.54 ECU in EU15 in 1994 (AEA-Technology Environment, 1998).
The costs of fertiliser N differ considerably between countries. In the UK the costs are relatively small. In France and Germany the average costs of fertiliser are respectively 123% and 170% from the price in the UK.

Appendix 2 Emissions

2.1 Emission routes

N-use in agriculture is responsible for emissions of 3 compounds that have negative effects on the environment:

- Nitrate (NO_3): Nitrate emissions to groundwater cause problems for the abstraction of drinking water as high nitrate levels are considered detrimental to human health. Nitrate leaching to groundwater also leads indirectly to pollution of surface waters. The problem of leaching is influenced by the physical and environmental characteristics of the soil. 87 % of the agricultural area in Europe has nitrate concentrations in the groundwater above the guideline of 25 mg/l, and 22% is above the 50 mg/l (Stanners & Bourdeau, 1995). Nitrate in surface water increases to growth of algae and water plants.
- Ammonia (NH_3): Ammonia emissions come mainly from farms, the figure ranging from 80% (in the Netherlands) to 98% (in Norway). Ammonia deposition causes eutrophication and acidification. Ammonia problems are most widespread in intensive livestock farming areas like the Netherlands, particularly when nature conservation areas are situated near livestock areas, and so ammonia emission is mainly a local or regional problem (Van der Bijl & Van Zeijts, 1999).

  Nitrous oxide (N_2O): nitrous oxide is produced by bacteria in the denitrification process in the soil. It contributes to the greenhouse effect. Other sources of N_2O, besides agriculture, are traffic ('the warming of the catalyst of the car') and the production of nitric acid and carprolactam. The amount of N_2O-emission from different sources is not exactly known. N_2O-emission is relatively small, compared to other greenhouse gases. However, N_2O will only be broken down slowly, and it will stay in the atmosphere for more than a century. More than 50% of the N_2O is the result of a natural process: it emits from soil and water. The principal environmental parameters affecting N_2O-emissions are the availability of a nitrogen source, moisture and temperature, with nitrogen availability being the most important.

  The mechanisms causing release of N_2O are still relatively poorly understood (AEA Technology Environment, 1998).

Obviously, nitrous oxide emission is a global problem in scope. So far, relatively little attention has been paid to this element of the nitrogen problem in agriculture.

Nitrate and ammonia emissions are regulated by specific policies, for instance the Nitrate Directive and the ammonia threshold. For nitrous oxide there has been no policy defined yet. All emissions are very hard to measure at farm level.

2.2 Global warming

'Global warming' means that certain gases (CO_2, CH_4, N_2O and some fluoride compounds) in the atmosphere form a blanket around the earth. This is a natural situation. However, due to various kind of human activities this blanket becomes too thick: the amount of gases in the atmosphere is increasing. It is hard to predict what the effects will be. Some areas will become warmer, others colder. Ice caps and glaciers can melt due to the global warming. In the last century this has resulted in a rising sea level.

2.3 Greenhouse gas emission in Europe

Table A2.1 gives the emissions of CO_2, CH_4 and N_2O in the EU in 1994. It is expressed in Global Warming Potential (GWP): influence of the different gases on the global warming compared to the effect of CO_2. This way, the emission of each gas is expressed in kton CO_2-equivalents.
Table A2.2 shows the N_2O-emission in the 15 EU-states in 1994, and the part that is due to agriculture.

Table A2.1. Anthropogenic emissions of CO_2, CH_4 and N_2O in the EU in 1994

	Emission (kt) in 1994	GWP (100 years)	GWP * emission	Percentage
CO_2	3,215,558	1	3.215,558	80%
CH_4	21,930	21	460,530	12%
N_2O	1,049	310	325,190	8%
TOTAL			4,001,278	100%

Source: AEA Technology Environment, 1998

Table A2.2. N_2O-emission in the 15 EU-states in 1994, and the part that is due to agriculture

Country	N_2O-emission (kt)	Due to agriculture (kt)	Due to agriculture (%)
Austria	13	3	23%
Belgium	32	11	34%
Denmark	34	30	88%
Finland	18	9	50%
France	169	52	31%
Germany	218	86	39%
Greece	14	8	57%
Ireland	26	19	73%
Italy	157	76	48%
Luxembourg	1	0	68%
The Netherlands	70	26	37%
Portugal	14	7	50%
Spain	87	58	67%
Sweden	10	0	2%
United Kingdom	188	98	52%
Total	1,050	484	46%

Source: AEA Technology Environment, 1998

Between 1990 and 1994 the agricultural emissions fell by 27 kt (5%). The main reason was a reduction in the consumption of inorganic nitrogenous fertilisers which fell by 6% (AEA Technology Environment, 1998).

Appendix 3 Environmental and economic effects of a levy

3.1 Environmental effects

To estimate the environmental effect on a European N-levy, we have to answer the following questions:

- What is the effect of the tax on total N-use?
- What is the effect of this change in N-use on the N-surplus?
- How are the different N emission routes affected?
- How large are the indirect effects: less CO_2 emission due to less production of fertiliser and concentrates.

We discuss these questions here.

The effect of a tax on total N-use and N-surplus

Rougoor et al. (2001) describe the experiences with a levy on fertiliser-N in Austria, Sweden and Finland. In these countries such a levy was introduced between 1976 and 1986. Rates varied between 10 and 72% of the price of fertiliser. Price elasticity[2] in these situations was estimated to vary between –0.1 and –0.5, showing that fertiliser is an inelastic product.

Besides these field experiences there are all kind of model calculations done to estimate the effect of a levy on N-use. The outcome of these studies differ:

- AEA Technology Environment (1998) states that it is doubtful that fertiliser taxes are an effective instrument for reducing nitrogen use.
- Vatn et al. (1996) report that a 50% tax rate is required for a 5% reduction in nitrogen per ha applied to grain crops and a 20% reduction on grass. A tax rate of 100% could induce a 10% reduction in N per ha applied to grain crops and a 40% reduction in N per ha to grass.
- Herlihy & Hegarty (1994) concluded that extreme price increases are required to decrease nitrogen applications. For example, a 200% tax is required for a 25% decrease in N per ha, except where nitrogen is applied in great excess.
- Clunies-Ross (1993) stated that according to several German and Danish economic studies, taxes of 100 to 200% are needed for a reduction of 30% in N-use.
- Knickel (1999) calculates the effect of different policies, including a nitrogen fertiliser tax scenario. He finds that a mineral nitrogen tax of 200% reduced fertiliser use by 57%, and a reduction in nitrogen surplus of 27%.
- Bäckman (1999) has made a literature review on the effect of levies on the use of fertiliser and the N-surplus. Table A3.1 shows the range of effects that was found in this literature review.
- Effects differ significantly between sectors.

Differences in results are due to different referent levels (time, prices, etc.), different calculation methods and different regional conditions. For the levy of 150%, differences are based on different farm types. the decrease of fertiliser use and N-surplus is only 0 for farms with extensive grazing and no fertiliser use (Knickel, 1994).

These data show that a tax rate of 100% will at least reduce N-use by 10%. This tax rate and effect on N-use is used as a starting point in this fact sheet.

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[2] Price elasticity = change in use of the product (in %) / change in price of the product (%)

The effect of the levy system on N-surplus is hard to estimate, because of the possibility to replace fertiliser-N by other sources of minerals. If we assume that the average utilisation of N is about 50% and that despite the decrease in use of N the production will not decrease (i.e. the decrease in N-use will be an increase of the efficiency), the N-surplus will decrease with 20%. Regarding table A 3.1 this seems to be a reasonable estimate.

Table A3.1 Effect of a levy on fertiliser estimated in different studies

Level of levy (%)	Farm type	country	Decrease of fertiliser use (%)	Decrease of N-surplus (%)
10	Agricultural sector	Greece	7	n.a.[1]
	Intensive livestock	France	4 - 7	n.a.
30	Several farm types	EU member states	7 -17	8 – 20
40	Several farm types	UK	4	n.a.
50	Several farm types	EU member states	10 - 44	8 – 34
100	Cereals	EU	6 - 12	n.a.
	Grain, dairy, pork	Norway	10 - 15	n.a.
	Barley, wheat	Finland	20 - 24	n.a.
	Several farm types	EU member states	23 - 53	26 - 67
150	Field crops / sugar beet	Germany	21	34
	Field crops / oil seeds	Germany	17	23
	Mixed farm	Germany	81	31
200	Several farm types	East England	28	n.a.
	Several farm types	Denmark	30 - 40	
236	Sunflower, cotton, corn	Spain	10	n.a.
300	Dairy	The Netherlands	n.a.	18 – 53
	Arable farms	Germany	45	n.a.
	Agricultural sector	Germany	81	51

[1] n.a. = no estimate available
Source: Bäckman, 1999

Different emission routes
The reduction of N-surplus will affect emissions of nitrate, ammonia and nitrous oxide. Opinions differ on the effect of such a reduction on these single emissions. We give three different calculations.

<u>Calculation 1: All emission routes face the same effect</u>
The simplest estimate is that emissions of all three kinds will be reduced equally by 20%. In that case, what will be the effect on total greenhouse gas emissions in the EU?
Nitrous oxide emission is responsible for about 8% of the EU greenhouse gas emissions (expressed in CO_2-equivalents; see Appendix 2). Of this 8%, 46% is due to agriculture, equalling 3.7% of total emissions. Thus, 20% percent less nitrous oxide emission from agriculture results in 0.7 % less greenhouse gas emissions in the EU.

<u>Calculation 2: Estimate based on the FAO statistics database</u>
A different figure can be obtained using a report made by AEA Technology Environment (1998) for the FAO. The report states that between 1990 and 1994 a decrease in the use of inorganic nitrogenous fertiliser in the EU by 6% resulted in a reduction of the N_2O-emission from agriculture by 5%. Using this ratio, we can calculate that due to a reduction of fertiliser use by 10%, N_2O-emission from agriculture will decrease by 8%. This equals 0.3% less greenhouse gas emissions in the EU.

This figure is an underestimate, if we assume that a levy will also be imposed on N in imported feedstuff, resulting in an additional effect. In addition the ratio used is debatable. The emission reduction was empirically measured. But this reduction may well have been the result of more agricultural factors than just the reduced use of nitrogenous fertiliser.

Calculation 3: IPCC standard method
A third estimate can be based on the IPPC, the Intergovernmental Panel on Climate Change of the UN. According to their standard method each kg reduction in fertiliser reduces N-emissions by 0.0125 kg N_2O-N. Mosier et al. (1998) also use this figure. Total fertiliser use in the EU equals 9,216 kt (Appendix 1). In our case 10% reduction of 9,216 kilotonnes (kt) equals 922 kt less N-use from fertiliser. This would result in 922 x 0.0125 = 11.525 kt N_2O. This equals 11.5 x [(2x14)+16]/(2x14)[3] = 18.1 kt N_2O. For comparison: total N_2O-emission from agriculture in the EU is 484 kt. Thus, this emission will be reduced by 3.7 % and total N_2O-emission by 1.7%. This equals 0.14% of total greenhouse gas emissions.
This figure, again, is an underestimate, if we assume that a levy will also be imposed on N in imported feedstuff, resulting in an additional effect.

Effects on CO_2-emission
Till now we discussed the direct effects of a decrease in N-use. However there is also an effect on indirect energy use. The additional energy use of N-fertiliser is estimated to be 65 MJ per kg (Leach, 1976). This includes:

- the production of fertiliser (60 MJ/kg)
- the packing of the fertiliser
- the transport to the farms.

Bøckmann et al. (1990) give estimates that are almost 50% lower. They state that fertiliser factories built around 1970 use 30% more electricity than factories built in 1990. So, 35 MJ per kg N might be a better estimate for the year 2000 than 60 MJ. The total energy use, including packing and transport, is then estimated to be 40 MJ/kg N.
Different energy sources result in different CO_2 emissions:

- natural gas: 2.24 kg CO_2 per kg N
- oil: 2.96 kg CO_2 per kg N
- pit coal: 3.76 kg CO_2 per kg N (Van Bergen & Biewinga 1992).

Use in Europe equals 9,216 kt N. If this is reduced by 10% (922 kt), CO_2 emission will be (2.24 to 3.76) x 922 = 2,065 to 3,467 kt less. Total CO_2-emission in the European Union is 3,215,558 kton CO_2. This is reduced by (2,065 to 3,467) / 3,215,558 = 0.06 to 0.11 %, i.e. 0.1% of the total emission in the EU.

Levy on N in feedstuff
The percentage of N in concentrates varies between 2.5 and 5%. A 100 % tax on N in concentrates will therefore increase the price of concentrates with only 2.5 to 5%. We estimate that the effect on amount of feed stuff used in the EU will decrease 1% at the most (we haven't found any specific information on the effect of a levy on N in feed stuff, but the effect on the price, and therefore on the feed bought, is small). This is taken into account in the calculations on effects on nitrate leaching and ammonia emissions. However, the effect of less production of concentrates on CO_2-emission has not yet been taken into account. Van Bergen & Biewinga (1992) calculate that with the production of 1 kt concentrates 0.824 kt CO_2 will emit.
We do not have exact data on the amount of feedstuff used in the EU. In 1999 in the Netherlands 102,108 kt feed was imported (Kelholt, 2000). If we assume that half of the feed from outside the EU is imported via Rotterdam, we estimate that 200,000 kt feed was imported in the EU. If 1% less feed is bought, 2,000 kt feed less is imported, i.e. 0.824 x 2000 = 1,648 kt CO_2 less will emit. Total CO_2-emission in the European Union is 3,215,558 kton CO_2. This is reduced by 841 / 3,215,558 = 0.05 %, i.e. 0.02% of the total emission in the EU.

[3] Based on the atomic weights of N (14) and O (16).

3.2 Income effects

It is assumed that the fertiliser use restrictions will not cause a loss of productivity nor reduce farm profitability, because:

- manure N will be used as substitute for fertilisers;
- the cost of purchasing manure would be off-set by the savings on fertiliser purchase;
- technological development and transfer over time will improve N use efficiency (AEA Technology Environment, 1998).

TEAGASC (1989) in Ireland stated that a tax on chemical nitrogen leads to severe income losses, so some system of refunding or a tax free quota is needed. It is stated that refunds defeat the purpose of the tax and a tax free quota encourage illegal fertiliser transactions.

3.3 Differences between farms, countries, etc.

Knickel (1999): The effect of a levy on nitrogen use depends on farm type: the levy tends to be more effective on arable farms and on high livestock density farms. In the present situation many farms are not making the most efficient use of nutrients:

- Arable farms can improve nutrient efficiency by fine-tuning soil fertility management and by dosing the application of mineral fertilisers to match the demands of the crops. A relatively simple mineral nitrogen tax is sufficient to promote this.
- On most mixed farms manure can replace a very substantial part of the mineral fertiliser used at present. Even under current conditions reducing the use of mineral fertiliser can result in significant economic gains for most farms. A relatively simple mineral nitrogen tax is sufficient to promote substitution.

The more specialised farming and production systems which highly depend on external inputs tend to suffer the highest income losses. Mixed farming, in contrast, has more substitutional options which tends to reduce income losses. More significant income losses were mainly found for those scenarios including a N-levy in feed concentrate.

3.4 Windmills

The introduction of a N-levy results in 0.3 to 0.9 % less CO_2-equivalents in the EU. This is 12,000 to 36,000 kton CO_2-equivalents. Gas, oil and pit coal can be used to produce electricity. The CO_2-emission due to this production will respectively be 56, 74 and 94 kg CO_2 per GJ (Van Bergen & Biewinga, 1992). Here we use an average number: 75 kg CO_2 per GJ. So, the levy will result in (12,000 to 36,000 kton) / 75 equalling 160 to 480 million GJ per year less energy production.
The average capacity of a windmill is 1000 to 1500 kW (Bootsma, 2000). On average a windmill will be in use for 2000 hours a year (De Jager et al., 1994), resulting in 2 to 3 x 10^6 kWh each year, or 7200 to 10,800 GJ each year. So, to produce 160 to 480 million GJ per year 18,000 to 53,000 windmills would be necessary.