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**Reduction of Greenhouse Gases Methane (CH₄)
and Laughing Gas (N₂O) in German Agriculture:
A Framework for Political Action**

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Summary

Agriculture is a significant source of greenhouse gas emissions.

The global climate is changing. The change is caused by human action. Greenhouse gases (GHG) play a key role in present climate change. Globally, agriculture (without deforestation) accounts for about 14 per cent of the anthropogenic warming. This is as much as the world's transportation sector or manufacturing industry contribute to global warming (Table 1). Deforestation (for the purpose of converting forest into farm land) included, agriculture accounts for almost one third of the anthropogenic greenhouse effect.

Table1: Global greenhouse gas emissions by source, (2000)

Source	Share (in %)
Electricity	25
Land use changes (including deforestation)	18
Agriculture without deforestation	14
Transportation	14
Manufacturing	14
Buildings (heating, air conditioning etc.)	8
Other	7
Total	100

Source: Stern (2007)

Agriculture's role in the emission of CH₄ (methane) and N₂O (laughing gas) is particularly pronounced as it accounts for 50 per cent of the global methane emissions and 70 per cent of global laughing gas emissions. This is significant as the climate impact of both greenhouse gases is large. One ton of methane has the same climate effect as 21 tons of CO₂ (carbon dioxide) while one ton of laughing gas is equivalent to 310 tons of carbon dioxide.

German agriculture is a significant cause of greenhouse gas emissions as well. The farm economy employs 2.5 percent of the workforce. It contributes only 1.3 percent to the Social product but accounts for between 6 and 11 percent of total German greenhouse gas emissions. Again the emissions of methane and laughing gas are particularly high at 45 and 63 percent respectively. In



CO₂ equivalent this is 64.6 million tons. The most important sources of German agriculture's greenhouse gas emissions are the enteric fermentation in the digestive tracts of ruminants, animal manure and synthetic nitrogen fertilizer (table 2).

Emissions from animal production

Total emissions from animal production are about 27 million tons in CO₂ equivalent per year. This is roughly 40 per cent of total agricultural emissions of greenhouse gases. Of these, 83 per cent are the result of beef cattle both for meat and for dairy production.

Emissions from animal manure depend on a variety of variables such as the moisture content of the manure, amount of straw being used, type of manure storage, application of manure and so on. Production methods therefore may have a significant effect on emissions. For instance free ranging cattle tend to emit fewer greenhouse gases. The use of manure in bio-gas production also acts to reduce emissions significantly.

Methane emissions of a dairy cow in Germany

The average dairy cow in Germany emits about 112 kg of methane per year through enteric fermentation in the rumen. The government's goal is to restrict the carbon dioxide emissions of the average passenger car to 130 g per km. Such a car, driven 18,000 km per year, would cause the same climate effect as one cow. The climate effect of the manure of this dairy cow would be the equivalent of another 6,000 km of driving the car per year.

Emissions from plant production

Plant production is a significant source of greenhouse gas emissions as well both globally and in Germany. As rice production does not exist in Germany, the main culprit is laughing gas. In 2004, 74,000 tons of laughing gas was emitted farmland in Germany. This is 23 million tons in CO₂ equivalent. Synthetic nitrogen fertilizer accounts for about half of these emissions.

There is a significant potential for a reduction in emissions of laughing gas, as the efficiency of nitrogen fertilizer is below 50 per cent. That is less than half the nitrogen applied leaks into the groundwater or is released into the atmosphere. Precision application technology, timing of fertilizer application and choice of fertilizers may significantly reduce emissions of laughing gas.

Laughing gas emissions of from one hectare of fertilized farmland in Germany

German agriculture emits about 1.3 tons of CO₂-equivalent per hectare and year in the form of laughing gas when the land is fertilized. This causes the same climate effect as the car described in the previous box being driven for about 10,000 km per year.



Table 2: Methane and laughing gas emissions of German agriculture, 2004

Greenhouse gas und source	1,000 tons	Mio. tons CO₂-equivalent
CH ₄ from animal husbandry Enteric fermentation	882.1	18.5
CH ₄ from animal husbandry Manure management	248.0	5.2
<i>Sub-total for CH₄</i>	<i>1.130.1</i>	<i>23.7</i>
N ₂ O from animal husbandry Manure management	9.2	2.9
N ₂ O from crop production Cultures with fertilizers	74.3	23.0
N ₂ O-Pflanzenbau Cultures without fertilizers	48.4	15.0
<i>Sub-total for N₂O</i>	<i>131.9</i>	<i>40.9</i>
Total	-	64.6

Source: Own calculations based on Dämmgen (2006a).

Agriculture has to be included in an effective and credible strategy in the fight against global warming.

In the Kyoto Protocol Germany, the European Union and many other countries have committed themselves to fighting global warming through the reduction of greenhouse gas emissions. At present the central goal in the EU is to reduce greenhouse gas emissions by 30 per cent by 2020 as compared to the emissions in 1990, conditional upon other countries being serious in their attempts to mitigate greenhouse gas emissions as well. Recently, the German government has contemplated even more ambitious mitigation objectives. The 2007 G-8 summit in Germany has suggested reducing greenhouse gas emissions by 50 % by 2050.

In order to meet these objectives, the government has already taken a number of measures aimed at mitigating greenhouse gas emissions by both industry and private households. These include a system of tradable emission rights. However, thus far only marginal measures have been taken that target regarding greenhouse gas emissions from agriculture. An exception is the German fertilization regulation (Düngeverordnung), which spells out in fine detail which type of manure or synthetic fertilizer may be applied at which time of the year, in what type of weather conditions, in which amount, and so on. Failure to meet the requirements of the fertilization regulations may result in the loss of the direct payments from the European Union. Therefore, farmers adhere to these regulations. However, these regulations do not go far beyond what is in farmers' own best interest and what they would do anyway, even if there were no government fertilization regulation. Hence, the impact of this regulation on greenhouse gas emissions has been



limited. This is particularly true since the recent oil price increase has resulted in higher prices for synthetic nitrogen fertilizers.

A credible and successful climate policy has to be comprehensive and must not leave out an entire industry which is a significant emitter of greenhouse gases. A rational climate policy has to aim at reducing greenhouse gas emissions at least cost. Therefore, agriculture has to be integrated into the political strategy for a mitigation of greenhouse gases; i. e., agriculture should reduce emissions by the same percentage as the economy at large has to mitigate emissions.

From 1990 to 2004 German agriculture made significant progress in this regard and has already reduced greenhouse gas emissions by more than 18 per cent. The potential for further reductions of emissions at low cost is significant, while the social welfare gains of mitigation are as high as in other industries. Hence, a total reduction of emissions of thirty percent by 2020 relative to 1990 is a achievable.

Agricultural policy reform can contribute to emission reductions.

The reduction of GHGs emissions in German agriculture is due primarily to two reasons. One has been the process of reform in the Common Agricultural Policy of the European Union which began in the early 1990s. In the course of these reforms, agricultural markets became more liberal and more emphasis was placed on environmental issues. Both have resulted in reduced input use and lower production. The other has been the process of transformation in East German agriculture after unification which has resulted in a reduction in the number of beef cattle (both for dairy and for meat production) and in fertilizer input. Continuing liberalization of agricultural markets in the European Union could further reduce greenhouse gas emissions. Dairy production is a major source of greenhouse gas emissions and the reforms have, to a large extent, left out dairy policy. Including dairy fully in the process of market liberalization could reduce agriculture's greenhouse gas emissions even further.

In addition, existing agricultural policy instruments could be used to target emission reductions. An obvious candidate for this is the investment subsidy program. This could be accomplished by changing the conditions for eligibility for this subsidy such that it would be paid only if the investment under the program acts to reduce agricultural greenhouse gas emissions. Also, the conditions for cross compliance and, thus, for the payment of direct transfers under the Common Agricultural Policy should be modified such that they include emission targets. In addition, one could think of including greenhouse gas emission standards into the catalogue of criteria for funding under the European Fund for the Development of Rural Areas.

Part of the problem is that agriculture is not yet part of European climate policy and that the Common Agriculture does not yet spell out greenhouse gas emission goals. Therefore, there is no attempt to develop a much needed and coherent agricultural greenhouse gas mitigation policy. This is, however, necessary for an efficient European climate policy.



Incentive based instruments of climate policy are efficient. They achieve emission reductions at low cost to both the private sector and society at large

The potential for further reductions in agricultural greenhouse gas emissions at low cost is large. This potential has not been realized because, thus far, emissions have not had a price. There was no economic incentive for farmers to reduce emissions. Therefore, German agriculture is in a position, probably envied by other industries, of easily being able to meet the 30 per cent target, or even more ambitious climate policy objectives.

Low cost strategies for the reduction of GHG emissions in manure management

1. The application of liquid manure is an important source of greenhouse gas emissions. It continues to be common practice to simply spray liquid manure on the fields. However, applying the manure close to the ground and mixing it with the soil immediately reduces emissions significantly.
2. When manure is stored without cover both methane and laughing gas are emitted. Covering the manure until it is applied is a low cost approach to reducing the greenhouse gas emissions from manure storage.

Low cost strategies for the reduction of greenhouse gas emissions in crop production.

1. More than 30 years ago researchers at the College of Agriculture of Bonn University developed the so called Cultan method of applying synthetic nitrogen fertilizer. With the Cultan method, nitrogen is applied as ammonium rather than nitrate. Ammonium, which tends to be rather stable in most soils, is injected into the soil and plants use about 95 per cent of the nitrogen. Only 5 per cent is emitted into the atmosphere and the ground water. At the presently rather high prices of nitrogen fertilizer, the Cultan method reduces the cost of fertilizer by € 20 to € 50 per hectare. It requires investment in additional equipment, however, which would become more profitable if emissions had a price.
2. The ENTEC fertilizer is similar in this regard, as it is based on Ammonium. The nitrogen in the fertilizer is stabilized by a chemical process and does not require special spreading equipment.

A combination of incentive based instruments together with consumer information about the climate impacts of agricultural production constitute a suitable low cost strategy for reducing agricultural greenhouse gas emissions for both farmers and society at large. Incentive based instruments of climate policy create a price for emissions. They make emissions more expensive.



This creates a threefold incentive to reduce emissions.

- (i) At given technology, the costs of production increase. Thus, both factor input and production decline. This is the short-term effect.
- (ii) The fact that emissions now have a price makes existing low emission technologies, which have not yet been used, more economical. Therefore, traditional technologies will be replaced by already existing, more climate friendly technologies. This is the mid-term effect.
- (iii) A price for emissions also generates an incentive to invest in research and development for new low emission technologies. This is the long-term effect of incentive based climate policy.

The key incentive based instruments of climate policy are emission taxes and tradable emission permits. With emission taxes the government levies a tax on each ton of emission of carbon dioxide or CO₂-equivalent. With tradable permits, an overall ceiling for emissions has to be set. The maximum overall emission then needs to be allocated to producers. For emission trading to work, the overall emission ceiling has to be smaller than actual emissions. Then emission permits are scarce and there will be a price for the permits. With emission permits producers who have low marginal cost of reducing emissions will be suppliers of permits, and producers with high marginal cost will demand permits.

Both instruments are efficient in principle in that they realize emission reductions at least cost. However, they may differ in their respective institutional requirements and in their administrative cost.

Emission taxes may be implemented quickly, as suitable institutional and administrative requirements already exist.

Emission taxes on synthetic nitrogen fertilizers could simply be collected from the producers of fertilizers. The value added tax for the government must be collected anyway. Therefore, the administrative cost of implementing a nitrogen tax and of creating the institutional framework for it is low. For animal manure the nitrogen tax would have to be collected from farmers. This might appear to be difficult administratively. However, most of the information that is required to collect the tax is already at hand, including the type of manure and its nitrogen content, as farmers have to provide this data in order to comply with the existing fertilization regulation. Therefore, a nitrogen tax could be introduced rather quickly.



Tradable emission permits facilitate the integration of agriculture into the general system of emission trading.

For the reasons mentioned above, the information on individual emissions can be derived from information farmers have to provide anyway. A system of tradable emission rights, therefore, could also be established. However, a functioning system of emission permits would require implementing suitable institutional arrangements, which account for the peculiarities of agriculture (e. g. many small farms, small denominations, trade in CO₂-equivalents) and which likely would require quite some time.

For this reason emission taxes should be introduced in German agriculture. This would yield the desired results rather quickly. However, in the mid-run, a system of tradable emission permits should be established which should be designed along the lines of the general system of tradable emission rights. This system is already in place; the institutional arrangements governing it are still emerging.

Efficiency of climate policy implies that the price of emitting one ton of CO₂-equivalent is the same in all industries. Integrating agriculture into the general system of emission trading ensures that.

Consumer information about the climate effects of agriculture is important for rational consumer decisions.

In most of the developed world there is a rapidly growing demand for quality in food and agriculture. This includes not only quality components which can be found in the final consumer good but also components of process quality. In order to signal consumers the presence of such quality components, producers often use labelling. The label may be a government approved quality seal or a label that has emerged from private sector quality assurance activities.

Three aspects matter for the effect of quality labels on consumer purchasing decisions. First, consumers need to know what quality aspects are being certified. Second, the quality component being certified must be relevant to consumer purchasing decisions. And third, the label must have credibility. This holds for government certifications as well as for private sector quality labels.

Consumers continue to be largely ignorant of the effects of agricultural production on global warming. If consumers had this information they could take it into consideration when buying food; i. e., rational consumer decisions require information on the climate impact of agricultural production. Therefore, providing consumers with this information would change their consumption patterns and, thus, contribute to reduced agricultural emissions.



At present technologies this would result in a declining demand for ruminant animal products and rice in favour of other food items. This in turn would create an additional incentive to develop technologies which act to reduce greenhouse gas emissions in ruminant and rice production.

Not all the information necessary for a socially efficient agricultural climate policy is currently available; yet it is necessary to act now.

As with climate policy at large, not all the information necessary to design socially efficient policies of climate change is currently available. This is true with regard to the socially efficient level of mitigation and thus the level of the emission tax, as well as with regard to the extent and cost of adaptation to the climate policy. Therefore, any climate policy must be socially suboptimal for the time being. To do nothing in the face of imperfect information does not solve the problem either.

However, a stepwise approach to climate policy can minimize inefficiencies. It enables policy makers to adjust policies when unpredicted and undesired side effects occur, and it has the advantage that policy makers can react incrementally and swiftly to new information.

The fight against global warming requires international agreements which include all countries.

Climate protection is a global public good. No single country can produce this good for its population in sufficient quantity through unilateral action. Therefore, international cooperation is required. Functioning international agreements are based on reciprocity and conditional commitment. That is, each country has to commit itself to reducing emissions by an agreed upon quantity, conditional upon all other countries doing the same.

The Kyoto Protocol has been an attempt to do just this. However, several major emitters of greenhouse gases have not signed the Kyoto Protocol, which obviously hampers its impact on the reduction of global warming.

The Kyoto Protocol is imperfect, but it is certainly a step in the right direction. What is needed now is a serious attempt at a new international agreement on climate policy which includes all major emitters of greenhouse gases. While a new international agreement may take a long time to negotiate, it is, nevertheless, necessary for a globally efficient climate policy.

Until new international agreements have been negotiated, unilateral action is appropriate. Unilateral climate policy, however, has a drawback. It acts to increase the cost of domestic production and not for foreign competitors. This, in turn, may trigger transboundary movement of production to countries with less restrictive emission policies. This makes unilateral action politically less palatable, and it reduces the desired climate effect. In fact, if production moves to a



country which has less restrictive emission policies than the initial policy at home, the emissions may increase rather than decline.

For this reason compensation of producers may be considered appropriate, as long as there are no functioning international agreements which also cover agriculture. The larger the number of countries which cooperate on emission control the less important compensation becomes. For instance, compensation for agriculture would have to be higher if Germany unilaterally introduced emission policies for agriculture than if the EU of 27 member countries would do this, as a large portion of international trade by EU member countries is internal trade.

At any rate, compensation has to be in line with WTO regulations. That is, border measures must not be used. Domestic measures have to meet the requirements of the “green box” of the Agreement on Agriculture of the Uruguay Round of multilateral trade negotiations. These are measures which are considered to be not at all or only minimally trade distorting. They include instruments such as direct payments to producers which are decoupled from production or public funding of research.

A central instrument of the European Union’s Common Agricultural Policy is a system of direct payments, some of which are decoupled from actual production. Compensation, if granted at all, could simply be provided as a separate payment, and as public investment in research which aims at both reducing greenhouse gas emissions from and other negative environmental effects of agriculture, and increasing the competitiveness of this industry.

The proposed mitigation policy results in additional cost to farmers. Failure to implement any appropriate climate policy would be more costly both for farmers and society at large.

25 theses for an agricultural greenhouse gas mitigation policy

1. Agriculture in Germany, the EU, and globally is a significant emitter of greenhouse gases. This is particularly true for methane and laughing gas.
2. Important sources of agricultural greenhouse gas emissions in Germany are digestive gases from the rumens of beef and dairy cattle, synthetic nitrogen fertilizer, and manure.
3. Agriculture’s potential for greenhouse gas mitigation is high and the costs of mitigation are low. A rational and credible mitigation policy has to include agriculture’s greenhouse gas emissions.
4. The process of liberalization of agricultural markets and the environmental reorientation of the Common Agricultural Policy have already resulted in significant reductions in both inputs and production. A continuation of the reform process will further reduce agricultural greenhouse gas emissions.



5. No political mitigation objectives have been defined for agriculture and there is a lack of consistent and coherent concepts for an agricultural greenhouse gas mitigation policy.
6. Much like with general climate policy, there is incomplete information on the private sector adaptation to mitigation policies. Therefore, a stepwise approach to the inclusion of agriculture is appropriate.
7. General greenhouse gas mitigation objectives should apply fully to agriculture as well. Agriculture in Germany has already reduced greenhouse gas emissions by 18 percent between 1990 and 2004. The potential for further emission reductions at low cost is high.
8. German agriculture is in the comfortable position to meet ambitious mitigation objectives without major economic drawbacks.
9. Extensive production practices in dairy and beef may reduce emissions significantly.
10. The use of animal manure in bio-gas production also has the potential to significantly reduce greenhouse gas emissions from agriculture.
11. With traditional synthetic nitrogen fertilization only about 50 percent of the nitrogen is available for crops. There is significant room for improvement in this regard through the choice of fertilizer type, timing of application and other adaptations.
12. The proposed liberalization of dairy policy would reduce greenhouse gas emissions further.
13. Suitable mitigation instruments should include incentive based measures such as tradable emission permits and emission taxes, as well as consumer information about the climate effects of agriculture.
14. Market based mitigation policies are efficient in that they realize mitigation objectives at least cost. And they create incentives for the adoption and development of emission reducing technologies.
15. Emission taxes could be implemented quickly, as the institutional framework for administering them are already in place.
16. The integration of agriculture into the general system of tradable greenhouse gas emission rights should be considered a long term perspective.
17. Climate protection objectives should become integrated into agricultural policy. Agricultural policy and climate policy should be coherent.
18. The principle of cross compliance should apply to greenhouse gas emissions as well.
19. Agricultural greenhouse gas mitigation should become an integral part of the EU rural development program. As a supplementary measure the present agricultural investment program



could be modified in that it targets investments which act to reduce agricultural greenhouse gas emissions.

20. For a globally efficient greenhouse gas mitigation policy it is necessary to include all industries and countries.

21. As long as international agreements on greenhouse gas emissions are not in place unilateral action is appropriate. However, unilateral action is less effective and may reduce political acceptance of mitigation policies, as production may move to pollution havens. Therefore, compensation may be considered in case of unilateral mitigation policies.

22. The more countries agree to coordinate their agricultural greenhouse gas mitigation policy the less important becomes compensation.

23. Any compensation granted to farmers must comply with WTO rules and must not counteract mitigation objectives.

24. Agricultural research has the potential to significantly reduce agricultural greenhouse gas emissions.

25. Consumer information about the climate effect of agricultural production has the potential to significantly enhance the impact of climate policy. Consumers increasingly consider aspects of process quality in their purchasing decisions. Information about the climate effects of alternative farming practices permits consumers to make informed purchasing decisions. This, in turn, creates an additional incentive to reduce greenhouse gas emissions.

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