ECONOMIC CONSIDERATIONS CONCERNING THE POSSIBILITIES OF ENVIRONMENTAL PROTECTION IN AGRICULTURE

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ABSTRACT

In agriculture there are many possible ways of reducing environmental pollution caused by plant and livestock production. In some parts farming can achieve the reduction of pollution without impairing income. Higher demands for environmental protection however, often lead to higher costs. Therefore it has to be discussed how far every individual farm has to carry those costs.
By the introduction of the "fertilizer regulation" farms are asked to make a higher contribution to the protection of natural resources without benefit. Improvements of environmental techniques, which could make it possible for the farmer to make intensive contribution to environmental protection, would be useful from a macro-economical point of view but in present conditions they are not economically effective for individual farms.

RÉSUMÉ

En agriculture, il serait possible de réduire la pollution environnementale causée par la production végétale et animale et, parfois, l'activité agricole peut le permettre sans porter atteinte au revenu. Toutefois, la nécessité d'assurer une meilleure protection environmentale comporte souvent des coûts supplémentaires et il faut, donc, vérifier dans quelle mesure chaque exploitation individuelle peut soutenir ces coûts.
A travers l'introduction du "contrôle de la fertilisation", on demande aux exploitations agricoles de contribuer un peu plus à la protection des ressources naturelles sans but lucratif. De meilleures techniques environnementales, qui pourraient permettre à l'agriculteur de donner une contribution importante à la protection de l'environnement, seraient utiles du point de vue macro-économique mais dans les conditions actuelles elles ne sont pas économiquement efficaces pour les exploitations individuelles.

Agriculture is on one hand a polluter of the environment and on the other hand it suffers from emissions from other actors. In this paper we will discuss the question of the economical consequences of selected possibilities to reduce environmental pollution caused by agriculture. Within the economical considerations we have to make a difference between macro- and micro-economical aspects.

MACRO-ECONOMICAL ASPECTS

Economical considerations of measures to reduce environmental pollution are concerned with macro-economical aspects and with micro-economical criteria. Within the frame of macro-economical aspects one has to find the optimal level of environmental protection. Then it has to be decided who has to cover the costs which arise from the level of environmental protection that has to be reached. It must be taken into account that the external costs of environmental pollution will be lowered with increasing environmental protection, whilst at the same time the costs for environmental protection will overproportionally increase. The economically optimal level of environmental quality from a macro-economical point of view is reached when the marginal utility of environmental pollution correspond to the marginal costs of environmental improvements (upper part of **figure 1**). Even if in reality these relations for the whole environmental quality are hardly describable, useful conclusions, however, can be drawn in individual areas. From a macro-economical point of view it is no use trying to reach the maximum level of environmental improvement. It has to be considered whether further steps for environmental improvements within a country should be taken — even if it was acceptable from a macro-economical point of view —if with the same financial effort in another country a higher level of environmental improvement could be reached. These considerations have to be taken into account, especially in the area of climatic protection, as the pollution of the climate can't be solved on a national basis.
After fixing the —from the macro-economical point of view —optimal environmental quality level it has to be decided who pays the costs of the environmental improvement (compare with WICKE 1993, overview 1). In this context the following three principles are important:
— the "polluter pays principle"
— the "taxpayer pays principle"
— the "beneficiary pays principle"
The "polluter pays principle" is considered to be the "environmental policy fundamental principle". Therefore the person who causes damage to the environment, is responsible for avoidance, clearance or compensation. The polluter will try to add the costs of environmental protection to the price of the manufactured products. With the internalization of the external costs that go with it the consumer will in the end pay a lesser or greater part of the costs involved in environmental protection. In fact the market usually prefers products with lower total costs (original production costs plus environmental costs) to products with higher total costs. Generally by use of "polluter pays principle" there can be negative side effects. On one hand they

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cause social duress on special groups of people (mainly i.e. members of the lower income groups in case energy taxes are introduced), on the other hand the competition of certain branches will be overduly burdened if, for example, their products won't be competitive on the world market, due to taxes. Whether from an economic point of view the "polluter pays principle" can be used depends on overriding political concerns. In agriculture, with its partly regulated markets, another difficult problem has to be considered, namely environmental costs can't generally be added to the price. In such cases environmental duties or taxes, which only concern a part of the partners in the market, entirely burden the profit of the concerned enterprises and impair their competitiveness considerably. For that reason the "polluter pays principle" has been used in agriculture only in a limited way. Examples of this are the prohibition of the pesticide "Atrazin" or the fertilizer regulation which was put in to operation in 1996.

The "taxpayer pays principle" comes into effect if the "polluter pays principle" doesn't apply for reasons mentioned above concerning the negative side-effects. In this case the costs of the environmental protection are paid by the tax payer. From an environmental point of view there are arguments against the use of the "taxpayer pays principle".

Especially in terms of agriculture measures concerning environmental protection (environmental programs) are put into effect via the "taxpayer pays principle".

Furthermore for agriculture the "beneficiary pays principle" plays a big part. In this case the beneficiary of the environmental protection measures pays a sum of money to the potential environmental polluter for the avoidance of environmental pollution. The loss of income for the potential polluter is balanced with that. For example in some counties the "Wasserpfennig" has been introduced. It will be paid by the beneficiary (consumers of water) and will benefit the farmers as payment for water protection measures. Against the use of the "beneficiary pays principle" there can be general objections. It is necessary to consider the pros and cons of this method. Which of the above principles will be used has to be decided on from an economical point of view. In this context the terms "agriculture according to rule" or "good agricultural practice" has to be defined, too. Within the frame of "good agricultural practice" the "polluter pays principle" is valid. The fertilizer regulation put into use recently is a further concrete example of the term "good agricultural practice". Nevertheless there are considerable drawbacks in this, i.e. in the

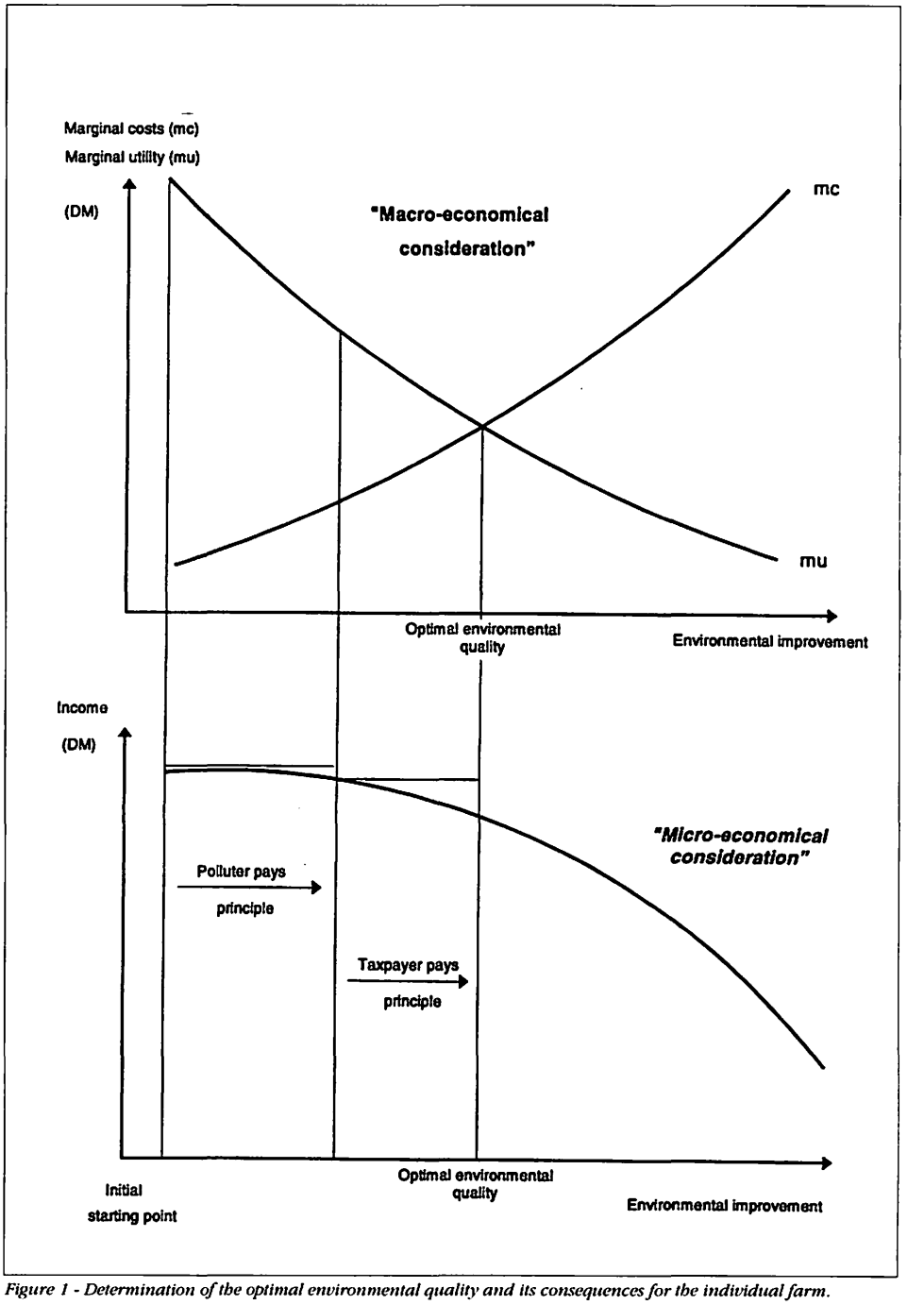


Figure 1 - Determination of the optimal environmental quality and its consequences for the individual farm.

realm of soil protection. If a farmer is in accordance with duties which lie above the level of good agricultural practice, he can expect payments, for example the rules of the law of water protection.
This method can be used for all environmental programmes.

Overview 1 ***"Who pays principles" concerning environmental protection.***

"Polluter pays principle"	"Taxpayer pays principles"	"Beneficiary pays principle"
Definition: Who causes the damage to the environment is responsible for avoidance, clearance and compensation and therefore has to pay resulting costs. **Purpose:** Internalization of external costs caused by production and consummation.w **Instruments:** environmental duites and taxes. **Example:** ban of atrazin **Problems:** Difficulties with identification, allocation and evaluation of external effects (spatial and temporal effects) No adding to price in regulated markets (e.g. agriculture) possible Negative side effects (social duress, impair of competitiveness)	**Definition:** Costs of environmental protection paid by taxpayer. **Explanation:** "Polluter pays principle" doesn't apply for following reasons: identification and allocation problems. Avoidance of negative side effects Instruments: environmental subsidies. **Example:** agricultural environmental programs. **Problems:** increase of money paid by government and objection with regard to the public environmental ethic.	**Definition:** The beneficiary of the environmental protection measures pays to the potential environmental polluter a sum of money for the evoidance of the environmental pollution. The loss of income for the potential polluter is balanced with that. **Explanation:** "Polluter pays principle" doesn't apply. The person causing the damage and the person suffering the damage are both causing lessening of the environmental good. Instruments: environmental subsidies. **Example:** "Wasserpfennig". **Problem:** objection with regard to the public environmental ethic

Source: Wicke 1995, Ahrens 1992.

ASPECTS OF BUSINESS ADMINISTRATION

From the farmer's point of view there is often a competitive relation between income and environmental quality level, which means an increasing environmental quality level leads to lower income and vice versa (lower part of **figure 1**). In certain starting conditions it may be possible, however, that improvements of an environmental quality lead to an increase of income. For example, this could be the case if grave mistakes in fertilizer application would be stopped. In this case there can be a positive economical and ecological effect. But there will be conditions under which the introduction of environmental protection and cost saving production techniques are related to higher costs of the technique, so that the income will remain uninfluenced but the environmental quality level will be improved. In this respect it has to be mentioned that production techniques which satisfy environmental quality will usually demand higher qualifications from the farmer. This also explains why such techniques can only be established very slowly. For the individual farm it must be taken into account, that the efforts for environmental protection within the frame of "good agricultural practice" go under the "polluter pays principle" and should therefore not be paid for separately.

SELECTION OF POSSIBILITIES FOR ENVIRONMENTAL IMPROVEMENT

Considerable damage to the environment is caused by agriculture, especially through the emission of nitrogen compounds. The main reason for this is the imbalance of application and take-in of nutrients due to mineral and organic fertilizers. A possibility for a decrease of emission can be the reduction of nutrient loss and at the same time the improvement of the balance of application and take-in.

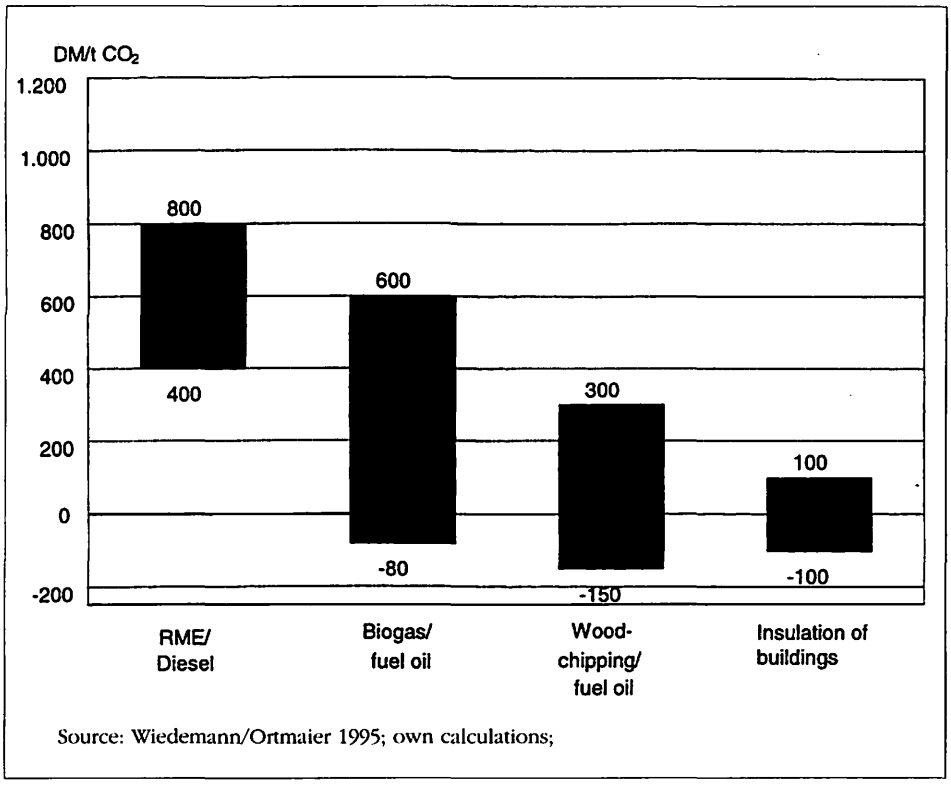
Decrease of ammoniac emission via injection of liquid manure

In the area of application of liquid manure, the injection of liquid manure is considered to be one of the most effective measures taken for the decrease of ammoniac emission. This technique is on one hand more expensive but on the other hand the efficiency of the nitrogen is improved, which reduces the expense. In the end, the surplus costs of the reduction of ammoniac emission by the injection of liquid manure, are about 2 DM/kg ammoniac (**table 1**).
In this context it is important to say that measures have to be taken against soil erosion and nutrient leaching so that the decrease of ammoniac emission in the air isn't

Table 1 ***Costs of the avoidance of ammoniac with the injection technique for liquid manure.***

Term	Amount
Injection cultivator for liquid manure	
Purchase costs	35.000 DM
Useful life	35.000 m³
Writing off	1,00 DM/m³
Interest[1]	0,30 DM/m³
Variable costs	0,40 DM/m³
Total	1,70 DM/m³
Additional costs of application	
Work[2]	1,60 DM/m³
Tractor[3]	1,69 DM/m³
Total	3,29 DM/m³
Additional costs total	4,99 DM/m³
Reduction of ammoniac emission	
23 kg NH_3-N bei 15 m³ liquid manure[4]	1,53 kg N/m³
Cost decrease based on improvement of N-efficiency (1,53 kg N/m³; 1,10 DM/kg N)	1,68 DM/m³
Remaining additional costs of the emission reduction	3,31 DM/m³
Costs of the reduction	2,16 DM/kg N

[1] Rate of interest 6%
[2] 2,5 instead of 1,3 AKh/ha; 15 m³/ha; DM/AKh = 20 DM
[3] For application 83 kW-tractor (20,57 DM/hour) instead of 54 kW-tractor (13,46 DM/hour)
[4] Reduction of NH_3-N-emission from 25 to 2 kg/ha (Reitmayr 1995, S. 239).:
Source: Reitmayr 1995; Ktbl 1995; Ktbl 1996.



Source: Wiedemann/Ortmaier 1995; own calculations;

Figure 2 - CO_2-reducing costs of selected measures.

outweighed by higher nitrogen leaching in the groundwater or in the surface water.

— Decrease of nutrient excrement by domestic animals

In the area of animal production the aim concerning environmental improvement is to use the nutrients in foodstuff as well as possible, so that relatively few nutrients are excreted in the excrement. The general rule is that the better foodstuff is used, the less is the potential for environmental pollution due to the excreted nutrients. Feeding according to what is necessary can therefore help to protect the environment. In the area of pig feeding the term "feeding adapted on stages" is used. The surplus costs due to better feeding techniques are mostly overcompensated by saving on costs for foodstuff (**table 2**). Nitrogen and phosphate excretion can be reduced by about 15 to 20 %. A further step in this direction is directed foodstuff supplementation with amino acid and phytase. In this case there are additional costs caused by feeding techniques and special foodstuffs. Surplus costs are about 5 to 10 DM/pig in all. In this way the excreted nitrogen and phosphate are reduced by about 30%. This possibility of reducing the nutrient excrement will be importantly increased with the introduction of fertilizer regulations. Specialized pig-farms often have got a too high amount of animals. For this kind of farm in general there are the four following possibilities for adaptation:

— additional leasing of land
— giving out liquid manure to other farms
— reducing livestock density and
— improvement of nutrient efficiency (for example bay phase feeding or addition of amino acids).

The farmer normally choose that measure, which brings the desired savings at lowest costs. As shown in **table 3**, this at first is usually the additional leasing of land, followed by the giving out of liquid manure. If those possibilities are not available, the adaptation of feeding offers a relatively high competitive effect. Normally the most unfavourable possibility is the reduction of livestock.

In the area of dairy cow husbandry the increase of yield leads to a decrease of nutrient excretion in the produced amount of milk. In this connection next to nitrogen and phosphate it is methane which is important, too, as it is a trace gas. From the point of view of the individual farmer there is a tendency for environmental protection to be connected with an increasing income. Furthermore, it has to be considered that an increasing yield at constant milk consumption, leads to a reduction of the number of cows and therefore there are also few-

Table 2 ***Possible effects of corrected nutrient adapted feeding strategies.***

Term	Feeding adapted on stages	Feeding adapted on stages + additional amino acid + phytase
Additional costs		
in the field feeding systems		
500 fattening places	5.000 - 12.000 DM	6.000-15.000 DM
per anima	0,6 - 1,3 DM	0,7-1,7 DM
Less/Additional costs		
in the field animal food stuff		
per 100 kg forage mixture	–1 - –2 DM	1-4 DM
per animal	–2 - –4 DM	2-8 DM
Reduction of N-liberation		
relative	10 - 15%	30-35%
absolute per animal	500-750 g N	1.500-1.750 g N
Reduction of P-liberation		
relative	15-20%	25-30%
absolute per animal	140-190 g P	240-290 g P

Annotation: The additional investment requirements vary in actual fact at a larger scale in the case of feeding engineering depending on applied engineering. The same applies correspondingly to the field of feed costs. The level of the actual nutrient reduction is also subject to great variation.
Source: Sommer 1994; Ratschow 1993; own calculations.

Table 3 ***Costs of selected measures for the reduction of the area related nitrogen lots.***

Costs/Measure	Additional leasing [1] (950/1.200 DM/ha)	Giving out of liquid manure [2] (5/15 DM/m³)	Adaptation of feeding [3] (4/8 DM/fatt. pig)	Reduction of livestock [4] (30/40 DM/fatt. pig)
DM total	1.200-4.950	1.925-5.775	5.760-11.520	14.400-19.200
DM/fattening pig	0,83-3,44	1,34-4,01	4,00-8,00	10,00-13,33
DM/kg N	0,50-2,06	0,80-2,41	2,40-4,80	6,00-8,00

Annotation: pig fattening farm; 30 ha farmland; 1.440 fattening pigs/year; decrease of N from 240 to 160 kg N/ha.
[1] Additional leasing of 15 ha (farm rent 950 and 1.200 DM/ha, respectively); cultivation of non food rape on set aside farmland.
[2] Disposal of 385 m³ liquid manure necessary (disposing costs 5 and 15 DM/m³ respectively).
[3] Decrease of N-liberation: 33% basing on feeding adapted on stages and additional amino acid (additional costs from 4 to 8 DM/fattening pig).
[4] Decrease of livestock: 33% or 177 fattening places or 480 fattening pigs (marginal income per fattening pig: 30 and 40 DM, respectively)
Source: Sommer 1994; Ratschow 1993; own calculations.

er calves. If it is assumed that the beef production remains constant, the lack of calves has to be remedied via suckling cows. All in all the result is not a decrease but a small increase in nutrient excretion. That means that the increase of efficiency with "two-purpose dairy cows" has to be considered in different ways in respect to environmental protection.

In the area of beef production we have a similar situation to the one of pig production, that means there is an increase of the daily gain which usually is economically favourable and normally goes together with a decrease of excretion. In this connection a question is interesting concerning the mass of excretion occurring in relation to one kg produced beef using intensive or extensive production measures (for example bulls on the basis of maize silage or suckling cows on the basis of pasture).

Calculations show that concerning global warming potential, beef from suckling cows is much more unfavourable than beef from bulls produced by calves from dairy cows. The reason for this mainly is that excretion of the suckling cow has to be exclusively attributed to beef production while the dairy cow shows a better nutrient efficiency due to the production of milk and calves. It needs to be mentioned, however, that production methods can't only be judged on nutrient excretion. For a conclusive judgement at least the following aspects should be taken into account:

— economic efficiency,
— nutrient excretion,
— animal well-being,
— possibility for use of low quality foodstuff,
— quality of the produced meat.

A complete consideration of the mentioned above criteria will, in the individual case, lead to the keeping of the suckling cow in spite of some disadvantages, because it is the only way of using the foodstuff growing in certain regions. On the other hand, bull production will be used if necessary demands are met, because it is better from an economical point of view, although it is more unfavourable in respect to animal well-being and the produced meat quality.

— *Biogas from liquid manure*

Farmers with livestock recently discussed the questions whether it wouldn't be economically useful to produce biogas and finally take electricity and warmth from liquid manure. This method is supported by the legally guaranteed prices of 0,1536 DM/kWh electricity. For the economic efficiency of biogas equipment the following points are important:

— investment costs (they are in the region of about 500 to over 3.000 DM/LU),
— possibility of electricity use in onés own operation especially of warmth during the summer month,

— technical efficiency of the equipment,
— variable costs and
— added income via co-fermentation.

According to the present price-cost-relation, equipment which needs an investment of up to 3 000 DM/LU is normally not economically effective, except when the most favourable conditions are reached by the exclusive use of liquid manure (**table 4**). The CO_2-saving effect of biogas equipment normally costs money, the so called "CO_2-reducing costs". These are about minus 80 to 600 DM/t CO_2.

Other possibilities of reducing the GWP (**figure 2**) need partly more money (i.e. the use of RME instead of diesel with about 800 DM/t CO_2). Similar to biogas production on a lower level (respectively), is the use of wood chipping instead of fuel (at minus 150 to 300 DM/t CO_2) or the improvement of insulation of buildings (at minus 100 to 100 DM/t CO_2). All in all it is shown that, in most cases, measures to reduce environmental pollution, especially in the reduction of GWP, aren't economically efficient from the point of view of individual farms. ●

Table 4 ***CO_2-reducing costs for biogas.***

	Term	Amount from	Amount to
Costs of biogas plant [1]			
Investment requirement [2]	DM/LU year	400	3.000
Repair and maintenance costs [3]	DM/LU year	20	42
Writing off and interest [4]	DM/LU year	53	398
Labour costs [5]	DM/LU year	32	20
total annual costs	DM/LU year	105	460
Proceeds by fuel substitution [6]	DM/LU year	16	4
Proceeds by current substitution [7]	DM/LU year	42	26
Remuneration of current fed into supply mains [8]	DM/LU year	144	45
total costs/profit	DM/LU year	—96	385
CO_2-reduction			
by CH_4-reduction [9]	kg CO_2/year	378	378
by fuel oil substitution [10]	kg CO_2/year	113	30
by current substitution and fed into supply m. [11]	kg CO_2/year	680	242
total CO_2-reduction	**kg CO_2/year**	**1.171**	**650**
CO_2-reducing costs	**DM/t CO_2**	**—82**	**593**

[1] Calculated for plant size of 100 LU.
[2] Costs allocated to construction (40%) and technique (60%).
[3] Repair and maintanance costs technique: 2-8%; construction: 0,5%.
[4] Annuity: technique 14,57%; construction 11,33%.
[5] 20 DM labour costs.
[6] 0,40 DM/l fuel oil; 35.000 kWh (in farm required); 10 kWh/l fuel oil efficiency boiler 0,85; supply of in farm required heat 95-25%.
[7] 0,26 DM/kWh current; 25.000 kWh in farm required; supply: 65-40%.
[8] 0,15 DM/kWh current; less in farm required current.
[9] Avoidance of 18 kg CH_4/LU; Global Warming Potential CH_4: 21.
[10] 2,9 kg CO_2/l fuel oil.
[11] 0,62 kg CO_2/kWh current.
Source: Wiedemann/Ortmaier 1995; own calculations.

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