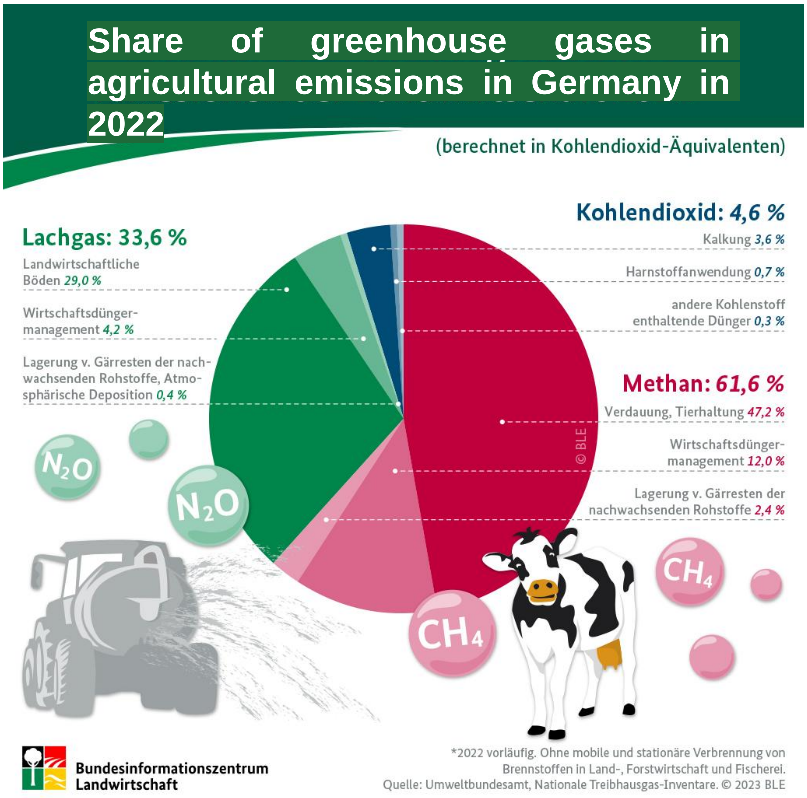
Strategies for methane reduction in dairy farming

The main share of greenhouse gas (GHG) emissions in German agriculture is methane emissions at 61.6% (2022). Methane emissions from fermentation account for almost 76 % and are almost entirely attributable to cattle and dairy cow farming (95%). As a greenhouse gas, methane (CH_4) is around 30 times more harmful to the climate than CO_2. Efficient reduction measures are therefore urgently needed. Methane is produced, among other things, in fermentation processes in the stomach of ruminants (see below) and can be influenced by feeding and breeding. The measure ‘g methane per kg milk’ will become significantly more important in the future and an important factor in the production of sustainable milk. Herd management measures can change this assessment standard. In addition to methane, nitrous oxide (N_2O), which is almost 300 times more harmful to the climate than CO_2, also plays a significant role in agriculture. These emissions can be influenced by the storage of cattle slurry and manure and its application as farm fertiliser. The aim of this paper is to provide an overview and knowledge of the topic, which can be helpful in discussions in this area.

Formation of methane in cattle

The carbohydrates fed with the ration (cellulose, hemicelluloses, starch, fructans, sugar and others) are broken down into volatile fatty acids (primarily acetic acid, propionic acid, butyric acid) and the gases carbon dioxide (CO_2), methane (CH_4) and hydrogen (H_2) by the anaerobic fermentation that takes place in the rumen. Methane is primarily produced by bacteria. The volatile fatty acids are absorbed through the rumen wall and transported directly to the corresponding tissues. The gases formed are excreted with the ructus. Thanks to this symbiosis with microorganisms, ruminants are able to utilise grassland that could not otherwise be used for human consumption. In order to maintain this advantage without greenhouse gases becoming a problem, it is necessary to optimise the supply of external feed. The possibilities of influencing methane production specifically through feeding is the subject of another, separate factsheet.

Share of greenhouse gases in agricultural emissions in Germany in 2022



This factsheet explains ways to minimise methane emissions and other greenhouse gases at the level of the cattle herd and slurry management.

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Outline

1. Herd management und milk production

- Herd management – Lifetime daily yield: Optimising the longevity of dairy cows
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- Breeding & co-product meat - Targeted insemination (fattening breed genetics, sexed sperm)
- Breeding & co-product meat - Dual-purpose breeds
- Further measures

2. Farm manure management

- Grazing
- Farm manure – Covering slurry store
- Farm manure – Slurry acidification
- Farm manure – Low-emission spreading
- Farm manure – Biogas plant

3. Summary

Herd management and milk production

Herd management - Lifetime daily yield: Optimising the longevity of dairy cows

- Mode of action: If the utilisation period increases, the GHG emissions per kg ECM (energy corrected milk) decrease slightly.
- Potential: Scientists calculated that an increase from 2.3 to 3.6 lactations per cow would result in savings per dairy farm and year of just under 6% per kg ECM. Cows only reach their maximum production potential in the 4th or 5th lactation. Any extension of the productive life is beneficial and reduces emissions at herd level. According to calculations, the savings potential amounts to 10% of GHG emissions if the replacement rate is reduced by 10%.
- BUT: With a longer service life, less meat is produced from cows for slaughter. In principle, fewer dairy cows are slaughtered, but the number of calves going to fattening increases with a longer service life. Meat production is fundamentally reduced by this shift. In order to maintain this advantage, the reduction in meat production must not be offset by an increase in meat production in other livestock farming systems such as suckler cow herds, otherwise GHG emissions in the overall milk and meat production system will increase.

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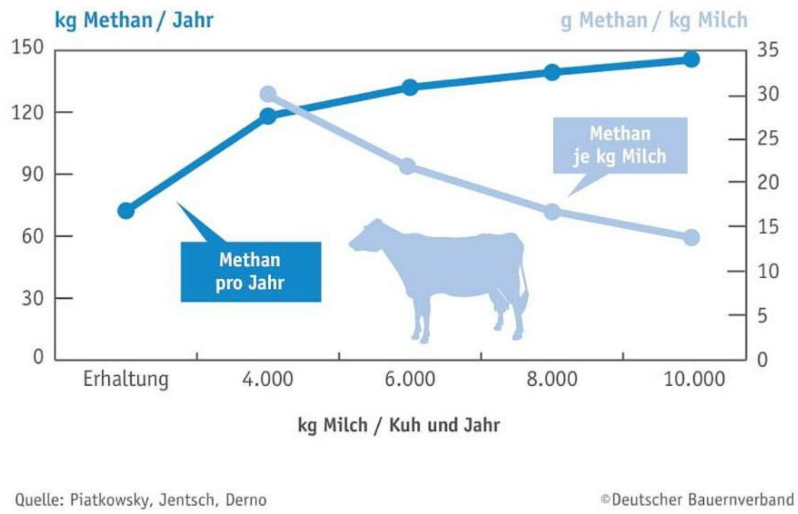
Herd management - Lifetime daily yield: Optimising milk yield

- Mode of action: More intensive and, above all, optimised production systems tend to have a more favourable effect on the global warming potential per kilogram of milk. As output increases, emissions per kg of product decrease.
- Improvement in animal performance and production efficiency: the amount of methane is reduced in relation to the animal product. The higher the daily yield, the fewer animals are needed to produce the same amount of milk.
- These include better feed efficiency (more than 1.5 kg of milk per kg of dry matter fed), higher lifetime efficiency (more than 15 kg of milk per day of life), a longer productive life (at least 3.5 lactations), a low replacement rate and heifer numbers adapted to the herd.

Cow methane emissions depending on performance



- Potential: With an increase in milk yield (taking into account the co-product meat at farm level) of 20%, for example, emissions per kg ECM could be reduced by approx. 8%.
- BUT: If the milk yield on the farm increases, the total emissions of the farm also increase! → In order to protect the climate, it is imperative that when milk yield per animal increases, livestock numbers are also reduced accordingly (aim: constant production). Otherwise, there will be an intensification of production and an associated increase in greenhouse gas emissions from the sector as a whole. Scientists set the limit for potential energy savings and GHG emissions per litre of ECM at approx. 8000 kg ECM/year, beyond which there is no further relevant reduction in product-specific energy use. If the milk yield is higher, the energy requirement per litre of milk increases, as the use of concentrated feed and high-quality forage leads to a disproportionate increase in energy requirements.

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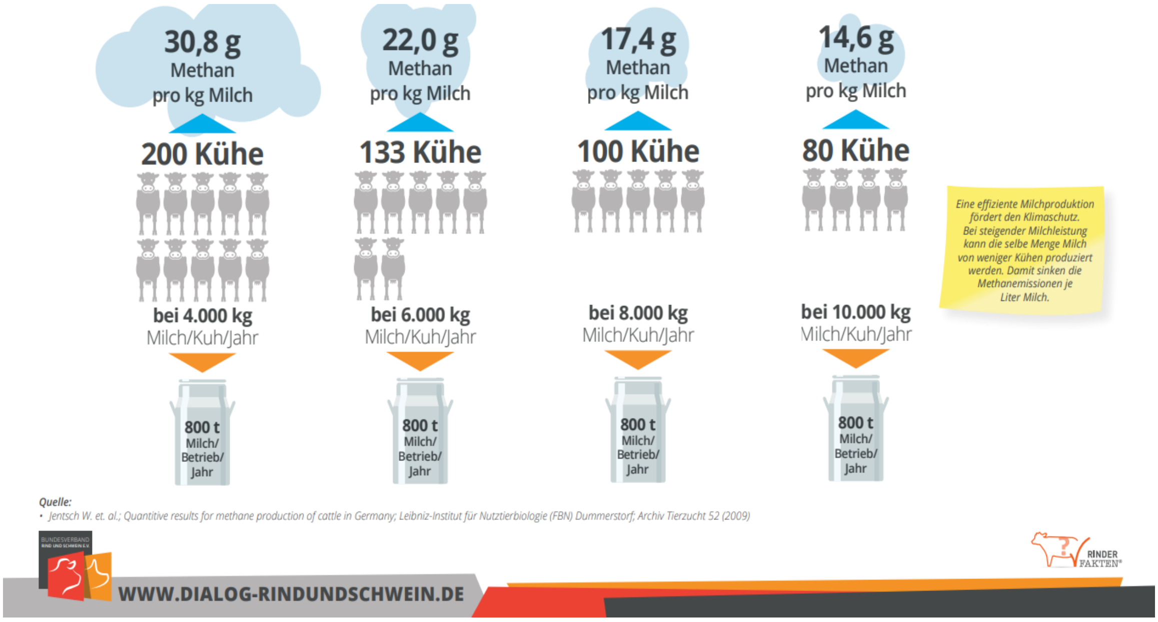
Efficiency: **higher milk yields, lower methane emissions**



Breeding & co-product meat - targeted insemination (fattening breed genetics, sexed sperm)

- Mode of action: The number of female calves should be limited to the actual need for replacement and the remaining calf production should be focussed on male calves for fattening.
- Potential: Based on studies, an emission reduction potential of 1-6% was assumed for the measure.

Breeding & co-product meat - dual-purpose breeds

- Mode of action: A study shows that systems with dual-purpose cows have better GHG efficiency than those with milk-orientated cows. Farms with a milk yield of more than 10,000 kg are an exception - these are more efficient in terms of GHG (prerequisite is targeted insemination with sexed semen or fattening breed genetics).
- BUT: In the modelling, the missing meat from predominantly dairy systems was replaced by meat from suckler cows. This is not correct, as the missing meat should not be replaced by other products. If the missing meat were replaced by sustainable plant proteins, the predominantly dairy systems would in principle be assessed more positively.

Further measures

- **Choice of animals with low methane emissions**: Research projects are looking into the fact that there are individual differences in CH_4 production between animals. Cows that produce less CH_4 or have fewer methane-producing bacteria in their rumen convert the feed into milk more efficiently. Breeding for low methane emissions could reduce emissions of the gas by up to 20%.
- **Immunisation** against methanogens (methane-producing bacteria): An anti-methanogenic vaccine stimulates the animals' immune system to produce antibodies against methanogens. However, the effects on CH_4 production in vivo have so far only been small or not measurable at all.

Farm manure management

Grazing

- Mode of action: During slurry storage, the solid and liquid excretions mix, which leads to chemical reactions that can also result in N_2O emissions. On the pasture, the solid and liquid excretions do not come into contact with each other; the chemical reaction and the associated emissions are therefore limited. On the pasture, the feed is directly consumed and the manure is directly re-applied by the cattle. This means that less CO_2 is emitted as a result of mechanical processing.
- Potential: The GHG reduction potential through more grazing is estimated at 1-3%, depending on the literature source.
- BUT: Fertiliser distribution is not always ideal and the area required can be larger.

Farm manure – Covering slurry store

- Mode of action: This measure reduces nitrogen losses (especially ammonia) during storage, which means that more plant-available nitrogen remains in the slurry.
- Potential: The reduction in emissions ranges from 50-90% depending on the type of cover and slurry quality. If the increased N efficiency is taken into account in fertiliser planning and less synthetic nitrogen fertiliser (mineral fertiliser) is applied accordingly, additional GHG emissions can be saved. The potential is all the greater if the farmyard manure is applied using low-emission spreading methods.
- BUT: A little more of the saved nitrogen can be lost in the field in the form of nitrous oxide.

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Farm manure – Slurry acidification

- Mode of action: If sulphuric acid is added to the slurry store, methane emissions can be reduced by around 60 to > 90%.
- Potential: An individual farm can reduce its methane emissions from farmyard manure storage by 60%. This would reduce GHG emissions at farm level by around 12-15%.
- BUT: High investment costs. To prevent increased methane formation during the acidification, the low pH value must be reached quickly. In biogas plants, acidified slurry leads to reduced methane yields by inhibiting microbial activity.

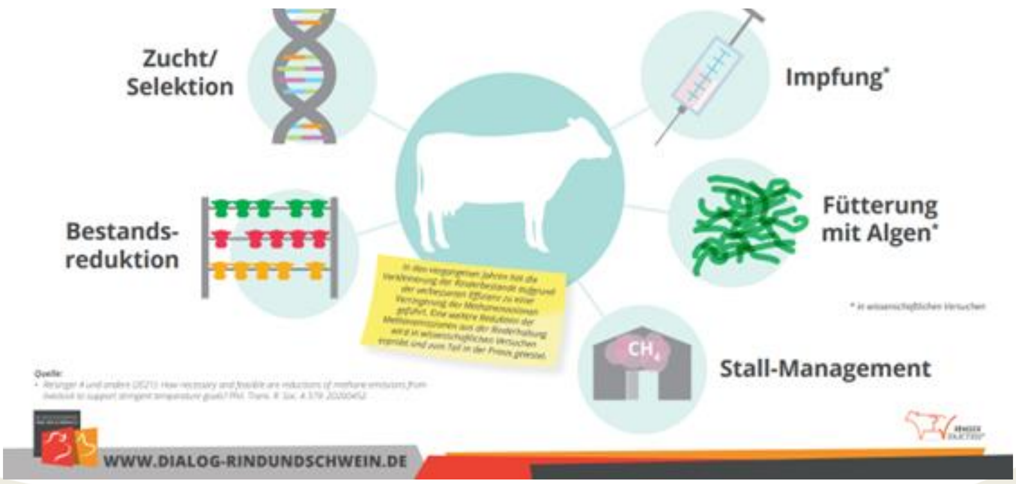
Farm manure - Low-emission spreading

- Mode of action: Ammonia losses can be reduced compared to wide distribution by using a strip spreading technique close to the ground (e.g. drag hose).
- Potential: Scientists have calculated that GHG emissions can be reduced by between 0.2 and 0.9% if all the slurry is spread using a drag hose.
- BUT: This effect is very small. A slightly positive effect occurs above all when the use of synthetic nitrogen fertilisers is reduced.

Farm manure - biogas plant

- Mode of action: In a biogas plant, the methane released from the slurry is captured and utilised instead of escaping into the atmosphere.
- Potential: If a dairy farm transfers its fresh farmyard manure to its own or neighbouring biogas plant, it can expect an average annual GHG reduction of around 615 kg CO_2eq/cow. For a farm with 30 cows, around 8% of the dairy farm's GHG emissions can be saved in one year.
- BUT: The reduction potential is highly dependent on the size of the system and the source material.

Methane reduction in cattle farming



Summary: opportunities and challenges

- A **holistic approach** is required (moving away from a pure consideration of methane to a consideration of the entire GHG balance!) Many measures do not relate exclusively to methane emissions, but to the GHG balance in general. The separation is difficult and makes little sense, as the overall value is actually more decisive for the climate than just methane emissions.
- The expected CH_4 reduction must always be considered both in absolute terms (per animal and day) and in terms of intensity (per unit of animal product). Some strategies are expected to lead to an immediate reduction. Others cause more gradual effects over time, e.g. the intensification or breeding of animals for lower methane emissions.
- The **impact** of CH_4 reduction strategies **on meat and milk production and feed efficiency** must also be assessed.
- The reference value must also be taken into account: Is a reduction achieved globally, product-related or area-related?
- The **impact** of CH_4 mitigation strategies must be assessed in terms of their impact **on emissions of other greenhouse gases (both upstream and downstream)**. Upstream changes include, for example, the direct and indirect release of carbon dioxide (CO_2) and nitrous oxide (N_2O) during plant growth and the production of specific feeds, certain feed additives or other products. Changes can also affect CO_2 and N_2O emissions from manure, for example. In addition, changes in plant production and pasture management may have an impact on carbon sequestration in the soil.

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