EIP-AGRI Focus Group

Reducing emissions from cattle farming

STARTING PAPER
14 JANUARY 2016

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funded by European Commission

Preface

Welcome to a hopefully inspiring workshop in this EIP-AGRI focus group on "Reducing emissions from cattle farming – How to reduce cattle livestock emissions in a cost-effective way for farmers?"

The aim is to collect and summarize knowledge on cost-effective practices, techniques and strategies for reducing emissions from cattle across Europe – and to analyze the possibilities and barriers for carrying these practices, techniques and strategies out in real life.

The hope is that bringing together farmers, advisors and scientists will bring forth new approaches and angles to the challenge of reducing emissions from cattle.

This starting paper is intended to set the scene for the coming work, but it is by no means a complete overview of the problem and its solutions. The aim is to inspire you – we count on you to bring all your good, innovative ideas and experience into the work.

We look forward to a fruitful collaboration.

Best regards

Ida MLD Storm (Coordinating Expert) and the entire EIP-AGRI Service Team

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1. Introduction

Livestock production is a source of pollution

Air pollution is a major problem for the health of people in Europe and for the environment, and livestock production contributes significantly to the emission of several air pollutants. Particularly the emission of ammonia (NH_3) is related to agricultural production. According to the European Environment Agency (EEA, 2015) agriculture is responsible for 93 % of ammonia emission in EU-28 and four of the five most important key emission categories are related to animal production.

Similarly, livestock production leads to emission of greenhouse gasses (GHGs), which contribute to global warming. Agriculture accounts for approximately 10 % of Europe's total GHG emissions when excluding emissions coming from Land Use, Land Use Change and Forestry (LULUCF). Out of these 10 % of the total emissions of CO_2-equivalents (CO_2-eq), enteric fermentation accounts for 42 % and manure management for 15 % (Fernandez et al. 2015). The main livestock-related GHGs are methane (CH_4) from enteric fermentation and manure and dinitrogen oxide (N_2O) from manure.

As illustrated in figure 1 ammonia, methane and N_2O are air pollutants, which have effect on climate, ecosystems and human health. Livestock production is also related to other environmental impacts like nutrient leaching to watercourses or nitrate leaching to ground water.

On the other hand cattle also has positive impacts on society and environment. For example they are able to transform types of biomass, which are inedible to humans, into nutritionally and economically valuable beef and dairy products. Another example is the preservation of certain ecosystems, where grazing is necessary to maintain the present biological balance.

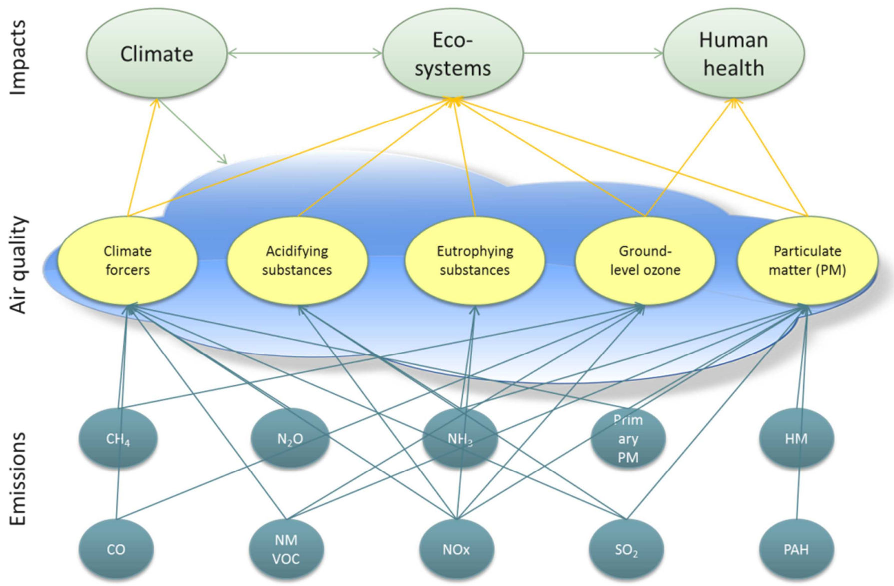

Figure 1: Overview of emissions of various air pollutants and their impacts on climate, ecosystems and human health. ***(Modified after figure A3.1 on page 94 in the EU commission impact assessment accompanying the proposal for a new NEC Directive (EU Commission, 2013).***

Within Europe there are large differences in agricultural emissions, which is a reflection of different livestock production patterns and varying roles of livestock production in society as a whole (Figure 2). Emission quantities, emission patterns and potential mitigation measures vary, depending on whether cattle farms are dairy or beef farms, whether they are large, medium or small scale and whether production is intensive or extensive.

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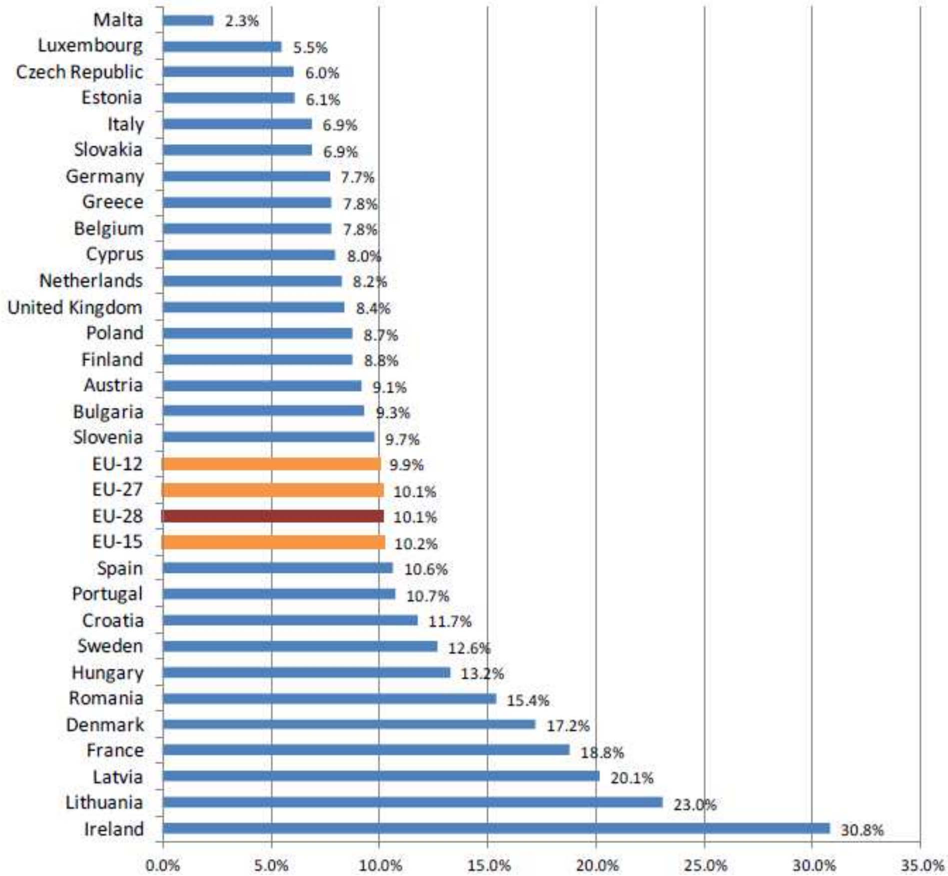

Figure 2: Share of agricultural GHG emissions in total national emissions in EU MS, 2011 (EEA database, 2013 cf. Doorslaer et al., 2015)

Political focus on agricultural emissions

Emissions from livestock are currently being discussed intensively at EU level and also in many of the individual member states. The year 2016 is thus expected to result in both an EU agreement to reduce GHG emissions from the agricultural sector and new reduction targets for the national emissions of ammonia (and possibly methane) in a revised directive on National Emission Ceilings (NEC directive).

This will put pressure on all livestock sectors to reduce emissions of particularly ammonia, methane and N_2O, which will also be the focus of the work in this EIP focus group.

Efforts have been done to reduce emissions from livestock and as a result the emissions of GHGs and ammonia have been reduced by 23 % from 1990 to 2011 (Figure 3) and by 27 % for ammonia from 1990 to 2013 (EEA, 2015). Figure 4 shows the trend in ammonia emissions from the five most important key categories, 1990–2013 (EEA, 2015) where manure management for dairy and non-dairy cattle are the second and third most emitting categories.

From an EU-legislative point of view, ammonia emissions from large intensive pig- and poultry farms are regulated by the directive on Industrial Emissions (IE directive). There is however no direct EU regulation of emissions from cattle. This obviously raises the question whether there are some easy reductions to be achieved in the cattle sector – perhaps initiatives that are already being applied in the pig and poultry production.

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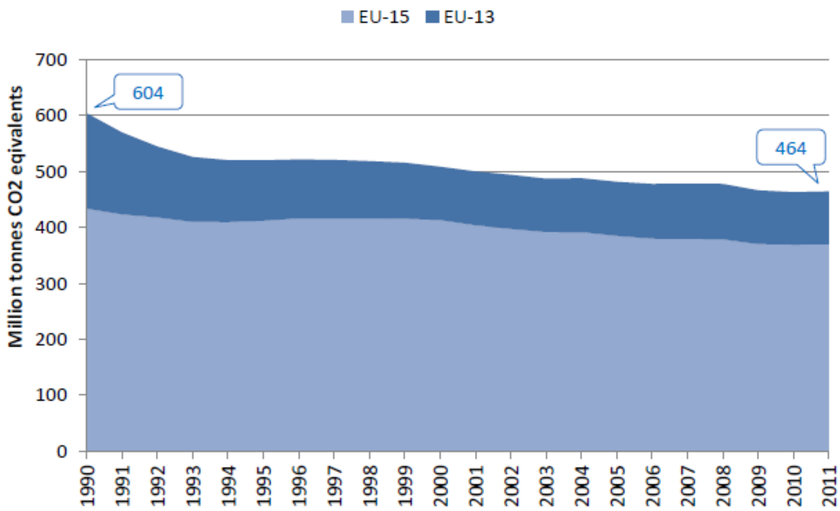

Figure 3: Development of agricultural GHG emissions in the EU, 1990-2011 (EEA database, 2013 cf. Doorslaer et al., 2015)

The world demand for high quality food is increasing

Many people argue that the environmental impact of meat, particularly beef, is so high that we should essentially stop producing and consuming it. Without question a continued and increasing food production is essential for the rising world population. The UN projects that the world population could increase by more than two billion people over the next 35 years compared to 2005/2007 and that income will rise around the world as well. This is expected to cause a higher demand for agricultural products in general (up to 60 % higher in 2050) and for beef and milk in particular (66 % and 62 % respectively by 2050) (Alexandratos and Bruinsma, 2012).

In its most recent prospects for EU agricultural markets the EU Commission expects a 2 % annual increase in world imports of milk and dairy products and a rising EU domestic demand, which will support an increase in deliveries of close to 1 % per year to 164 million t in 2025 (European Commission, 2015). For EU beef production a slow decrease in production is expected in the same time range (European Commission, 2015). This is because EU beef production is driven mainly by dairy herd developments and while milk production is expected to rise, it is due to higher yields per cow, not more cows.

Reducing the production in Europe in order to reduce emissions will therefore not solve the problem – particularly not when a large portion of the agricultural products are exported. The EU's share of world dairy product exports is expected to grow slightly towards 2025 As long as there is a world market demand for milk and beef, these products will be produced – if not in Europe, then somewhere else.

From a political point of view the problem is that simple legislative "command and control"-measures are most likely to simply reduce production in Europe. Doorslaer et al. (2015) have estimated the effects of various mitigation scenarios on agricultural emissions, production and export. If a total EU-27 reduction target of 28 % for GHGs is distributed unevenly between member states on the basis of the distribution key of the EU effort sharing agreement (with no possibility of trading emission rights) the estimated consequences are reductions in the EU-27 production of beef of 31 % and of milk of 9 %. At the same time, the prices of European beef and milk would increase, which would reduce the export of beef by 97 % and of dairy products by 31 %.

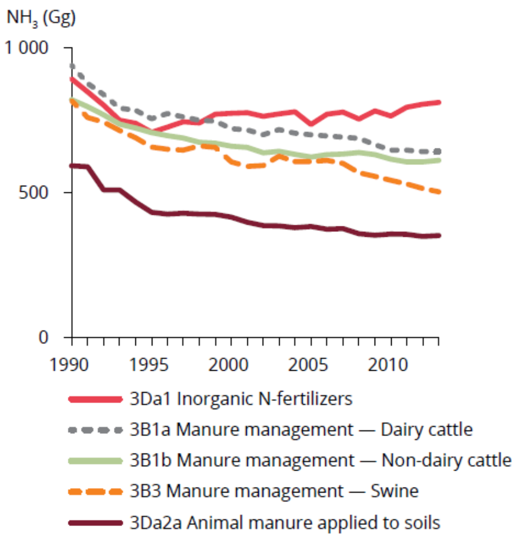

Figure 4: Trends in ammonia emissions in the EU-28 from the five most important key categories, 1990-2013 (EEA, 2015)

2. Cost-efficient measures for reducing emissions

Therefore, a major challenge for the agricultural sector is to increase the production and at the same time decrease the environmental impact. This calls for cost-efficient methods of reducing net emissions. Fortunately, there are already techniques, practices and strategies in the pipeline or already being applied around the world that may also be of benefit to the farmers.

Many of these approaches actually stem from the wish to save money because saving resources and minimizing waste are an advantage for the farmers. This also goes for emissions from cattle.

Basically, all emissions of enteric methane from cattle are a loss of potential energy for the cow. The feed is literally going up in the air instead of sustaining milk or beef production. Reducing the amount of methane emitted therefore makes sense from a farming perspective.

Similarly, all emissions of ammonia or N_2O are a loss of nitrogen, which could otherwise fertilize plants in the field or sustain animal production, as illustrated in figure 5. It therefore also makes sense to safeguard nitrogen – both from an environmental and from an economic perspective.

For a mitigation measure to be cost-effective, there must however be a balance between the effect on emissions, the effect on production, the investments that will have to be made and possibly also side effects. Emission efficiency (emission per kg of milk or beef) is an obvious way to compare different production systems but does not tell the whole story on cost-effectiveness.

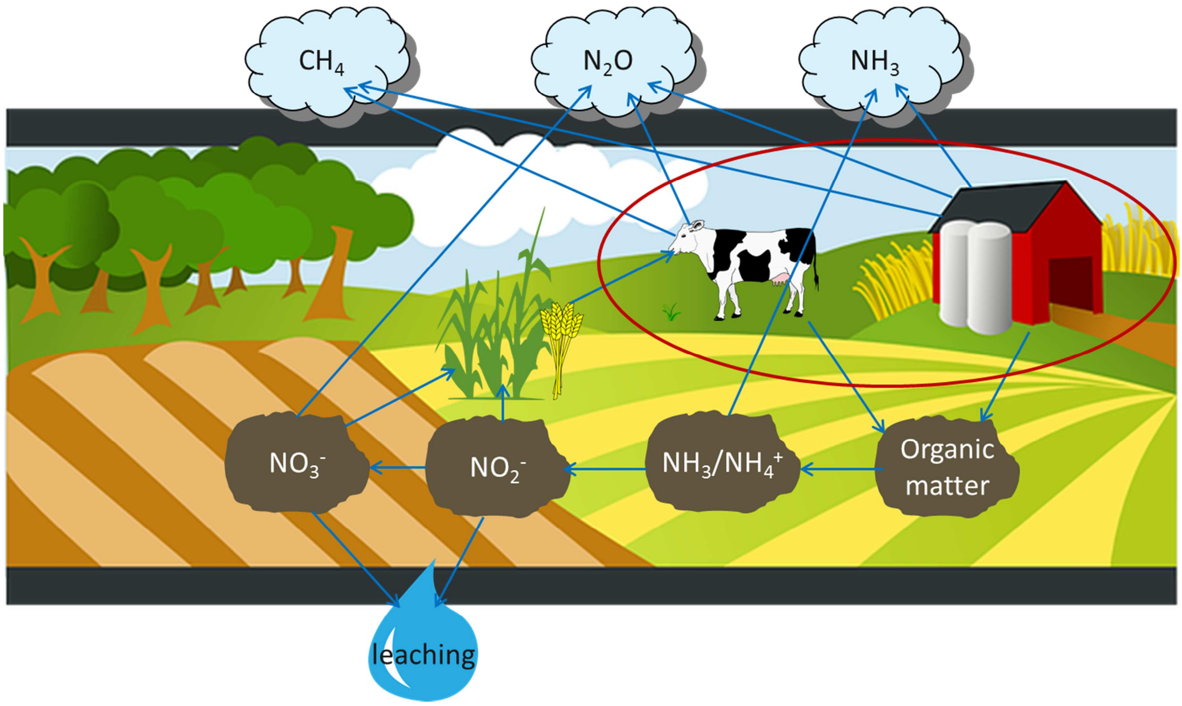

Figure 5: Simplified diagram of methane (CH_4), ammonia (NH_3) and nitrous oxide (N_2O) emissions and farm level nitrogen flows related to animal production. The scope of this focus group is mitigation measures applied at animal and farm house level, as indicated by the red oval.

2.1 Existing measures

Based on this, a range of mitigation methods have been developed and more are currently being developed for ammonia, methane and N_2O. Within the last couple of years, the available approaches for reducing emissions of these emissions from livestock have been reviewed and evaluated by two different branches of the United Nations: Under the UNECE Convention on Long Range Transboundary Air Pollution, the Task Force on Reactive Nitrogen has published a guidance document on "Options for Ammonia Abatement" (Bitmann et

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al., 2014), and in 2013, FAO published "Mitigation of Greenhouse Gas Emissions in Livestock Production – A review of technical options for non-CO_2 emissions" (Gerber et al., 2013).

Summarizing these two review reports, the on-farm livestock related techniques, practices and strategies can roughly be categorized into four categories depending on the level in the production chain they target:

- Animal level – e.g. measures related to feeding, the digestive system, and breeding
- Stable and manure storage - measures related to housing and manure handling at the farm
- Post stable and storage - Techniques for manure handling e.g. in the field or at biogas plants
- Farming system - Practices related to overall farm management taking account of multiple of the underlying production levels

Examples of abatement approaches from these four categories are mentioned in the sections below. This is not a complete list but illustrates the diversity of mitigation approaches.

2.1.1 Measures at animal level

The rumen is a complex microbial ecosystem within the even more complex organism of the whole ruminant. By affecting the rumen or the rest of the digestive system, it is possible to reduce GHG emissions or lower the nitrogen concentration in the manure.

A simple measure is to alter the feed composition. By switching to roughage with a higher digestibility or increased amount of concentrates, it is possible to reduce emissions of enteric methane from cattle, if not overall then relatively to the production of milk or meat. The same effect can be achieved by feed processing, which increases the digestibility of roughage or concentrate. Reducing the dietary content of protein for cows can also decrease ammonia, methane and nitrous oxide emissions. The tricky part is not to impair the animal production or to shift emissions to later stages in the production chain, e.g. during manure application.

Adding different additives to the feed can also change emissions of enteric GHGs. The idea is that the additives change the microbiology or biochemistry in the rumen so that less methane is produced. Examples of additives are nitrates, ionophores, fats, plant- or fungal-derived bioactive compounds, e.g. tannins, and direct-fed microbials like yeast.

Attempts have also been made to directly affect the composition of the microbial community in the rumen and thereby reduce GHG emissions. This can be done by vaccinating the animals to suppress the methane-producing archaea, by inhibiting protozoa (defaunation) or by affecting the initial microbial colonization of the digestive system of the ruminants shortly after birth.

Without understanding the underlying mechanisms completely, it is a fact, that emissions vary a lot between individual animals, even when they are in the same herd, of the same breed and consuming the same feed. An interesting approach is therefore to select animals for breeding on the basis of low emissions. Breeding for higher production is well known and will often result in a lower emission per kg of product. If this can be coupled with measurements of emissions, breeding can be even more focused on improving emission efficiency.

2.1.2 Measures in stable and manure storage

Moving further on in the production chain, manure management is very important in order to control emissions from livestock. This goes for all livestock production systems, and some lessons and advice can therefore be gathered particularly from the pig and poultry production. There are, however, substantial differences between the different animal production systems, both regarding the properties of manure and factors like housing systems.

An important factor is the choice of animal housing system with the most common systems being deep litter and slurry-based systems. The risk of N_2O production is higher in solid manure/deep litter because of the alteration between aerobic and anaerobic conditions. Generally, there is an inverse relationship between emission of N_2O and ammonia from manure – aeration reduces N_2O formation, but increases ammonia evaporation.

In slurry-based stables, an effective measure against ammonia emissions is to minimize the surface area of manure from which ammonia can evaporate. This can be done by building stables that quickly lead the manure into storage. A proven technique is grooved floors combined with regular scraping of manure. Another simple way of reducing the surface area is shorter storage time of slurry in the stable. If the canals underneath the stable are emptied regularly and the slurry is transported to a closed storage facility, the emissions will be reduced.

Cooling liquid manure has an effect on both ammonia and methane emissions. With lower temperatures the evaporation of ammonia is reduced and the microbial production of methane is slowed down. Natural cooling outside the stable can be used if the climate is cool. Technical solutions are based on active cooling of the manure canals. If the heat extracted from the manure can replace other heat sources, slurry cooling can even be profitable for the farmer. This is the case for new stables for piglet production in a temperate climate like Denmark. The heat from the sow manure is used to warm the stable for the piglets.

Another option is acidification of manure, which can be done already in the slurry canals underneath the stable floor in new stables or in the slurry tank. Acidification lowers the pH of the slurry, which prevents ammonia evaporation and inhibits the methane producing microorganisms.

During the storage a good cover of the manure can reduce ammonia emissions substantially. There are various forms of manure covers ranging from tent structures on slurry tanks to natural covers (crusts) formed by fibers in the manure, possibly supplemented with added fibers.

In the technical end of the range of mitigation options chemical or biological cleaning of the air from the stable can be applied, if the animals are housed in closed systems. This is well known from production of pigs and poultry but cattle are often housed with natural ventilation, which prevents this approach to emission mitigation.

2.1.3 Post stable and manure storage

The use and treatment of manure after it has left the stable and manure storage facility also has a large effect on emission of particularly ammonia and N_2O. This part of the production chain is closely related to both feeding initiatives and choices regarding housing and is therefore a part of the whole picture.

The scope of this focus group is however on the animal and housing related processes. Measures directed at manure handling will therefore not be discussed directly, but are a part of the perspectives of all reduction measures.

Existing measures to reduce emission of ammonia include technical solutions that incorporate liquid manure into the soil or deposits it directly on the surface with e.g. trailing hoses. This reduces emissions compared to broadcasting of manure. For solid manure ammonia emissions are reduced if the manure is incorporated into the soil immediately after spreading.

As mentioned above acidification can be used to reduce emissions from the stable or manure storage. It can however also be done later on in the production chain, i.e. directly before spreading of the manure. The earlier in the process it is applied, the larger is the overall effect on ammonia and methane emissions. Acidification applied directly before spreading has no effect on methane emissions.

On the other hand, acidification of manure in the stable or storage is not compatible with another mitigation option: anaerobic digestion of manure for biogas production, because it inhibits biogas formation. If the manure is only stored for a short- term at the farm and instead transferred to anaerobic digestion facilities, the production of methane can be collected and exploited instead of polluting the environment.

2.1.4 Farm systems approaches

From a management point of view there are also various tools, which can help reduce emissions from cattle. These are for instance management tools that take several of the parameters mentioned above into account and estimate overall emissions. Depending on the complexity of the models behind the tools interactions between different mitigation measures can also be included in the estimate.

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Assuming that the aim is to improve emission efficiency (reduce emissions per kg of product), rather than reducing emissions from individual cows or calves, a straight forward approach is to improve production. Producing a lot more milk or meat with the same or only slightly higher emissions, means that the demand for livestock products can be fulfilled with fewer total emissions. Focusing on increased production has the benefit that it corresponds well with most farmers' general aims.

There is however a large range of factors, which can affect production and the importance of factors for emission efficiency, differs from farm to farm. Examples of factors with relevance for emission efficiency are milk production, feed utilization, nitrogen utilization and number of heifers per cow. A possible tool for farmers is to benchmark these factors against standards or against other farmers. If a farmer can see that his or her cows emit more enteric methane per kg milk than the average it will be natural to focus attention on e.g. feed composition and utilization.

On an animal level the replacement rate of milking cows is very important for the overall emission efficiency at the farm. Even though emissions from a heifer are lower than from a high-yielding dairy cow, the heifers are not producing any milk and therefore reduce overall emission efficiency.

The use of grazing as a tool to reduce emissions is also a management approach. Grazing is mostly applied for other management reasons but the effects on emissions are also worth quantifying and the correlation with period of grazing or grazing pressure is not straight forward.

Nitrogen budgets are another way of visualizing where an effort to reduce emissions will have the greatest impact. By setting up a roadmap for the recycling of nitrogen at the farm any losses of nitrogen can be spotted and mitigated. Potentially this can improve plant production in the field and thereby benefit the farmer.

Such budgets are normally based on models where average factors are used to estimate nutrient flows for the individual farm. In theory this can be supplemented with actual measurements of for instance nitrogen content in the manure or ammonia emission from the stable. Cattle is however often housed in naturally ventilated stables or grazing parts of the year, which makes actual measurements impractical as part of a daily management tool.

3. The focus group work

The above mentioned examples of mitigation measures show that there are many different ways of reducing emissions from cattle production. The challenge for this focus group is to summarize knowledge on cost-effective measures for reducing emissions from cattle - and to analyze the possibilities and barriers for carrying these practices, techniques and strategies out in real life.

More specifically there are six tasks:

- Make an inventory of competitive farm management practices and strategies related to <u>housing and feeding</u> which are currently available, to tackle emissions from cattle at farm level in the EU. Which working examples can be found in the EU? To delimitate the work of the focus group input and output from the farm like feed, fertilizer, fuel, electricity and transport of products will not be included directly in the evaluation.
- Compare these different management practices and strategies, which reduce emissions from cattle, taking into account the cost-effectiveness, production efficiency and emission reduction efficiency. How can emission measuring methods contribute to this? This comparison will be very dependent on production system e.g. farm size, milk vs. beef production or intensive vs. extensive production.
- Explore cross-fertilisation from livestock other than cattle, which could be beneficial for the reduction of emissions in cattle production systems.
- Identify success factors and fail factors that stimulate or limit the use of the identified management practices and strategies by farmers, and summarize how to address these factors and explore the role of innovation and knowledge transfer in addressing these fail factors.
- Identify needs from practice and possible gaps in knowledge on particular issues concerning emissions from cattle which may be solved by further research.

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- Propose potential innovative actions to stimulate the knowledge and use of management practices and strategies in reducing emissions from cattle and to multiply positive effects within the agricultural sector.

The first meeting of the focus group will primarily be concerned with the first three specific tasks: To make an inventory of relevant mitigation measures including relevant measures from other animal production systems and decide how to compare them.

Between the first and the second meeting group members will work in depth with selected topics.

The second meeting will then focus on success and fail factors for emission reduction measures and what needs to be done with regards to research and from an implementation perspective.

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