

Methane and Ammonia Air Pollution

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There are significant interactions between ammonia and methane emissions from agriculture. Overall, measures to reduce these gases go hand-in-hand through links to sector activity. While some measures offer synergistic benefits, there is an ongoing need to optimize practices in order to minimize trade-offs between the two gases. These interactions highlight the opportunity to further develop synergies when including both ammonia and methane the revised EU National Emissions Ceilings Directive (NECD).

Introduction

The EU National Emission Ceilings Directive 2001/81/EC (NECD) is currently being reviewed in context of [The Clean Air Policy Package](#). As a part of this, it has been planned to include reduction targets for the emissions of methane (CH₄) in addition to those for ammonia (NH₃) and other key air pollutants (SO₂, NO_x, NMVOC, and fine particulate matter PM_{2.5}).

The present brief outlines the effects of methane as an air pollutant and the possible interactions between the mitigation of ammonia and methane emissions. This can serve to inform on the merits of linking measures to control methane and ammonia in the NECD revision and as a background for future policy development.

Methane as an air pollutant

While the effects of ammonia as an air pollutant have for many years been targeted in air pollution policies, methane has until now primarily been considered as a greenhouse gas (GHG), and the regulation of methane emissions has been related to GHG reductions. However, in addition to methane being a powerful GHG (about 84 times stronger than carbon dioxide on a 20-year time horizon and 28 times stronger over 100 years), it also contributes to ozone formation in the troposphere. Ozone is health damaging via inflammation in the respiratory tract, causing increased mortality, and also contributes to significant crop losses in Europe. It is formed in the atmosphere via interactions between NO_x, CO and VOCs (Volatile Organic Compounds; including among others methane). In this way the atmospheric chemistry of NO_x, CO, VOCs including CH₄ is closely linked.

The emission of ozone precursors with a short life time (NO_x, non-methane VOCs) primarily affects the local and regional ozone concentrations. However, because of the longer life time of methane in the atmosphere (approximately 10 years) it has a much wider effect (in practice over the whole

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northern or southern hemisphere), while the local emissions have relatively little impact to the local air pollution effects of methane. This means that control strategies for methane need to be addressed at trans-boundary, international scales.

Table 1. Sources for emissions of methane (EEA 2014) and Ammonia (EUROSTAT 2011) in the EU.

Source of emission	Methane	Ammonia
Agriculture	50%	93%
- Livestock	37%	
- and livestock manure	12%	69%
- Other	1%	24%
Waste (household, sewage, garden)	31%	-
Energy industry and other sectors	19%	7%

Interactions between ammonia and methane emission mitigation

- Most ammonia emissions in Europe and around half of the methane emissions result from agricultural activities (see Table 1). In the case of methane, waste and energy sectors are also major sources.
- Agricultural ammonia emissions arise predominantly from livestock manure management and nitrogen fertiliser use. By contrast, methane emissions arise mainly from enteric fermentation in ruminant livestock, with manure management as a secondary source. Rice production also gives rise to both methane and ammonia emissions, although this is only a small source of methane emission in the European Union.
- Although there is no direct causal relationship between ammonia and methane emissions, the feed intake and the level of activity in the livestock and crop sectors affects the emission of both gases, as do specific management practices.
- Increases in the efficiency of animal production are likely to be associated with lower emission intensities for both ammonia and methane. For example, increasing the productive lifetime of a dairy cow will result in fewer replacement animals being required and therefore a lower overall ammonia and methane emission from the whole dairy system (i.e., cows and replacement animals) per litre of milk produced.
- Similarly, improvements in dairy and beef cow fertility, reductions in the incidence of diseases and production-impairing conditions (e.g., lameness) will result in higher productivity per animal for a given input and therefore lower ammonia and methane emission intensity per unit product.
- Some mitigation measures targeted at reducing ammonia emissions will also reduce methane emissions (and vice-versa), but this is not always the case. There are three possibilities:
 - *Measures which reduce both ammonia and methane emissions*
Examples include the coverage of slurry stores, extracting biogas from slurries, and/or acidification of the slurry. Each of these will reduce emissions of both gases. For example, acidification of slurry lowers ammonia emissions by retaining ammonia as ammonium in the slurry, while also inhibiting the activity of the methanogenic bacteria.

The production of biogas from slurries offers obvious win-wins to reduce methane and ammonia emissions, so long as low-emission land-spreading techniques are used for the liquor remaining after digest, the high pH of which can otherwise increase ammonia emissions.

- *Measures which reduce one pollutant but have no effect on the other*
For example, any measures aimed at reducing ammonia emissions from nitrogen fertiliser applications or manure applications to land are not expected to affect methane as these are not significant sources of methane emission. Natural crusting of slurry storage reduces ammonia emissions, but will only have a small benefit in reducing methane emission. This is because methane readily escapes through cracks in the crust, while some methane can be consumed in the crust (being converted to carbon dioxide). Similarly, lowering protein diets for ruminants may decrease N excretion, but, if overall dry matter and fibre intake is similar, there will be little effect on enteric methane emissions. Finally, novel feed additives may selectively reduce methane emissions.
- *Measures which reduce one pollutant but increase the other*
Some animal feeding strategies or dietary supplements to lower enteric methane emission can have the effect of increasing N excretion, which will increase subsequent ammonia emissions. Similarly, active aeration of stored manure to reduce methane emissions will generally increase ammonia emissions. These examples point to the opportunity to further refine practices to minimize such trade-offs.

Relationships between livestock intensity, methane and ammonia emissions

These relationships between methane and ammonia are affected by a trade-off between production intensity and efficiency. This can be illustrated by the fact that higher production intensity is associated with lower methane emissions per unit of milk produced (Figure 1).

For low intensity, low yielding systems, a high rate of emission indicates that there is also a large mitigation potential. This particularly refers to systems with extensive grazing and a high proportion of roughage feed compared with concentrates (Figure 1, left). By contrast, for high intensity, high yield systems, a low rate of emission indicates that there is also a low mitigation potential. This particularly refers to systems with a more yield-optimized fodder ration, and a higher proportion of concentrates (Figure 1, right). Essentially, if methane emissions per unit product are already low (as in intensive milk production systems), there is less potential to reduce them even further.

In general, the potential to reduce methane emissions in the extensive systems may be more than 50%, whereas the potential to reduce methane emissions in the more optimized, intensive systems is less than 25%.

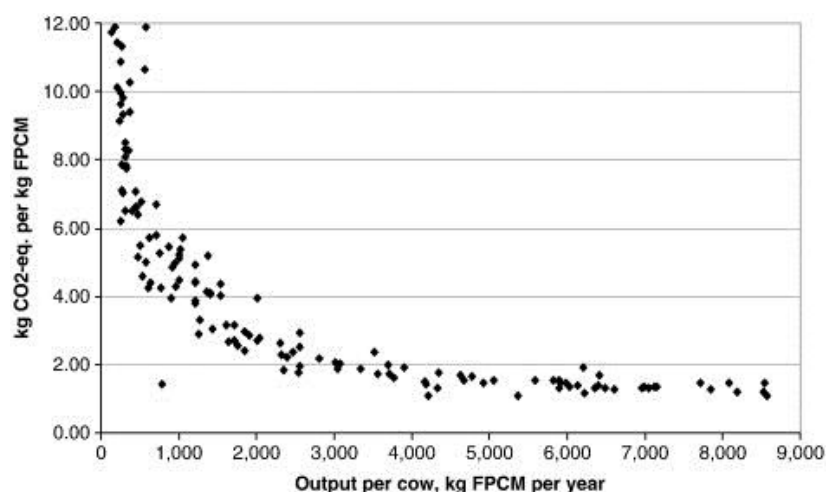


Figure 1. Relation between dairy farm production intensity (annual milk output per cow), and the emission of methane and other minor greenhouse gases (expressed in CO₂ equivalents, where FPCM is Fat Protein Corrected Milk) (from Gerber P. *et al.* 2011, *Animal* Vol. 7, pp 100-108).

For instance it has been estimated that, with existing and expected new technologies, around 11% reduction would be possible in such high intensive milking systems in Denmark. By contrast, a reduction of the smaller emissions from pig production could be reduced by c. 26% by 2030. This corresponds to about 15% overall reduction potential over this period (see also Dalgaard T. *et al.* 2011, *Environmental Pollution*, Volume 159). Further reduction in the methane emissions from the most efficient farming systems (e.g. in Denmark and The Netherlands) may only be possible by reducing milk and meat production.

However, the total emission and air pollution effect of methane is not decided by the production (or reduced production) in single countries, but to a much larger extent by the consumption of milk and meat. If the production is moved from the most efficient systems (to the right in Figure 1) to less efficient systems (to the left in Figure 1) there would be a risk of significantly increased methane emissions and air pollution effects (See comparison for EU regions by Lesschen *et al.* 2011, *Animal Feed Science & Technology*, Vols. 166-167, pp 16-28).

From the perspective of methane, these relationships point to the continued opportunity to benefit from high intensity systems to reduce methane emissions per unit product. This also implies an interaction with ammonia emissions, since the intensive farming practices are often associated with larger ammonia emissions. An example is the tendency to increase the extent to which cattle are housed all year round, in order to increase productivity per unit product, which increases the amount of manure that must be managed as compared with that deposited to fields. This therefore increases ammonia emissions from animal houses, manure storage and manure spreading hot spots. The example emphasizes the need to implement ammonia control measures in the context of policy drivers to reduce methane emissions.

Essentially, in situations where high intensity systems are preferred in order to reduce methane emissions, then it becomes even more important to match these with measures to avoid increases in ammonia.

Conclusion

The combined effect of ammonia and methane mitigation measures are important to take into account, especially in relation to measures targeted for the livestock sector. While there are obvious win-wins between ammonia and methane mitigation, there are also trade-offs which also need to be addressed. Examples include the extraction of biogas from slurries and the use of more intensive systems to reduce methane emissions per unit product.

In the case of biogas production, digesting manure in sealed environments simultaneously reduces methane and ammonia emission. However, while the methane is taken off for biogas production, the remaining liquor has high pH and is liable to high ammonia emissions. This emphasizes the need to connect a methane targeted measure (biodigestors) with the use of low ammonia emission spreading methods for the liquor (e.g. acidification, band-spreading, injection). The example also offers the prospect to further refine bioreactors to produce improved N fertilizer products.

The example of livestock intensification shows that high yielding milk production systems produce less methane per kg of milk produced. This argument could be used to highlight that measures to reduce methane emissions should not be used to favour a higher share of extensification in milk production. However, (in the absence of additional measures) such intensive systems can be associated with higher ammonia emissions, which are especially associated with longer housing periods, with emissions from buildings, manure storage and associated manure spreading. This trade-off may be addressed by emphasizing the need adopt more ambitious ammonia mitigation techniques when using more intensive livestock farming strategies.

Both these examples therefore emphasize that there is substantial merit in joined up thinking on agricultural ammonia and methane emission mitigation. Inclusion of methane in the proposal to revise the NECD offers an opportunity to exploit the synergies and develop approaches that minimize the trade-offs between control of these two gases, with extensive environmental benefits.