

Inventory of best practices and available technologies of methane mitigating actions in agriculture

(Action 11 of the EU strategy to reduce methane emissions COM(2020) 663 final)

Adopted by the ‘EXPERT GROUP FOR SUSTAINABILITY AND QUALITY OF AGRICULTURE AND RURAL DEVELOPMENT (E02733) - Sub-group on methane emissions in agriculture’ on 19.12.2023.

The list of practices which may reduce methane emissions from agriculture draws on two reports of the Intergovernmental Panel on Climate Change (IPCC): The Working Group III - Mitigation of Climate Change (2022) – report for the IPCC 6th Assessment Report and the Special Report on Climate Change and Land (2019). A third key source is the European Commission’s Joint Research Centre’s iMAP wiki¹ (2021) which synthesises a large amount of scientific evidence to assess the impacts of farming practices on the environment, climate, and agricultural productivity. The fourth and most important input are expert discussions on options held on 1 June 2022, on 13 July 2023, on 26 September 2023 and on 17 October 2023. To note that although the list covers the relevant areas of action to mitigate methane from agriculture, the list is not exhaustive as regards specific options. New scientific evidence and regulatory approvals may add methane reducing practices – or even alter the previous assessment regarding their methane mitigation potential. The expert group intends to revise this inventory in due time.

To note also that methane reduction effects depend largely on the context of implementation, including climatic, genetic, dietary, technological, socio-economic, and environmental factors. This context-specificity makes it challenging to provide specific recommendations, this holds true in particular for interventions regarding the feeding of ruminants, storage and management of manure.

Co-benefits and trade-offs: To note that a practice or a technology can have a direct positive effect on methane emissions and lead to an increase in emissions in the same or in another inventory category, e.g. substituting roughage from grassland through feed crops may lead to increases in emissions from land use change even more in case of deforestation. Equally, a neutral or very slight effect on methane mitigation can lead to strong mitigation in the same or in another category, e.g. increasing the share of legumes can lead to less synthetic fertilizer production, transportation, and use. In the form of fodder legumes in pasture, it can in addition increase soil carbon. The use of protein-rich crop by-products such as brewers’ grains as feed has also co-benefits in terms of production of feed elsewhere. To note that structural changes in the livestock production systems without changes in consumption of livestock products bears the risk of carbon leakage. Some methane reduction practices have effects on ammonia emissions. It is important to find synergies i.e. practices that reduce both ammonia and methane emissions, especially as Member States already have defined ammonia emission reduction obligations under the NEC Directive.

¹ <https://wikis.ec.europa.eu/display/IMAP/IMAP+Home+page>

Enteric methane emissions:

Methane emissions from **enteric fermentation** can be targeted directly via changing the metabolism in the rumen or the biome in the rumen (emissions per animal go down) or, more indirectly, via productivity gains (emissions per unit of product go down).

Modifying diets for ruminants can contribute to reduce the amount of methane produced per unit of animal product. Among the available mitigation options, improved feeding incl. through higher digestibility is relatively easy to implement at the farm level, but the potential to further reduce the methane intensity is limited in already highly productive livestock systems. Increased methane efficiency can be achieved through supplementation of lipids e.g. the use of flax-/linseed and rapeseed. To note that significant changes in ruminants' diets, e.g. substituting roughage from grassland through feed crops may lead to changes in GHG emissions from the feed system, incl. from land use and land use change which is reported under LULUCF. To note that animal diets (and dietary changes) need to respect animal health and welfare.

Improved pasture management includes the optimization of the grazing rotation and timing, adequate stocking rates, appropriate application of fertilisers, modification of the soil pH. Also changing the composition of the pasture species, within the climatic constraints, may reduce enteric methane. Grazing of fresh grass, compared to feeding grass silage in the stable, also seems to be a way to reduce methane emission that should be considered.

There is a vast amount of research currently conducted on how to modify methane emission from enteric fermentation and especially on various feed additive candidates and feed rations. *In vitro* experiments help to understand physiological mechanisms. However, also long-time *in vivo* studies are necessary to confirm persistency of the effects, and finally on-farm experiences prove whether any given technology/method is useful in practical conditions.

Use **feed additives** which effectively reduce methanogenesis in the rumen and which are safe for the animals, humans, and the environment. Currently the only feed additive approved for reducing enteric methane is 3NOP. Feed additives which claim to reduce enteric methane are subject to pre-market authorization, including comprehensive safety assessment by EFSA, according to [Regulation \(EC\) No 1831/2003](#).

Use **feed materials** which effectively reduce methanogenesis in the rumen and which are safe for the animals, humans, and the environment. Emerging options include a wide variety of substances such seaweed, macroalgae. Further research is needed, and science is evolving fast. Also, some feeds such as red algae contain components that could inhibit methanogenesis. Regulatory approval may be required as issues concerning the use of feed additives include (lack of) mitigation persistence, potential toxicity and animal health/welfare issues may need to be assessed. Food safety issues (for milk in particular) may arise from (overdosed) nitrate-rich feed and feed with high levels of iodine and bromoform (algae). Administering feed ingredient-based solutions in livestock systems with permanent grazing on pastures poses a practical challenge at present.

Improvements in animal health can also significantly reduce methane intensity by improved productivity, better fertility per animal, and reductions in mortality. Extending the reproductive life of the animal is key to reducing methane emissions. Comply with welfare of livestock through microclimate in stable, hygiene of the housing, preservation of natural animal behaviour. Ensure a balanced ration and prevent animal diseases in general (probiotics, vitamins, minerals), with a focus on metabolic diseases and diseases of the digestive tract.

Herd management: Overall earlier calving can significantly reduce methane emissions. Earlier calving needs earlier conception. A certain body frame (body size) is necessary for a problem-free gestation.

Changes in livestock species/breeds. Switching to species or breeds which are better suited for a specific environment can lead to higher productivity per animal within the given natural constraints. Also, structural changes of a livestock system, to other ruminants, or from ruminants to monogastric animals could lead to reduced methane emissions.

Breeding of low emitting animals which exploits natural variation of enteric methane emissions within a breed is a promising mitigation solution that is permanent and cumulative. However, to effectively implement breeding strategies to reduce enteric methane and to achieve the expected breeding impact, enough animals need to be phenotyped and genotyped.

Manure management:

Manure management measures aim to mitigate methane (and nitrous oxide) emissions from manure storage. Measures include livestock housing, anaerobic digestion, composting, improved storage, and manure treatments. Implementation of good manure management practices contribute to reducing nutrient losses, improving water and air quality. However, the potential antagonistic relationship between methane, nitrous oxide and ammonia mitigation needs to be taken care of. Applying manure to agricultural land enhances soil organic matter content and provides nutrients for soil microorganisms.

Regarding **livestock housing**, many practices (such as regarding air and temperature in the stable, floor, bedding, space) have primarily an impact on animal welfare and health and, thus, via better herd productivity, also indirectly on methane emissions. The installation of **biofilters** to filter the exhaust air from the stable or storage may be an emerging option to reduce methane emissions in closed systems (pigs and poultry), especially if the air in the stable is not mechanically ventilated. If not optimized biofilters may increase N₂O emissions. Currently, biofilters are proven and being applied mainly for reducing ammonia. They are not effective for naturally ventilated housing systems which are common for ruminants. They are also not effective for mechanically ventilated stables.

Manure is mainly stored as slurry in closed tanks or anaerobic lagoons, which tend to emit less nitrous oxide and ammonia during storage than in open storage but can increase methane emissions. Slurry also has increased risk of ammonia emissions during spreading. Slurries are a significant source of methane (plus ammonia and nitrous oxide) emissions. GHG emissions from manure management can be most effectively abated, if methane emissions **during storage** are

reduced. Also, the **frequent removal of manure** ideally emptying the storage pits can reduce emissions from livestock housing, but then it is crucial do address also methane emissions from storage. Cooling of slurry in slurry pits can reduce methanogenesis and thus CH₄ formation.

Mainly to avoid ammonia (and N₂O) emissions from storage, slurry tanks should be covered. This, in turn, creates more favourable conditions for anaerobic processes leading to increased methane production. The **generated methane should be captured and oxidised** (biofilters, flaring) if not used for renewable energy. Natural 'living' covers/crusts oxidize (part of the) methane generated.

Anaerobic digestion (AD) of animal manure aims at renewable energy production. The methane produced is collected and used as fuel. Anaerobic digestion not only reduces CH₄ emissions from manure stores but also improves the fertilizing quality of the digestate compared to manure. AD is thus a means to foster the overall circular economy in terms of energy production, nutrients recovery and providing organic matter for soil fertility. Differences in the methane reduction effect mainly depends on the configuration of process, e.g., either mono-digestion (only manure) or co-digestion (manure and other substrates) or anaerobic digestion with digestate-treatment technologies, such as filtration, reverse osmosis, additives (microalgae), drying, stripping. Sufficiently long retention time is crucial for reduced methane emissions and maximal biogas yield. Appropriate gas-tight design to avoid fugitive methane emissions from leaks in the installation needs to be taken into consideration. Furthermore, the digestate continues to emit methane, best practice is gas-tight storage with capture of gas. The possibility to co-digest biowaste with manure may provide additional climate benefits and organic fertilizer.

During **slurry separation**, solids are mechanically separated from slurry. This results in two fractions: a liquid slurry fraction with low dry matter content and a solid fraction. Separation can also be applied to the digestate after AD. Although the main aim of the separation is to improve nutrient utilization, it also helps to reduce methane emissions.

As regards **manure acidification**: Acidification helps for both, ammonia and methane reduction. To note that part of the observed methane reduction with acidification may stem from the fact that acidification also requires moving/homogenization of the slurry after adding the acid – which itself reduces anaerobic conditions favourable for methanogenesis. The earlier in the manure handling chain the acid is added into manure, the more effective acidification is in reducing methane emissions. Work safety and effect on soil health need to be considered.

Composting of manure can reduce methane emissions compared to non-treatment of manure but leads to nutrient losses. Unless the nitrogen is collected, it's lost during composting. Methane emissions can still occur in case there are anaerobic spots in the stacks. There are differences in the effect mainly depending on the type of composting process techniques (e.g., C/N adjustment, vermicomposting, addition of bulking agents, periodical turning, forced aeration e.g. of poultry litter of the composting piles).

Wetting and flooding alternance reduces methane from rice fields. Not to apply manure to flooded fields (e.g., paddy rice) also can reduce methane emissions.

